ON THE NATURAL PHONOLOGY OF VOWELS

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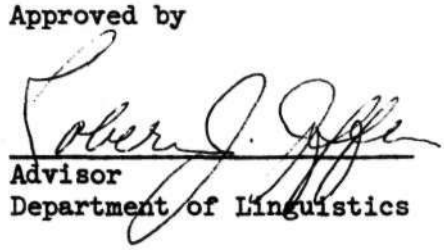
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To David, of course,

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LIST OF SYMBOLS

1. Transcription symbols: Features.

Symbols in square brackets in this dissertation have the following features:

	-chromatic	+chromatic					
	-palatal -labial	+palatal -labial		+palatal +labial		-palatal +labial	
	(-tense)	-tense	tense	-tense	tense	-tense	tense
high	ɨ	ɪ	i	ʏ	y	ʊ	u
mid	ʌ	ɛ	e	œ	ø	ɔ	o
low	ɑ	a	æ	ɶ̈	ɒ̈	ɑ̈	ɒ

[ɨ, ʌ, ɑ] symbolize non-palatal non-labial vowels, either 'central' or 'back' (retracted). But [ɯ, ɤ̟, ɑ˖] are used for the retracted varieties where the central/back difference is under discussion.

[ʌ] is used for [ɵ] where [ɵ] occurred in my sources, but no phonetic difference from [ʌ] is intended.

The features are discussed in detail in Chapter II.

2. Transcription symbols: Examples.

The following list includes examples of the vowel quality (without regard to length) designated by each symbol. Most coincide with the IPA symbol values, although I interpret these somewhat differently, in terms of features, from the IPA descriptions.

ɨ N. Welsh dŷn, bryn; some American dialects just, children

ʌ RP English and American cup, bug (Br. dial. [ ], So.U.S. often [ɤ̟].)

ɑ RP English car, father; Midwest Am. hot; Parisian Fr. pas; Ger. fahren

i English heat, French si, German wie, Japanese ki

ɪ English bit, German bitte

e French thé, German mehr, Italian pesca (fishing)

ɛ Northern English and American bet, French mettre, maître, Ger. Bett Ital. pesca (peach)

æ American English hat, nap ('Tense æ' in urban U.S. dial. is [eə̯].)

a Parisian French patte, la; Boston Engl. park; Detroit, Chicago, Buffalo locks; So. U.S. height (vs. hot or hat); Canadian Engl., former RP ask, half

y French lune, German über

ʏ German fünf, Glück, Faroese krúss

ø French peu, German schön

œ French oeuf, German zwölf

u English boot, soup; French tout; German gut

ʊ So. British and American book; German Hund

o French beau; German wohl, Ital. dove

ɔ Midwest American port; French porte; German Sonne

ɒ Midwest American bought, taught; British stock, yacht

ɑ So. British lawn, all; some American dial. card (esp. where card = cord)

I - INTRODUCTION

1.0. Introduction.

In this dissertation I present a theory of the natural phonology of vowels and diphthongs. I use as evidence the regular substitutions of one vowel or diphthong for another in (1) productive synchronic alternation and variation, (2) child speech, (3) diachronic phonetic change, and (4) constraints on systems of vowel phonemes, which manifest themselves in the pronunciation of foreign vowels.

The substitutions encountered in these four settings are virtually identical. For example,

(1.1) In some dialects of American English, [ɔ] as in hawk has a variant pronunciation [ɑ].

(1.2) A child regularly pronounces the vowel [ɔ], as in ball, as [ɑ].

(1.3) Middle English [ɔ], as in not, became [ɑ] in various Modern English dialects, especially in America.

(1.4) The phoneme system of the African language Nupe does not include [ɔ]. [ɔ] in words borrowed from the neighboring language Yoruba is pronounced [ɑ] by Nupe speakers (Hyman 1970).

These parallel substitutions, which are typical of many to be cited, are manifestations of a single natural phonological process, delabialization, which replaces rounded vowels (such as [ʊ]) with their unrounded counterparts.

According to the general theory of natural phonology (Stampe 1969, 1973a, Donegan and Stampe 1978a), every regular sound-substitution --including assimilations, dissimilations, insertions, deletions, and metatheses, as well as 'unconditioned' substitutions like (1.1-4)-- reflects the operation of one or more of a set of natural phonological processes--'natural' in that they respond to innate limitations of the human speech capacity. Any limitations which the individual does not overcome in his early, plastic years in the acquisition of language remain with him throughout his life. The living phonology of a language, everything that determines the 'accent' of its speakers, is the collective, systematic manifestation of those natural phonological processes which the language fails to challenge.

Thus, whereas the American child eventually overcomes her substitution of [ɑ] for [ʊ], the Nupe child confronts no [ɔ] in his mother tongue, and the [ɑ] substitution manifests itself when, in the inflexibility of adulthood, he encounters [ɔ] in a foreign word.

If one could collect all the sound-substitutions of children, the diachronist Grammont (1965) said, one would have a sort of grammar of all the possible sound-changes. The synchronist Baudouin de Courtenay (1895) would have added, also all the possible phonological alternations. And, as the panchronist Jakobson argued in his monumental Child Language, Aphasia, and Phonological Universals (1968), also all the possible phoneme systems. Such systems are determined, as Greenberg (1966) concluded in his study of phonological universals, by the collective effect of phonological processes (particularly the 'unconditioned' processes which, since they affect a sound in all its occurrences, thereby affect the inventory as well as the distribution of phonemes). But, pace Greenberg, such processes are not mere historical events: they are the living expression of the phonetic capacity of the individual.

This dissertation presents my explorations in the world of vowels. Although I have occasion to mention assimilatory processes, my focus is on those processes traditionally labeled 'unconditioned' or 'spontaneous'--the ones pessimistically called unexplainable because they apply to segments regardless of their contexts (or worse, in dissimilation, despite their contexts), and because, as is implied by their classification as 'strengthening' processes, they seem to defy the law of least effort. These are processes which, in the earliest speech of a child, can scramble all his vowels into one, and yet can, in a language like Faroese, juggle two dozen vowels with hardly a merger.

A full account of the nature, operation, and causality of these processes is not in sight. Thorough and useful descriptions are unavailable for many languages: the brief phonemic sketches of vowel systems that appear in many surveys and in some monographs often fail to provide sufficient phonetic information on vowel quality; and conversely, some descriptions which do provide such phonetic information lack the phonological data that is crucial to the sort of analysis that the study of processes requires. For many little-known languages, historical studies, which provide much useful data, are unavailable--and indeed impossible, given linguists' current knowledge of such languages.

Not only are there all too few languages, dialects, and even language families well-known enough to allow for a full and universal account of natural processes; the phonological features, on which the description and explanation of processes depend, continue to be a serious problem for phonological theory. Some features which seem to be limited to certain language areas (like the 'vocal register' features of various Austroasiatic languages of Southeast Asia) have not yet been studied enough to warrant hypotheses about either their phonetic

character or their phonological effects. And even some features as familiar as vowel height, lip rounding, or syllabicity remain phonetically mysterious. Vowel height does not always correlate directly with tongue height or jaw opening--and yet one would expect that there must be some consistent articulatory difference between vowels of different heights to correspond to the consistent acoustic differences between such vowels. Lip rounding, on the other hand, has a relatively simple and consistent articulatory manifestation, but no simple and uniform acoustic correlate has been identified (Ladefoged et al. 1972:74).

Nevertheless, common phonological substitutions which appear, in various manifestations, in language after language provide a great deal of information on which a theory of possible substitutions can be based, and even an incomplete phonetic understanding may offer the beginning of an explanation.

1.1. Natural processes.

A natural phonological process, according to Stampe (1973a:1) is 'a mental operation that applies in speech to substitute, for a class of sounds or sound sequences presenting a specific common difficulty to the speech capacity of the individual, an alternative class identical [in all other respects] but lacking the difficult property.' Natural processes, then, are the natural and automatic responses of speakers to the articulatory and perceptual difficulties which speech sounds or sound sequences present to their users.

It should be kept in mind that natural processes are mental operations--that is, the substitutions occur in the central nervous system. They are not merely physical or motor slips due to faulty timing or missed targets; they represent the substitution of new phonetic targets. There seems to be no reason to believe that the kinds of adjustments processes involve could be made by the organs of articulation themselves, or by the peripheral innervation of these organs. Anticipatory substitutions, in particular, suggest that the substitutions occur in the central nervous system, before any articulatory commands are sent out (cf. Donegan and Stampe 1978a, Sec. 2.1). The fact that children do learn to suppress processes when their native language requires them to do so (as the American child does when she learns to say [ʊ]) argues for their mental nature, as does the fact that adults can suppress certain 'optional' processes in some styles but allow them to apply in others. Finally, the mental nature of processes is clear from their application in silent, mental speech, in which there is no reason for physical misses or mistimings, and from the psychological reality of process outputs, as attested by spontaneous spellings (Stampe 1973a: 6).

But although processes are mental substitutions, they clearly have physical motivations or functions. This is seen from the fact that they characteristically apply to classes of sounds that can be

defined in terms of their articulatory and/or acoustic properties. They characteristically apply, then, to novel inputs which fulfill their requirements:

(1.5) the regressive nasalization process which affects English vowels before English nasals applies in English speakers' pronunciations of the [y, œ] of French lune, jeune, as well as to their native English vowels; and it applies to vowels before the foreign [ɲ] of Spanish cañon, piñon, etc. as well as to vowels before native [m, n, ŋ].

In context-sensitive processes like nasalization, or like assimilation of the point of articulation of a nasal to that of a following stop ([nb] → [mb]), the physical motivations sometimes seem quite obvious. Even for some context-free processes, the function of the substitution may be relatively easy to determine (e.g. the substitution of voiceless obstruents for voiced ones is due to the difficulty of maintaining voice when an obstruction of the tract causes increased supraglottal pressure and consequently diminished air flow across the glottis). But even when the physical motivations are complex or obscure (as are, for example, the motivations for the context-free changes by which [i:] and [u:] become [ɑi] and [ɑu] in the course of vowel shifts like those of English and Standard German), such motivations are there to be discovered. One of the purposes of this study is to try to discover some of these less-obvious physical motivations in the processes which affect vowels.

1.1.1. Processes versus 'rules'.

The natural phonological processes of natural phonology (Stampe 1969, 1972, 1973, Ohso 1972, [Donegan] Miller 1972, 1973, 1976, Dressler 1974, Bjarkman 1975) are not the same as the phonological rules of generative phonology (Chomsky and Halle 1968, Anderson 1974, Kenstowicz and Kisseberth 1977, etc.). Although generative phonologists may speak of 'natural' rules, many--or even most--of the substitutions they describe are of a fundamentally different character from the processes to be discussed here. The distinction between processes and rules is the same kind of distinction drawn by Baudouin de Courtenay (1895 [Stankiewicz translation 1972, 161 ff.]) between neophonetic (or anthropophonic) and paleophonetic (or traditional) alternations.

The synchronic phonetic motivation of processes strictly distinguishes them from phonological constraints and alternations which lack such motivation. The vowel alternations of serene/serenity, dream/dreamt may be said to be governed by phonological rules, but they are not, in Modern English, governed by processes. Rules do not represent real constraints on pronunciation, but only on 'correctness'; they are often morpheme-specific, allowing exceptions like obese/obesity or dream/dreamed, and occasionally allowing analogical levelings like ser[ ]nity, obsc[ ]nity, patterned on serene, obscene, etc.

Processes, on the other hand, do represent pronunciation constraints, and it requires a special effort on the speaker's part to violate them, if he can do so at all. Thus, while any English speaker can violate the rule which forbids obsc[ʲ]nity or verb[ᵊ]sity and pronounce these forms with ease,

(1.6) a process like the fronting of the [ɑ] in the diphthong [ɑo̯] to [æ], as in [dæo̯n] down and [æo̯t] out, can only be violated at the expense of a special effort by the English speaker--if he can manage to suspend the process and produce [dɑo̯n] or [ɑo̯t]. The application of this process and the difficulty involved in its suppression are also apparent in loans with original [ɑo̯], e.g. German [hɑo̯sfrɑo̯] Hausfrau, in attempts to imitate English speakers who do use [ɑo̯], and in foreign-language learning, e.g. English-accented German.

These last-cited examples show what the process applies even if [æo̯] should be derived from underlying /æo̯/ rather than /ɑo̯/ and thus the process normally applies vacuously, as a constraint rather than as a substitution, in native vocabulary.

Processes, then, are different in nature from rules, because processes are responses to specific innate limitations of the speaker's phonetic capacity--the same limitations which the child encounters in his early efforts to speak.

Since they are spontaneous responses to innate difficulties, processes are said to be natural, in the sense that they are not acquired cognitively--at least not in the sense that rules in the sense of generative phonology (e.g. in Chomsky and Halle 1968) are acquired by a cognitive manipulation of observed speech. Processes apply involuntarily and unconsciously, and they are brought to consciousness only negatively: a process becomes noticeable to a speaker only when he confronts pronunciations to which it does not apply, as when he tries to imitate a foreign sound or sound sequence and finds that he has difficulty doing so. Rules, on the other hand--although they may be quite habitual, and therefore unconscious and involuntary, as habits often are--are learned: rules are formulated on the basis of observed alternations or differences of which one necessarily is, or has been, conscious; when a speaker confronts an exception to a rule, he may find it hard to remember, but never hard to pronounce.

Corresponding to this difference in the nature of processes and rules is a difference in the order of application in speech processing: processes apply after the applications of secret-language rules, and after unintentional slips of the tongue (Stampe 1973a:45; Donegan and Stampe 1978a, Sec. 2.5).

(1.7) For example, the process that palatalizes [k] to [c] before a palatal vowel applies after the secret-language

rule of Pig-Latin. Thus the /k/ of cool is a back [k] in normal speech, but a palatal [c] before the [ɛ̟] of Pig Latin: [u̟cɛ̟]. Conversely, the /k/ of keel is a fronted [c] in normal speech but a back [k] before the infixed /ɑb/ of the secret language Ob: [kɑbi̟]].

Phonological rules, on the other hand, apply before secret-language rules:

(1.8) The 'velar softening' rule that exchanges the final [k] of electric and the [s] of electricity before the suffix -ity must apply before the Ob rule, since electricity is pronounced [ɑb↓lɑb↓kɪrɑb↓sɑb↓tɑb↓] with [s] rather than [k].

Similarly, processes apply to the results of slips of the tongue.

(1.9) Such productions as [stɑč kʰɛ̟p] for Scotch tape show that the slip /stɑč kɛ̟p/ for /skɑč tɛ̟p/ arose before the process aspirating initial stops applied, since otherwise [stʰɑč kɛ̟p] would have been produced (Stampe 1973a:44).

Since phonological processes apply to the non-lexical outputs of secret-language rules and to the results of slips of the tongue--which certainly must arise during speech processing--it follows that processes too must apply in actual speech production. Phonological rules, on the other hand, apply before these two production phenomena, and therefore their role in speech processing is less clearly established. Whatever their role, examples like those cited here show that rules apply before, not after, processes.

Processes may be optional, or variable. That is, a process may apply or not depending on speech style, tempo, attentiveness, etc., and its domain of application likewise may vary depending on such factors. As far as I know, phonological rules exhibit no such variation; they seem always to be obligatory. Since rules are entirely conventional or traditional, their application has no phonetic value--it does not make utterances easier to say or easier to perceive--so rule application does not vary according to variations of style, tempo, etc., which affect the phonetic difficulty of an utterance.

Because processes are responses to phonetic limitations of the speaker, they cannot be borrowed, any more than the inability to say [w] could be borrowed from a Swede. That is, they cannot be borrowed as processes. If a borrowed vocabulary is marked by frequent alternations which result from a process that applies in the loaning language, speakers of the borrowing language may formulate a rule which mimics the process of the loaning language. (English appears to have acquired its Velar-Softening rule from French in this manner.) But the rule in

the borrowing language is merely a rule, and whatever characteristics it shares with the original process are matters of superficial similarity.

I will be concerned here with processes, rather than with rules. Most rules, of course, originate as processes; an example is the Trisyllabic Laxing rule of English, which produces alternations like serene/serenity. This rule originated in the Middle English shortening of vowels in closed syllables, but subsequent phonetic changes--particularly the re-coding of the vowel length distinction as tense versus lax, and the following changes of the Great Vowel Shift--so changed the nature of the alternations that they can no longer be attributed to the synchronic application of the original process. However, I will use reconstructed processes, and reconstructed sound changes, based on the evidence of rules, as evidence of processes.

1.1.2. Processes in children's speech.

The study of natural phonological processes in children's speech has received considerable attention in natural phonology (Stampe 1969, 1973a, Edwards 1973, Dressler 1974, Major 1977). The limited articulatory abilities of young children make it necessary for them to employ many substitutions and to apply them quite generally. But children do not typically make these substitutions randomly or irregularly.

(1.10) Thus, a child who substitutes [ȷ] for [l] in lady and look will substitute initial [ȷ] in all words beginning with [l] (cf. Edwards 1973:16): e.g. my daughter Elizabeth's lion [ȷaɐ̯], light [ȷaɐ̯t], etc.

(1.11) Similarly, a child who substitutes [ɑ] for stressed [ʌ] will produce [ɑ]'s for all stressed [ʌ]'s (Velten 1943: 286-7): e.g. Joan's brush [bɑs], thumb [mɑm], mud [mɑt], etc.

It is generally agreed (Stampe 1969, Kornfeld 1971, Edwards 1973, etc.) that children can perceive distinctions (as between [l] and [ȷ] or [ʌ] and [ɑ]) long before they can produce them. It is consequently assumed that children typically know what the correct sounds are--that is, that their internal representations of words correspond to the adult forms. This assumption is verified by the observation (Stampe 1969:446) that when a child does acquire some sound (like [l] or [ʌ]) which he had previously been unable to produce, he does not have to re-hear all the words he had been mispronouncing in order to correct them. Instead, he changes the pronunciation of just the words in which he had been making a substitution. That is, the child who substitutes [ȷ] for [l] in look and lemon does not have to re-hear the [l] in lemon, once he has learned to pronounce it in look, to verify that lemon really does begin with [l] rather than with [ȷ]. And, pace Jakobson (1968), children do not overgeneralize these developmental corrections to change 'real' [ȷ]'s into

[ɪ]'s in words like yes and yarn. (Apparent overgeneralizations, like my daughter Elizabeth's [ɪɛlo] for yellow and [ɪɛlɪŋ] for yelling, and Jakobson's example (54, note 22)--in which a child's Duten Ta Herr Dotta became for a while Guken Gag Herr Goka--seem always to result from non-adjacent assimilations (cf. Stampe 1969:447).)

The consistent substitutions with which children alter their internal representations to fit their articulatory abilities are instances of natural phonological processes. In my discussion of vocalic processes in Chapter III, I will show that the processes that affect the speech of children have the same functions and are subject to the same conditions on their application as processes which apply in adult speech or in language change.

As the child masters new articulations and learns to produce the more difficult segments or sequences of his native language, he stops making the substitutions that his limited abilities had required him to make at first; now he can suppress the processes he had been applying, or he can limit their application, so that he no longer makes substitutions for segments or sequences that his language requires him to produce.

(1.12) For example, Velten's daughter Joan at one stage substituted high vowels for adult tense mid vowels, as in [dɪ·] day, [bɪ·vɪn] bathing, [ɬɑwɑfud] telephone, [dɑwɑput] davenport. In learning to produce an [eɪ̯], Joan limited the process which raised mid vowels so that it applied now only to labial vowels: adult [o(u̯)] still became [u] in her speech, but mid front vowels remained mid. Of course, Joan subsequently learned to make an [oɥ̯], and as she did so, she suppressed the raising process altogether.

In learning to produce the sounds and sound-sequences of his language, a child will have to suppress some processes altogether, as Joan did, but he can let some processes continue to apply in a limited way. The language may require that a process be limited to a subset of its original inputs:

(1.13) For example, there is, in some American and British dialects of English, a process which diphthongizes the high and mid tense palatal and labial vowels [ɪ, e, u, o] to [ɪɪ̯, ɛɪ̯, ʊu̯, ɔɥ̯] (cf. Labov 1972). Children learning these dialects must learn not to allow this process to apply to the low tense palatal and labial [æ] and [ɒ].

This represents a limitation of the diphthongization process to a subset of its original inputs: roughly speaking, [V, +tense] → [VV̯] is limited to [V, +tense, -low] → [VV̯].

Another way in which children sometimes limit the surface effects of a process is by constraining its natural iterative application (Stampe 1973, 59-68). The function of each process is to substitute a less difficult class of sounds or sound-sequences for a more difficult class. But once a process has applied, sweeping away, as it were, a certain class of difficulties, another process may (subsequently or simultaneously), in removing some entirely different difficulty, create new mem rs of the very class the first process got rid of.

(1.14) For example, for a child who substitutes zero for [ʃ], this [ʃ]-deletion eliminates a difficult segment. But suppose another process--delateralization, as in (1.10)--simultaneously substitutes [ʃ] for [l]. Unless the first process is allowed to apply again, the child will have to produce [ʃ]'s--for [l]'s. If each process is to accomplish its function on the surface forms (the forms that are actually pronounced), then the [ʃ]-to-Ø process should apply again, after the [l]-to-[ʃ] process, and again after any other process that creates [ʃ]'s.

Such absence of ordering restrictions--unconstrained iteration--is the natural state of process application. But there is a catch to this free-handed elimination of difficulties: the processes thus applied merge, in actual pronunciation, the distinction between between /l/ and /ʃ/ in the child's underlying representations (corresponding to adult [l] and [ʃ]); both become zero, so that e.g. less and yes would both be pronounced [ɛs]. One way for the child to maintain a distinction without having to suppress either process is to restrict the iteration of [ʃ]-to-Ø, so that it may not apply again after [l]-to-[ʃ]. Thus the child says [ɛs] for yes but [jɛs] for less--not the underlying or adult distinction, to be sure, but a distinction nevertheless. This seems to be the situation which holds with children who initially substitute zero for both [j] and [l] but who later produce zero for [ʃ] and [ʃ] for [l] (cf. Jakobson 1968:15, and Donegan and Stampe 1978a, Sec. 3.3).

Such apparently paradoxical sets of substitutions, described by Jakobson as 'sound shifts', may persist into adulthood. Thus, such constraints may account for some of the peculiar situations in language in which a speaker cannot pronounce a segment or sequence when he tries to produce it, but produces that very segment or sequence when he is trying to pronounce something else.

(1.15) For example, many speakers of English find it difficult or impossible to produce the sequence [ɑɻ] in phrases like How now, brown cow? or in borrowed or foreign words like Hausfrau or Laut (cf. (1.6)). Instead they substitute [æɻ] quite automatically. But many of the same speakers in whom the [ɑɻ]-to-[æɻ] process is active also make a substitution which produces the phonetic sequence [ɑɻ]: dark, syllable-final [ɹ̩] optionally becomes [ɻ̩]~[ɻ] so that doll, Sol, etc. are pronounced [dɑɻ], [sɑɻ], etc.

This [oo̯] sequence does not undergo palatalization to [æo̯]. While now and German Bau become [næo̯] and [bæo̯], and doll and Poll become [do̯o̯] and [po̯o̯], doll and Poll are never *[dæo̯] or *[pæo̯].

Such restrictions on process application in child and adult speech and their relationships to real diachronic 'sound shifts' will be further discussed in Chapter V (5.1.3-4).

Besides being limited with respect to their inputs, environments, or reapplication, processes may also be limited to certain styles of speech.

(1.16) *Monophthongization of* [ae̯] *to* [a] *occurs in the speech* of many children; for example, Joan Velten at 25 months said [naf] for knife, [sa·d] for side, slide, sign, etc. (Velten 1943:290). Most American children learn to suppress, in careful speech, the processes of assimilation by which [ae̯] becomes [ae̯] or [a:], and thus to distinguish between pairs like side [sae̯d] and sod [sa:d]. But *in casual or careless speech the assimilations are* allowed to apply, particularly in weakly-stressed words like I'll and my, and they thus remain as optional processes in American speech.

1.1.3. Processes in phonological change.

If, in learning a language, a child continues to make a substitution which does not apply in the language as spoken by others, he has, in effect, added a process to the phonological system of his language by failing to learn to pronounce its input. That is, his phonological system differs from the 'standard' system in that he applies a process which other speakers do not apply.

(1.17) For example, Joan Velten substituted [a] for [o] in American English words like lawn [za·d] and coffee cake [fa·fafu·t] (Velten 1943:290-1). Younger speakers of the eastern Midwest have begun to continue to apply this delabialization process ([o] → [a]) and so fail to develop a distinction between pairs like cot/caught, Don/dawn, Otto/auto.

These speakers have thus added a process to the phonology of English. So have many English speakers (of widely scattered geographical origins) who now devoice final obstruents in English. Such additions are, of course, motivated by the phonetic teleologies of the individual processes being added.

Similarly, if the child continues to apply generally a process which is limited in the adult language, he has in effect generalized

the process.

(1.18) Southern speakers of U.S. English, for example, who diphthongize [æ] and [ɒ] to [aɐ̯] and [ʊɒ̯], as in half [haɐ̯f], hog [hʊɒ̯g], have allowed the diphthongization of palatal and labial vowels to continue to apply to all vowels, instead of limiting it to low vowels, as dialects more conservative in this respect require--cf. (1.13).

Phonetic changes often seem to be optional at first, only later becoming obligatory (cf. Greenberg 1966). This reflects the fact that children, and thus speakers in general, may suppress or limit a process in some careful styles but allow its application (or its more-general application) when they can get away with it.

(1.19) For example, many American speakers allow the [ɑɐ̯]-to-[ɑ:] assimilation processes to apply in casual speech, so that [aɐ̯l] I'll becomes [[ɑ:l] and [fɑɐ̯l] file becomes [fɑ:l], but suppress these assimilations in careful styles, saying only [ɑɐ̯l] and [fɑɐ̯l]--cf. (1.16). If the stylistic (and lexical) domain of the process increases sufficiently, learners may hear only forms in which the process does apply, and they will consequently fail to suppress the process at all. Then the process becomes obligatory--as [ɑɐ̯] → [ɑ:] has become obligatory in some southern U.S. dialects (Kurath and MacDavid 1961: 91-3).

(Not only do processes apply more freely in some styles--they also apply more freely to certain lexical items. I'll and file, for example, show a certain asymmetry with respect to this monophthongization: for many speakers I'll, while are monophthongized even in careful speech, but file, style etc. undergo monophthongization only in very casual speech. Further examples of such differential application of processes are not hard to find and may represent what Wang (1969) and Chen and Wang (1975) call lexical diffusion.)

If a change becomes obligatory, and if, furthermore, it fails to leave any surface alternations, speakers of the next generation may adopt the output of the process as the underlying representation of the sound in question. In a case such as /ɑɐ̯/ → /ɑ:/, the speakers who adopt /ɑ:/ do so because they have no reason to think that the representation should be otherwise, since they rarely or never hear variants with [ɑɐ̯] in their intended dialect. These speakers, then, no longer actively apply these assimilations, but neither do they suppress them. The processes remain as latent limitations on these speakers' production capabilities and only appear in substitutions if the speaker attempts to acquire a new language or imitate a 'foreign' dialect.

1.1.4. Processes in loan phonology.

A process that remains unsuppressed in the phonology of the adult speaker of a language represents a constraint on his ability to produce certain sounds or sound sequences. As noted above, in continuing to apply the process, the speaker has failed to learn to pronounce its input. So sounds or sound-sequences that do not occur in the native language are 'hard to pronounce' and are subject to replacement when the adult speaker encounters them in a foreign language. Thus

(1.20) speakers of languages like German and Russian, in which devoicing of final obstruents is retained as a process in the adult language, tend to devoice final obstruents when they speak English.

(1.21) And speakers of languages like Hawaiian, in which devoicing of all obstruents remains as a process in the adult language, devoice all the voiced obstruents they encounter in English.

(1.22) Similarly, speakers of languages like Greek or Japanese which lack the vowel [ʌ] retain the process which lowers [ʌ] to [ɑ], and produce [ɑ]'s for English [ʌ]'s.

But processes affect speakers' perceptions of foreign sounds as well as their production, and the interactions of processes in these two roles in loan phonology are too complex to be included here. Ohso (1973) and Lovins (1973, 1974) discuss these interactions in considerable detail, and I will mention them briefly in Chapter V (5.2.2).

1.1.5. Processes in synchronic alternation and variation.

Processes which survive in the adult speakers of a language may of course be context-sensitive, in which case they may give rise to alternations.

(1.23) For example, in many southern and some midwestern U.S. dialects, lax vowels are diphthongized (by a process to be detailed in Chapter III) when long, as in bid [bɪ̯d], bed [bɛ̯d], would [wʊ̯d], etc., but they remain monophthongal when short, as in bidder [bɪɾɚ], bedding [bɛɾɪŋ], wouldn't [wʊdn̩t], etc.

Optional processes may produce variation, since their application may be limited to certain styles. For some speakers, the just-noted diphthongization occurs only in highly-stressed syllables in emotive speech. The monophthongization of [ɑ̯] (1.16, 1.19), on the other hand, may be limited to less formal or less attentive styles for some speakers.

1.2. The form of processes.

In my discussion so far, I have spoken of processes as, on the one hand, rather specific substitutions ([ʊ] → [ɑ], [ɑo̯] → [æo̯]) and, on the other, as universal patterns of (possible) substitutions. Clearly, the form of processes requires some discussion.

First, the segmental notation I have used in describing particular instances of processes in children, in synchronic variation, etc. is of course an abbreviatory device. As noted earlier (Sec. 1.1), processes apply to (or are conditioned by) classes of segments characterized by particular phonetically-based phonological features--not to individual segments, or to particular 'listed' sets of segments. So nasalization applies to <u>vowels</u>--not just to the vowels we could list for English; and it applies before nasals--not just before [m, n, ŋ]. In Chapter II, I will discuss the individual vocalic features I will use in describing vowel processes. In Sec. 1.2.1, I will make just a few preliminary remarks on the nature of phonological features in general.

Second, the universal pattern of substitution that a natural phonological process represents is rarely (if ever) overtly manifested in a single language or the speech of a single individual. Processes may apply in varying forms in different languages or dialects and at different periods in the historical or acquisitional development of a language. But we can often identify similar sets of substitutions as representative of a single natural process. I have already spoken of processes applying in more-general or less-general form. I will discuss this varying generality of application briefly in Sec. 1.2.2, and in greater detail in the description of the possible constraints on application of individual processes in Chapter III.

1.2.1. Features.

Many of the features or properties by which segments are classed have readily identifiable physical correlates. Nasality and continuance, for example, can be clearly described in articulatory terms. There are some classes of sounds in which a common property or unifying feature is less easily discovered (e.g. 'tense' vowels, 'low' vowels, etc.), but many phoneticians and most phonologists continue to assume that each feature or property by which segments are classed is based on a phonetic (i.e. physical) reality. The physical correlates of some of these classificatory features may turn out to be far more complex than originally supposed, but without the assumption that every feature has identifiable physical reflexes, we lose the hope of understanding many of the regular, class-sensitive substitutions that are the content of phonology.

The natural processes by which these regular substitutions occur are, as noted earlier, <u>mental</u> operations, even though their

motivations are physical. And if the processes are mental, the features by which segments are classed must also be mental features, which actually exist in the minds of the speakers who make the substitutions. The means of determining which properties of segments are relevant phonological features, then, must, for the linguist, be indirect: to discover the classifying properties on which substitutions are based, one must observe the substitutions. Sets of substitutions which consistently refer to a particular feature are evidence for the phonological relevance of that feature. In other words, if speakers of various languages perform related substitutions which involve a class of segments distinguished by some common phonetic property, then that phonetic property is a relevant phonological feature.

Each of these phonological (mental) features necessarily has phonetic (articulatory and acoustic/perceptual) correlates. Speakers have a physical basis for making the classifications they do regarding which segments undergo a particular substitution and which do not. And, although substitutions based on natural processes take place in the mind, the explanation of why they occur must be based in articulation or perception if there is to be any explanation at all.

Phonological features are essentially mental classifiers, used in both the production and the perception of speech; the description of their physical correlates cannot be <u>entirely</u> articulatory or <u>entirely</u> acoustic. Ideally, we should be able to specify both articulatory and acoustic correlates for each feature, as attempted by Jakobson, Fant, and Halle (1951), since speakers--who both produce and perceive sounds--certainly relate articulations and their acoustic or auditory effects. But the difficulty of establishing both kinds of consistent physical correspondences for vocalic features has been apparent to phoneticians for some time. Ladefoged et al. remark:

> Vowels cannot be adequately described using only acoustic terms; nor can they be described entirely in articulatory terms. Listeners and speakers (and languages) organize two aspects of vowel quality [vowel 'height' and 'the traditional front-back dimension'--pjd] primarily in auditory/acoustic terms and have a third feature [lip rounding--pjd] which is organized primarily in articulatory terms (1972, 74).

It is quite true that for some features unique and consistent auditory/acoustic correlates have been easier to identify, and for other features it is the articulatory correlates which have been easier to establish, but the conclusion that some features 'have articulatory' correlates and other features 'have acoustic correlates' is unsatisfactory for several reasons. First, as Ladefoged et al. continue,

> At the sensory-motor level of the cortex, which is where the phonetic units are encoded for the production of speech, both articulatory and auditory images are available; and similar images are probably used in the process of decoding incoming

speech signals (ibid.).

Speaker-hearers clearly use both the articulatory and auditory aspects of speech signals, and a complete description of their activity must cover both aspects completely.

Second, it may be the case that phonological processes with apparently articulatory motivations and processes with apparently perceptual motivations may both depend on the same feature: e.g., the palatalization of a consonant before a palatal (front) vowel, and the raising of palatal vowels ([æ] → [e], [e] → [ɪ]) both refer to the class of palatal vowels. If the feature which defines this class (I have called it palatality) has only an auditory/acoustic correlate, the explanation of consonant palatalization will be problematic; but if, on the other hand, the palatality feature has only an articulatory correlate, it will be difficult to explain a perceptually motivated change like raising.

Third, a feature with obvious acoustic correlates (like palatality) may have phonological effects which parallel those of a feature with obvious articulatory correlates (like labiality or rounding): in fact, palatal and labial vowels undergo similar kinds of substitutions, which are different from the substitutions which affect non-palatal non-labial vowels. This parallelism cannot be explained in a framework which assigns to one only an acoustic and to the other only--or even principally--an articulatory correlate.

It seems reasonable to suppose, then, that what a phonological feature <u>is</u>, is the mental association of the articulatory properties which characterize a set of sounds with the acoustic properties which characterize the same set. And if the feature itself is this mental association of classifying properties, then there is no reason to assume that both classifying properties would necessarily be simple; it often seems to be the case that one aspect of the feature is simple and the other is complex.

1.2.2. Subparts and hierarchies.

The application of a natural process does not always result in exactly the same substitutions from language to language, child to child, or time to time.

(1.24) In Old English, the mid labiopalatal [ø] was delabialized to [e], but the high labiopalatal [y] remained unchanged (Campbell 1959:78ff.).

(1.25) In Middle English, the mid labiopalatal [ø] (from <u>eo</u>) was delabialized, and its high counterpart [y] was as well (Brunner 1965:10-11).

The process of Delabialization is the same in both cases except that it applies with different degrees of generality. In (1.24) and (1.25), it is limited to labiopalatals; [u], [o], etc. remain labial. But Delabialization may apply to all labial vowels:

(1.26) Adyghe and Abkhas lack (underlying) labial vowels entirely (Trubetzkoy 1969, 97).

Though such unconstrained delabialization is rare in adult phonology, it is *not uncommon in children*:

(1.27) Curt (Oller 1972), Hildegard Leopold (Leopold 1939), and Michael Kiparsky (Paul Kiparsky, pers. comm.) all went through stages during which they replaced all adult vowels with non-labial counterparts.

But once the struggle of acquisition is over, languages--or speakers--ordinarily end up with a process like delabialization limited to a subset of its possible applications. Thus, the general process, [V] → [-labial], of (1.26) and (1.27) is allowed to affect only the labiopalatals in Middle English (1.24): [V, +palatal] → [-labial], and is even more limited in its occurrence in Old English: [V, +palatal, -high] → [-labial].

Examination of classes of substitutions with similar functions (which we would attribute to a single natural process) shows that the possible limitations on natural processes are subject to strict hierarchic conditions. For example, palatal vowels like [y, ø, œ] may be delabialized while non-palatals like [u, o, ɒ] remain labial; but if the non-palatals are delabialized the palatals must be also. The condition is unilaterally implicational, and it falls out from the fact that processes are phonetically motivated. It is phonetically more difficult to maintain labiality in palatal vowels (see the discussion of these properties in Chapter II--Sec. 2.3.2): so, other things being equal, if any vowels lose their labiality, the palatals will do so more readily than the non-palatals.

These implicational conditions on processes may refer not only to the presence or absence of a feature (like palatality), but also to *the degree to which a feature is present*. For example, the lower (or more sonorant) a vowel is, the more susceptible it is to delabialization: a higher vowel is unrounded only if any corresponding lower vowel in the system is also unrounded--that is, [y] → [i] ⊃ [ø] → [e] ⊃ [œ] → [ɛ]. Unrounding of a lower vowel implies nothing about any higher vowel.

A substitution may also be subject to implicational conditions on the environments in which it occurs:

(1.28) In some English dialects (British and American), the monophthongal [o] in words like <u>going</u> [goɪn], <u>November</u>

[novɛmbr̥] remains labial, while the nucleus of the diphthongal [oʊ̯] of go, snow, is laxed and delabialized: [gʌʊ̯], [snʌʊ̯] (personally observed; cf. Kurath and McDavid 1961:106, Jones 1940:97).

Comparison of this with other delabializations reveals that such dissimilative unrounding may affect labials adjacent to labial glides while labials without adjacent like-colored glides remain unaffected. (I will establish in Chapter III that such dissimilations are phonetically motivated and that their motivations are the same as those of context free changes.)

Ordinarily, a process will have a number of possible conditions on its application, as Delabialization does, for example. As noted in the above discussion, Delabialization is sensitive to:

a. height: ! lower (read 'especially if lower') is the condition; this condition means that a lower vowel will be delabialized if the corresponding higher one is;

b. palatality: ! +palatal (read 'especially if palatal') means that a palatal vowel will be delabialized if the corresponding non-palatal is;

c. dissimilative environments: ! / [+vocalic, +labial] (read 'especially when adjacent to a labial vocalic') means that the process applies dissimilatively if it applies at all.

(These and other conditions on delabialization will be discussed in detail and further exemplified in Chapter III.)

Each of these various implicational conditions on a process is independent of all other conditions on the process: each condition holds, all other things being equal. For example,

(1.29) In Cockney English (Sivertsen 1960:34 et passim) the mid nucleus of [oʊ̯] is delabialized, while the low vowel [ɒ] remains labial.

This might appear, at first, to violate the ! lower condition, since [o] delabializes and [ɒ] does not; but [o] delabializes dissimilatively, and we may presume, in its absence, that [ɒ] before [ʊ̯] would do so as well. When, as in this example, other things are not equal, two different aspects of the phonetic motivation of the process may be involved; speakers may attend to one of these aspects rather than the other.

The implicational conditions on process application are universal, like the processes themselves, but since each process is subject to a number of possible conditions, and since these limitations may be invoked, independently, to different degrees and may intersect in

different combinations, each process may apply in a considerable variety of forms. Some of these forms may be more complex than others:

> (1.30a) In some Midwestern American dialects, [ʊ] delabializes to [ɑ] in all environments, but [o] and [u] delabialize only before a labial glide.

The formal statement of this process requires the complexity of angled brackets:

$$(1.30b)\begin{bmatrix} V \\ \langle -low \rangle \end{bmatrix} \rightarrow [-labial] \quad / _ \begin{bmatrix} +vocalic \\ -syllabic \\ \langle +labial \rangle \end{bmatrix}$$

but--assuming that dissimilation can be natural--the process does not seem unnatural. It is the phonetic motivation of the process, not its formal simplicity, that matters.

One can hardly mention unilateral implications in phonology without referring to the pioneering work of Roman Jakobson (1956, 1968). Jakobson's well-known implicational laws express a number of universals or near-universals regarding developmental and synchronic inventories of phonological segments--e.g.,

> The acquisition of fricatives presupposes the acquisition of stops in child language; and in the linguistic systems of the world the former cannot exist unless the latter exist as well. Hence, there are no languages without stops, whereas P. Schmidt cites a number of ... languages in which fricatives are completely unknown (1968:51).

Jakobson cites many such 'laws of solidarity' and attempts to explain why phonological inventories are constrained as they are by these laws: in each case, the implied value of a particular feature is phonetically the more-optimal value.

Jakobson also proposes a relationship between the general synchronic laws of solidarity and the evolution of linguistic systems:

> without the primary value [e.g. stop], the corresponding secondary [e.g. fricative] cannot arise in a linguistic system, and without the secondary value [being eliminated], the corresponding primary value cannot be eliminated (1968:59).

But the laws of solidarity are static, and even if they can be said to constrain the successive segment inventories which appear in the evolution of a linguistic system, they do not account for the substitutions by which these inventories evolve. Similarly, even if they can be said to constrain the limited phoneme inventories of children, they make no prediction as to which of his phonemes a child may substitute for a given adult sound. And worse, the implicational laws Jakobson

proposes are in fact tautological, since they refer to distinctive rather than purely phonetic features.

Natural processes, on the other hand, do account for substitutions; they also underlie the constraints on segment inventories. In fact, both the implicational laws and their occasional exceptions result from the application of natural processes in language. Because these processes are subject to implicational hierarchies of applicability, they can give the impression that there are static laws of solidarity which govern segment inventories. For example, Jakobson notes that the 'palatal-versus-velar' opposition in narrower (higher) vowels precedes the palatal-versus-velar opposition in wider (lower) vowels; i.e., the latter opposition--[e] vs. [ʌ] or [o]--implies the former--[i] vs. [ɨ] or [u]. This is generally true, but it is true because the process of depalatalization, which eliminates the palatal-versus-velar opposition, favors lower vowels. That is, a lower vowel may lose the palatal quality which distinguishes it from the 'velars' while the higher palatal vowels remain palatal and thus distinct from the velars: [æ] may become [ɑ] while [e] and [i] remain, but the loss of palatality in a higher vowel implies the loss of palatality in a corresponding lower one. Since the opposition is eliminated among lower vowels if it is eliminated anywhere, we reach (approximately) the same implicational conclusion--that a palatal/non-palatal opposition in lower vowels implies a similar opposition in higher vowels.

In this section, I have attempted to give an idea of what I mean by implicational hierarchies of applicability. I wish to avoid in particular the confusion of these hierarchies, which are dynamic in that they govern process applications, with the more static Jakobsonian hierarchies which govern the presence or absence of elements in phonemic systems. The application hierarchies I discuss here are part of every process--that is, for every process, the segments or sequences which may be affected vary in susceptibility, and the more-susceptible must undergo the substitution if the less-susceptible do so. Such differential application, of course, reflects the different degrees of phonetic motivation to which each process is subject. Discovering these hierarchical conditions is crucial in the investigation of each process; and for each process I describe in Chapter III, I will describe the implicational hierarchies, give evidence for each, and attempt to show how they reveal the phonetic motivation of the process.

1.3. Kinds of processes.

It has long been recognized that a language, like any system for encoding and decoding information, is shaped by two opposing forces: the need to maximize intelligibility and the tendency to minimize effort. As Passy put it,

> On parle pour etre compris. . . Tout ce qui est nécessaire pour être compris et bien compris, on le conserve soigneusement, on

> l'accentue, on l'exagére; le reste, on le néglige, on le laisse aller, on l'omet (1890:229).

Passy, like Sweet and others before them, recognized two principles which result from this single fact; he called them principe d'économie and principe d'emphase. They have also been called, perhaps less felicitously, the principles of 'ease' or 'least effort' and of 'clarity' or 'maximum intelligibility'. These two conflicting demands on the system require some form of compromise in almost every aspect of language form and use. The necessary compromises are reached in different ways in different languages and at different levels of language structure.

On the phonological level, the conflict is between the need to maximize the articulatory and acoustic properties of individual sounds--mainly in the interest of perceptibility--and the need to minimize the articulatory effort required to produce the sequences of segments that form syllables, words, and other units. These two demands result, sometimes, in opposite changes:

(1.31) Standard English /o:/ has diphthongized to [ʌu̯] in Cockney English (Sivertsen 1960:88 et passim)--cf.(1.29).

(1.32) Sanskrit /au/ (=[ʌu̯]) monophthongizes to [o:] (Whitney 1960:43).

Generally speaking, the need for intelligibility can be seen to underlie the phonological substitutions by which individual segments are made phonetically optimal. To explain the examples above: the vowel [o] has the articulatory and acoustic properties of a labial vowel, but it has them to a lesser degree than the higher labial vowel [u], or the higher and non-syllabic [u̯]. But on the other hand, [o] has greater sonority than [u]--though not as much as the non-labial [ʌ] or the lower and non-labial [ɑ]. [o] therefore represents a compromise between the optimal labiality of [u̯] and the optimal sonority of [ɑ]. This balance may be changed to favor one or the other: [o] may be raised to [u], becoming more labial; or it may be delabialized to [ʌ], becoming more sonorant. A third possibility, particularly if the vowel is long ([o:]), is that half the vowel may be delabialized to [ʌ] (and perhaps lowered to [ɑ]) and the other half raised to [u̯], producing a diphthong [ʌu̯] or [ɑu̯].

The tendency toward 'ease', on the other hand, underlies the phonological substitutions which make sequences of segments phonetically optimal from the point of view of articulation. The sequence [ɑu̯], although it optimizes both sonority and labiality, has the liability of being two segments, requiring two different articulatory gestures. The 'ease' criterion would favor changes in which the two segments in the sequence are made more similar: [ɑu̯] becoming [ʌu̯] or [ou̯], with the [ɑ] assimilating to the [u̯]; or [ɑo̯], with the [u̯] lowering in assimilation to the [ɑ]; or ultimately even [oo̯] (=[o:]), with the two segments

becoming not only similar but (qualitatively) identical.

Segmental (as opposed to prosodic) phonological processes can be classed according to their functions, and the principal division reflects the old 'clarity-versus-ease' dichotomy. Fortition processes increase the phonetic properites of individual segments, making them more perceivable; lenition processes increase the pronounceability of segment sequences.

1.3.1. Fortition processes.

Fortition processes make individual segments more perceivable (and often, more pronounceable) by emphasizing specific phonetic features, even at the expense of other features within the segment. Given free rein, these processes function to produce paradigmatic--exemplary or archetypal--segments. They are called fortitions or strengthening processes because they increase some phonetic property of the segment, often increasing the contrast between the segment and its environment. These segment-optimizing processes are especially applicable in 'strong' positions: i.e., they are especially likely to affect stressed vowels, syllable-initial consonants, segments at or near intonation peaks, etc.

Fortition processes increase their domain in hyperarticulate speech. Slow rate, careful articulation, and affective or emotive style all promote their application. In other words, their domain is increased when articulatory effort is likely to be high (or even exaggerated) and when heightened perceptibility is desirable or necessary.

Fortition processes are frequently context-free changes--and appropriately so, since their function is to maximize the phonetic properties of individual segments rather than sequences. When they do apply in context, they often cause segments to increase a phonetic property not shared by adjacent segments at the expense of a property that is shared by adjacent segments, as when [oʊ̯] becomes [ʌʊ̯]. That is, fortition processes often apply dissimilatively.

1.3.2. Lenition processes.

Unlike fortitions, lenition processes function to produce more-optimal sequences of segments; they make sequences more pronounceable by assimilating the properties of one segment to those of a neighboring segment, by deleting segments, and by substituting segments that are 'weaker' in some respect for those that are 'stronger'. ('A segment X is said to be weaker than a segment Y if Y goes through X on its way to zero' (Hyman 1975:165).) Such processes are 'weakening' in the sense that they decrease phonetic properties of segments, eliminating contrast between the segment and its environment. These sequence-optimizing processes most often affect segments in 'weak' positions--e.g. unstressed vowels, syllable-final consonants, segments in

intonational 'valleys', etc.

Lenition processes increase their domain in hypoarticulate speech; they increase their application in fast or careless articulation or in casual styles. Most substitutions studied as 'fast-speech rules' or 'casual-speech processes' represent lenition processes. In short, the domain of application of lenition processes increases when articulatory effort is likely to be low and when informal situations or highly predictable content make lowered perceptual qualities acceptable.

Lenition processes are typically context-sensitive, since they function to produce more-easily-articulated sequences. They may be assimilative, since sequences of similar segments are (it is usually assumed) easier to articulate than sequences of dissimilar segments. Or they may be reductive, since shorter segments require less effort than longer ones, segments with few or no special articulations require less effort than those with several, single segments are less demanding than geminates, and deleted segments require no articulatory effort at all.

As noted earlier, my principal concern here will be with fortition processes, although lenition processes will occasionally be mentioned. I will discuss fortitions both in their context-free and context-sensitive--usually dissimilative--applications.

1.4. Following chapter topics.

In Chapter II of this thesis, I will discuss individually the features I will use in describing vowels and stating the processes which alter them. This chapter will be primarily concerned with describing, as nearly as I can, the physical properties to which each feature refers, and with offering preliminary justification for the use of the particular features I have chosen. Since the selection of features is largely a matter of discovering which properties of vowels condition the application of processes, full justification of each feature will come only when the processes it figures in are discussed.

In Chapter III, I will describe and justify the principal vocalic fortition processes, including their hierarchies of applicability. Both context-free and context-sensitive applications of each process will be discussed, and tentative phonetic explanations for the processes and their hierarchical conditions will be offered. Apparent counter-examples will be noted and explanations offered. Historical antecedents of the ideas presented here will be noted, and I will explain certain differences between the theories of earlier authors and my own.

The topic of Chapter IV will be diphthongization--the paradigm example of vocalic dissimilation. I will note different types of diphthongization and their typical roles, especially in language change, and I will describe the conditions under which diphthongizations

are to be expected, with synchronic and diachronic examples.

Chapter V will be concerned with certain principles of process application and organization, particularly the existence and nature of process 'ordering', and with the relation of process application to segment inventories--specifically vowel inventories. Here I will examine the function of processes in limiting vowel phoneme systems.

II - FEATURES

2.0. Introduction.

In this chapter, I will briefly discuss the physical characteristics of vowels and relate these to the functions of vowels in speech. I will discuss vowels first 'as vowels'--i.e. as they differ phonetically and functionally from consonants, and then as distinctive elements --as they differ from each other. I will then present the features to be used in describing the universal phonological processes which will form the principal material of this thesis.

There are basically two approaches to the discovery of the categories of phonetic and phonological representation. One may investigate first the speech signal itself, or the speech event itself, seeking 'phonetic features'--categories which refer to independently-controllable mechanisms of production or unambiguously-discernible parameters of perception which might serve, respectively, as the bases for articulatory instructions and as cues for the perception of phonetic or phonological distinctions.

Alternatively, one may search first for 'phonological features', examining evidence from various kinds of natural phonological processing (contextual and stylistic alternations and variation, historical change, substitutions used by first and second language learners, etc.) and attempting to discover the categories into which sounds are classified in such processing.

In fact, many attempts at a theory of features have been aimed toward a goal somewhat different from this latter one. The work of Jakobson, Fant, and Halle (1963), of Ladefoged (1967, 1971), Chomsky and Halle (1968), and others have been attempts to characterize the possible phonological distinctions which languages might maintain (cf. Fant 1972:172 ff.) or to characterize systematic differences between languages or dialects, rather than attempts to define the categories on which phonological processing might depend. But as McCawley (1971) pointed out, the limited set of features needed to mark phonemic distinctions in a language may be insufficient or inappropriate for describing the processes which segments may undergo in that language.

It seems only reasonable to assume that the categories of phonological processing--i.e. the categories which determine whether or not a particular segment in a language undergoes (or conditions) a

particular phonological substitution in actual speech processing--are the true, psychologically real phonological classes or features of the language. And there does not seem to be any reason to assume that the set of such features used across languages is necessarily small.

However, there is reason to assume that these 'phonological features' and 'phonetic features' are in fact the same. First, the assumption that the classifications used in phonological processing are the same classifications as those used in the production and perception of speech is the simple assumption. Second, and far more important, the possibility of finding physical explanations for phonological facts rests on this assumption. Some phonologists--notably James Foley (1977)--do not make this assumption. They observe the parallel behaviors of sets of sounds and name the sounds that belong to each set, and they may attempt to discover the implicational hierarchies which constrain substitutions; but, maintaining that the sets or features and the hierarchies are purely abstract, they make no attempt to explain them phonetically.

But if one wishes to understand rather than just describe the parallel behavior of a certain set of sounds, one must look for an intensional rather than just an extensional definition of that set of sounds. One must look for the physical (articulatory, acoustic, perceptual) properties that characterize the sounds of the set and distinguish them from sounds that do not show parallel behavior. Only then can one attempt to show a causal or teleological relationship between the physical characteristic that marks the set of sounds and the phonological behavior of that set.

In generative phonology, there is some discussion of features as defining 'natural classes', but since generative phonologists make no distinction between rules without synchronic phonetic motivation and processes, which have such motivation (cf. 1.1.1), the range of phonological facts which they attempt to cover is far too broad to expect a very direct relationship between such phonological facts and natural (phonetic) classes. Confining the evidence for features to sets that appear in processes (rather than rules) works to eliminate 'accidental' features, such as might be posited to characterize classes of sounds which participate in 'paleophonetic' alternations (artifacts of historical change) and which no longer share a critical phonetic property.

It is in this framework that I will discuss the features used here. For each feature, I will suggest its phonological function and discuss its phonetic realization. But both the phonological and the phonetic descriptions in this chapter are preliminary and to some extent incomplete, though for different reasons.

The phonological discussion is only suggestive because full phonological justification for a feature is only to be found by examining the phonological processes in which that feature plays a part. For example, to say that 'height' is a relevant phonological feature of

vowels and that it is scalar rather than binary in nature, one must show that degree of 'height' affects the susceptibility of vowels to phonological processes, that processes may change the 'height' value of vowels by degrees in scalar fashion, etc. Since I have not yet described or discussed the processes (and since I cannot hope, of course, to give a truly complete account in any case), the phonological effects of my chosen features cannot be completely detailed at this point.

The phonetic discussion of each feature is an important part of this chapter, but there may be certain difficulties involved in defining precise articulatory and acoustic correlates for each feature I wish to use. I will discuss these difficulties and will come as close as I can to physically accurate descriptions of the features. I consider these phonetic descriptions important even though they are tentative, because of the necessity of assuming physical correspondences for features (and seeking out these correspondences) if one hopes to discover the phonetic motivations of phonological processes.

2.1. The physical nature of vowels.

In simple articulatory terms, vowels are sounds produced with a relatively open vocal cavity; their articulation offers minimal restriction to the air stream, with no constriction sufficient to cause friction. However, vowels are produced with varying supraglottal cavity shapes; the degree and/or location of relative constriction within the tract varies from one vowel to another.

In correspondingly simple acoustic terms, vowels are speech sounds resulting from a sound modified by a resonating cavity; glottal vibration or voice is the sound-source, and the supraglottal vocal tract is the resonating cavity. The shape of this resonating cavity affects the acoustic spectrum of the laryngeal tone (voice), reinforcing some of its harmonics and weakening others, so that a particular vocal-tract shape is associated with a particular pattern of spectral-energy peaks or formants. The formant pattern is what gives a vowel its peculiar perceptual quality ([ɑ] vs. [i] vs. [u], etc.); The formants, or resonance frequencies of the vocal tract, depend on vocal-tract shape, and are independent (within a certain range) of the fundamental frequency (pitch) and intensity of the sound wave generated at the glottis.

2.2. Vowel functions.

Unlike consonants, which consist essentially of interruptions in the speech stream, vowels are the continuing, or sustaining, or <u>sounding</u> elements of speech. As the principal sonorant or resonant elements of speech, they can, for example, be heard at distances which make consonants inaudible; and they can be amplified, as in singing or shouting,

to a far greater extent than consonants can.

Because the vocal cavity, or supra-glottal tract, is minimally constricted in vowel articulations, vowels are the optimal manifestations of voice. The close relationship of vowels with voicing has been recognized throughout the history of phonetics. The ancient Indian phoneticians regarded the vowel a [A] as 'pure voice', on which the various vowel articulations were superimposed (Allen 1953:59 ff.). The word vowel, French voyelle, comes from Latin vocalis 'vocal', a derivative of vox '(the) voice'.

In his Handbook of Phonetics, Henry Sweet (1970:11) suggests that 'A vowel may be defined as voice (voiced breath) modified by some definite configuration of the supraglottal passages, but without audible friction.' Daniel Jones' definition also reflects the centrality of voicing in vowels: 'A vowel...is defined as a voiced sound in which the air issues in a continuous stream through the pharynx and mouth, there being no obstruction and no narrowing such as would cause audible friction (1940:23).'

Acoustic phoneticians view vowels in what amounts to the same way--as sounds produced by glottal vibration or voice, and modified by the shape of the vocal tract above the glottis (Fant 1973, Stevens and House 1961, etc.). The form of excitation which issues from the glottal source can be friction or turbulence, as in the case of voiceless or whispered vowels, but this is by far the exception rather than the rule. The normal form of glottal excitation is the regular vibration associated with normal voice, and in many studies it is the only one mentioned; Jakobson, Fant, and Halle define vocalic as having 'a single periodic ('voice') source' (1963:18). The view of vowels as voice modified by (minimal) supraglottal constriction survives--and it is still essentially correct.

The centrality of voicing to the nature of vowels has phonological manifestations. Because vowels are by nature unobstructed and thus the optimal voiced segments, we find that if anything in the syllable is voiced, the vowel is voiced. When voiceless vowels occur, they occur only in voiceless environments.

(2.1a) The Japanese devoicing of unaccented vowels, for example, occurs only between voiceless consonants, or between a voiceless consonant and the end of a word: [kiʃi] 'shore', [kuʃi] 'comb, [desu] 'is' (Han 1962:19 ff.).

(2.1b) Vowels are also devoiced word-finally in Yana women's speech; in this Yana register, a vowel may be devoiced after a consonant that is voiced in the men's register--but if the word-final vowel is devoiced, this preceding voiced consonant must become voiceless too: Male [kiu:wi], Female [kiu:wi] 'medicine man'; M [kiu:wiya], F [kiu:wiya] 'medicine-woman' (Sapir 1929:207).

Thus, we see that if the optimal voice-bearer, the vowel, loses its voicing, the rest of the syllable must do so as well.

It is because vowels function as voice-bearers, having an essentially unconstricted vocal tract, that they are the sounds with by far the highest degree of intensity or power, as Sacia and Beck (1926), Fletcher (1929), Black (1949), and Fairbanks, House, and Stevens (1950) have shown. This has long been recognized: the Sanskrit word for vowel, svara, is related to the root svṛ 'sound', and vowels have long been referred to as 'sonants', from Latin sonare 'to sound'.

The continuance and intensity of vowels have the important function of making speech audible (cf. Studdert-Kennedy 1975). Consonantal interruptions of the vocalic continuum (cf. Ohman 1966) are of course necessary for their distinctive values, but in many cases these interruptions are audible principally by virtue of their association with the unobstructed voicing of adjacent vowels. An extreme case of this is the voiceless stop, which appears on a spectrogram as silence for the duration of its closure but is clearly marked as [p], [t], or [k] by the preceding and following vocalic transitions--the predictable variations in formant frequencies of the adjacent vowels.

Besides their purely vocalic functions, however, vowels have, in most languages, distinctive functions, too. Because the shape of the resonating cavity may be changed in various ways, vowels may differ from each other in quality. These differences bear phonological distinctions, and they affect the behavior of vowels in phonological processing.

Vowel quality differences have distinctive function in most languages; anywhere from two qualities (as in Kabardian, according to Kuipers 1960), or three (as in Arunta, Cree, Eskimo, some Arabic dialects, and many other languages, according to Hockett 1955:84), to perhaps a dozen different qualities (as in Tibetan or Akha, according to Sedlak 1969) may be distinguished. These distinctions are traditionally divided into differences of 'vowel height' or 'properties based on degree of aperture' (Trubetzkoy 1969:94) and differences of vowel 'timbre' or 'properties of localization' (ibid.). I will refer to the former as differences of height or sonority and to the latter as differences of color or timbre.

2.3. Vowel features.

The following features are the ones I will use in describing vowels and the processes that affect them. This is not, of course, a complete list of all the features by which vowels may differ--only a very basic one.

2.3.1. Sonority and vowel height.

Vowel height differences occur in almost all--most probably, in all--languages. Trubetzkoy, for example (1969:105 ff.), does not mention a single language which lacks a height distinction, although Kabardian has since been subjected to an analysis which avoids using vowel height distinctions (Kuipers, 1960).

There are, on the other hand, a number of languages which appear to lack distinctions of timbre. Trubetzkoy mantions Adyghe, Abkhas, and Ubykh (1969:97) as having only a height distinction; Kuipers offers an analysis of Kabardian as having only a height distinction (1960); and the African languages Higi (Mohrlang 1971) and Gude (Hoskison 1974) and the Micronesian language Marshallese (Bender 1971) may be viewed this way as well. (Phonetic timbre differences exist in such languages, but they appear to be attributable to the effects of surrounding consonants--i.e., they are non-distinctive.) The existence of such languages suggests that vowel height distinctions may be more basic than timbre distinctions are.

2.3.1.1. Phonological manifestations of vowel height.

Whether or not height distinctions are more basic than timbre distinctions--after all, a huge majority of languages do have timbre distinctions in vowels--the property of sonority, to which vowel height most closely corresponds, seems to be a more basic property of vowels than is timbre. In fact, the suitability of a vowel to its vocalic function appears to depend to some extent on its degree of height or aperture: the lower or more sonorant the vowel, the better suited it is to serve as a syllabic or syllable-center, or consonant-bearer, to serve as the continuing, sustained, voice-bearing element of speech.

Degree of sonority clearly affects the capacity of a vowel for syllabicity; there are many languages in which higher vowels have nonsyllabic alternants while more sonorant vowels remain syllabic under similar conditions.

(2.2a) In Spanish vowel sandhi, for example, unstressed /i/ and /u/ become non-syllabic before /e/, /o/, or /a/, and desyllabification does not apply to /a/ (Contreras 1969:2).

(2.2b) Along the same line, Eastern Ojibwa /i/ and /o/ have nonsyllabic variants but /a/ does not (Bloomfield 1956:4),

(2.2c) and the desyllabification of prevocalic /i/ and /u/ but not /a/ in Sanskrit (Whitney 1960:44) is well known.

Similarly, in historical change, higher vowels lose syllabicity earlier than corresponding lower vowels:

(2.2d) unstressed prevocalic i and u became [j] and [w] in Classical Latin (Kent 1940:60-1); unstressed prevocalic e became [j] only later, in Vulgar Latin (Williams 1962: 4 ff.).

When two vowels of unequal sonority come to be adjacent, there is a strong tendency for the more sonorant to retain syllabicity. The Spanish example above suggests this: /e/ and /o/ do not desyllabify when the adjacent vowel is less sonorant.

The greater suitability of more-sonorant vowels as syllabics sometimes manifests itself in a shift of syllabicity,

(2.3a) as when British English speakers who substitute [ə̯] for syllable-final [r], as in dear ([dir] → [diə̯]) pronounce instead [dje:] ([diə̯] → [dje:]) (Jones 1940:58, note 11).

Parallels to this are familiar in historical change:

(2.3b) Middle High German ie, which became in the 11th and 12th century (standard) New High German i (bieten, diep, tier ...cf. bluot, buoch, büecher), became je in certain words, like iegelicher, ietwëder, ieman, iezuo; thus jeglicher, jetzo, etc. (Priebsch and Collinson 1948:151).

I will discuss such shifts of syllabicity in more detail in Chapter IV (Sec. 4.3.2).

Sonority is also directly related to voice-bearing in vowels. Like other relatively open segments, vowels are naturally voiced, but more sonorant vowels are more capable of retaining their voicing in voiceless environments or causing voicing to be extended to adjacent segments than are higher or less sonorant vowels.

(2.4) In Japanese, for example, unaccented short vowels can be devoiced between voiceless consonants, or between voiceless consonant and word boundary--cf. (2.1a). But although the high vowels devoice regularly in such circumstances, even in carefully articulated normal speech, the more sonorant [e, o, a], which 'are often weakened under certain circumstances...do not usually become unvoiced at normal speaking tempo' (Han 1962:17-22).

Conversely, the natural voicing of vowels may be continued through a medial consonant. Intervocalic consonants become voiced in many languages--irrespective, in most cases, of vowel quality. But Grammont suggests that intervocalic obstruent voicing may be dependent on the sonority of the adjacent vowels,

(2.5.) as when obstruents were voiced after a in Middle Italian: acum > ago, patrem > padre, but not after e : caecum >

cieco, petram > pietra (1965:163).

The sonority of vowels also seems to correlate with their sustainability or continuance. Less sonorant vowels may be more susceptible to deletion.

(2.6) In Yawelmani, for example, short high vowels are deleted in the environment /VC_CV, but in similar circumstances, short mid and low vowels (and all long vowels) are retained (Kuroda 1967:17, 33).

The more sonorant a vowel is, the more susceptible it is to lengthening, and conversely, the less sonorant it is the more susceptible to shortening (or loss).

(2.7) In early 13th century English, for example, the short vowels a, e, and o were lengthened (to ā, ē, and ō) in open syllables; only later, and only in some locales, was this lengthening generalized to include short i and u (> ē, ō) (Brunner 1965, 17).

(2.8) In Middle Indo-Aryan, /i:, u:, a:/ became short in final position, but since final [a:] was still retained in some words in Old Gujarati, it can be assumed that the low vowel retained a length distinction longer than the less sonorant vowels did. The long high vowels were more susceptible to shortening, succumbing earlier than /a:/ (Pandit 1961:57).

The relation of sonority to sustainability may be mediated by intrinsic length, however, since more sonorant vowels are intrinsically longer than less sonorant vowels (cf. Sec. 2.3.5.1).

It should also be noted that the vowels which are themselves most sustainable promote continuance in neighboring consonants. It is not unusual for stops to become continuants between vowels.

(2.9) Spanish is an example: intervocalic b, d, g (from Latin p, t, k and b, d, g) have become [β, ð, ɣ], except in environments where they are lost entirely (Menendez Pidal 1944:129-30).

But Grammont maintains that processes whereby stops become continuants may depend on the degree of sonority of the adjacent vowel(s). He gives the following examples (1965:163):

(2.10a) in Sotho, a Bantu language, stops have become spirants intervocalically, but only when the preceding vowel is non-high;

(2.10b) in Galoa or Mpongwe, spoken in Gabon, stops become approximants under similar conditions;

(2.10c) and in Ganda, d becomes l intervocalically, but only when the preceding vowel is the low vowel a.

The above examples of phonological processes show what few linguists would question: that the traditional dimension of 'vowel height' is a relevant phonological feature, since there are a wide variety of natural processes which refer to degrees of height in vowels. More importantly, however, the examples also suggest that vowel height or degree of sonority is related to other features such as voicing, syllabicity, continuance, and sustainability. In each case, the properties which are central to the nature of vowels seem to be present more strongly in the lower, more sonorant vowels. To state it informally, in each case the lower, more sonorant vowel 'acts more like a vowel' than its higher, less sonorant counterparts.

Vowel height is the most direct manifestation of degree of sonority in vowels. It is tempting to propose that vowel height differences are sonority differences, with no further qualification, but there are differences in degree of sonority (which I will define as intrinsic intensity--see Sec. 2.3.1.2) that are not treated phonologically as differences in vowel height--e.g. the differences between [i] and [ɪ] and between [æ] and [ɑ] both involve differences of sonority. The evidence for a feature of vowel height--both in the preliminary examples presented here, and in the more comprehensive material to be offered in Chapters III and IV--is drawn from the phonological manifestations of the feature; the principal phonetic manifestations of this feature are manifestations of sonority.

The examples above suggest that there are more than two relevant degrees of vowel height, but they do not indicate strongly how many degrees there may be, or whether the height feature is better expressed in binary or scalar terms. The phonetic manifestations of sonority and, more importantly, the further phonological evidence to be given may provide some basis for these decisions.

2.3.1.2. Phonetic manifestations of sonority.

The principal physical correlates that have been proposed for vowel height--the feature which most directly corresponds to degree of sonority--are tongue height, degree of aperture, location of the point of greatest constriction in the tract, and height of the first formant; certain combinations of features, like jaw opening/pharyngeal constriction, have also been proposed. A much-neglected aspect of sonority, intrinsic intensity, which is closely related to both oral aperture and F_1 frequency, appears to be particularly important.

2.3.1.2.1. Articulatory manifestations.

Vowel height has been described by many phoneticians, including Bell (1867), Sweet (1877 [1970]), Jones (1940), Grammont (1965), and Heffner (1950), in terms of the height of the tongue. It was (and still is) maintained that a higher tongue position (relative, say, to the plane of the lower edges of the upper teeth) produced a greater constriction in the vocal tract and consequently a less sonorant vowel, and that a lower tongue position produced a more open and thus more sonorant vowel.

One difficulty with this view is that a lowered tongue arch does not necessarily produce a more open vocal tract. Even when vowels like [ɑ] are truly low in terms of the highest point of the tongue, they do not necessarily have the greatest aperture along the entire length of the vocal tract; there may be considerable narrowing of the pharynx for [ɑ] and even for [æ] (Perkell 1971).

Further, Wood (1975), after examining 38 sets of X-ray tracings of vowel articulation in some twenty different languages and dialects, points out that the tongue arch may in fact be higher for traditionally mid [e] than for traditionally high [ɪ], and that there are a number of of discrepancies between the traditional height categories and the actual tongue arch outlines among the labial/back vowels: [ɔ] vs. [ɑ], [o] vs. [ɔ], [o] vs. [ɑ], and [ʊ] vs. [o]. Other studies of vowel articulation suggest that, although the description of vowel height in terms of tongue height may work fairly well for front or palatal vowels (like [i, e, æ]), particularly if jaw opening and tongue raising are allowed for separately, the height of the highest point of the tongue does not by any means reflect the auditory or acoustic differences among back vowels (like [u, o, ʊ]).

Consequently, attempts have been made to relate back-vowel height differences to differences in the location of maximal tongue constriction: in this view, higher vowels are characterized by having a constriction farther from the glottis than lower vowels (Stevens and House 1955). But this parameter can only be used to define height for back vowels--just as height of the tongue arch can only be made to work for front vowels. Location of maximal constriction does not correspond to degree of sonority in front vowels, because although the maximal constriction for [ɛ] and other front vowels is between the hard palate and the tongue blade, the maximal constriction for [æ] and [a] is between the tongue back and the rear wall of the pharynx (cf. Ladefoged 1971: 68-9).

For a more complete discussion of the weakness of the attempt to describe vowel height or sonority in terms of the position of the tongue arch, see Wood (1975). In addition to criticizing the old High-Mid-Low and Front-Central-Back features, however, Wood suggests a different set of articulatory vowel features based on articulatory gestures and the consequent shaping of the vocal cavities.

In Wood's scheme, the traditional height feature would in part be represented by the binary feature [±Open]; this feature would replace [±High] or [±Diffuse]. [±Open] would refer specifically to mouth or jaw opening: [+Open] vowels like [e, o, æ, ɑ, ɔ] have a relatively open oral cavity, ordinarily with a lowered mandible; [-Open] vowels, like [i, ɪ, u, ʊ, y] have a constricted oral cavity, ordinarily with a higher jaw position.

Wood's system would also include features describing the location of constriction in the vocal tract. Among these, [+Pharyngeal] would represent the [+Low] or [+Compact] vowels like [æ, a, ɑ, ɔ], referring specifically to their pharyngeal constriction. Mid vowels, then, formerly [-High, -Low] or [-Diffuse, -Compact], would be [+Open, -Pharyngeal] --and high vowels would be [-Open, -Pharyngeal]. (Extra heights would be added by means of a tenseness feature.)

In effect, then, Wood maintains that, among the palatal vowels, for instance (he designates them palatal, p. 98), [e] differs from [i] by a feature specifying degree of constriction ([+Open]), but [e] differs from [æ] by a feature specifying constriction location ([+Pharyngeal]). This may reflect articulatory facts--though not all articulatory facts--but it is very difficult to reconcile with the phonological properties of [i, e, æ], as I will show in Chapter III.

Perkell (1971) noted this pharyngeal constriction of low vowels, and he proposed that [±Low] be replaced by [±Constricted Pharynx]. As I understand proposals of this sort, they make pharyngeal constriction the primary articulatory correlate of low vowels and the generally more-open oral cavities of such vowels a 'by-product' of this pharyngeal constriction. Neither Perkell nor Wood, however, seems to consider that (since the mass of the tongue is constant) the relation of pharyngeal constriction to sonority may be, in a sense, the reverse--that opening of the oral cavity is primary and pharyngeal constriction is, like jaw opening, absence of tongue-bunching or lifting, and absence of lip-rounding, a means of creating a larger anterior oral cavity.

An examination of data from cineradiography published by Ladefoged (1971, 1972) and Perkell (1969, 1971), however, suggests this as a possibility--that sonority is related to the degree of aperture in the oral cavity forward of the pharynx (mouth and lips). Jakobson, Fant, and Halle (1963) refer to something like this in their description of the compact/diffuse feature set:

> The essential articulatory difference between the compact and diffuse phonemes lies in the relation between the volume of the resonating cavities in front of the narrowest stricture and those behind this stricture. The ratio of the former to the latter is higher for the compact than for the diffuse phonemes (27).

The more-sonorant compact vowels, then, have a larger forward (oral) cavity (and a smaller pharyngeal cavity); the less-sonorant diffuse

vowels have a smaller oral cavity (and a larger pharyngeal cavity).

A number of different gestures act to increase the cross-sectional area of the vocal tract forward of the pharynx. Lowering the jaw is, of course, one way of increasing sonority, because increasing the jaw opening increases the size of the oral cavity, other things being equal. Thus, as Lindblom and Sundberg (1969) note, there is a direct relationship between jaw opening and sonority.

The old correlate, tongue height, also plays some role. If the tongue is not bunched up or lifted toward the palate (or velum) but lies flatter in the mouth, the cross-sectional area of the anterior tract will be larger.

The pharyngeal constriction associated with low vowels, too, increases sonority by raising the front-cavity to back-cavity ratio; it increases the size of the oral resonating cavity as it decreases the volume of the pharyngeal area.

Having suggested this as a possibility, I will in the next section examine the acoustic manifestations of sonority and try to see if the acoustic properties reveal anything about how the articulatory patterns should be interpreted.

2.3.1.2.2. Acoustic manifestations.

Acoustically, sonority is related in a straightforward way to the frequency of the first formant (F_1): a more sonorant vowel has a higher F_1 than a less sonorant one. And this F_1 correlation is truly a sonority correlation rather than a 'height' correlation: other things being equal, a vowel with a higher F_1 has a higher overall intensity than a vowel with a lower F_1 (Fant 1956:118).

Since intrinsic intensity may turn out to be the most phonologically revealing phonetic aspect of the sonority feature, its relation to vowel height deserves some attention. As Stevens and House note,

> It has long been recognized that vowels generated with the same vocal effort have different over-all [intensity] levels. The range of over-all levels for the common vowels of American English is roughly 4 to 5 db, with /ɪ/ and /u/ having the lowest levels and /æ/, /ɑ/, and /ɔ/ the highest levels (1961:314).

Thus, the vowels traditionally recognized as most sonorant are in fact--just as the term implies--those with the highest levels of intensity, or sound.

Lehiste (1970:119-23) offers a discussion of intrinsic intensity --particularly as it is related to perception, noting that differences in intrinsic intensity appear to be discounted in speakers' judgements

of loudness: speakers identified vowels as louder when they were produced with greater effort, even though actual intensity levels were the same.

> This suggests that the listeners may associate a certain intrinsic relative amplitude (or perhaps average power) with each vowel spectrum, and apply a corresponding 'correction factor' to the incoming signal (118).

Stevens and House report that the higher intensity levels of more sonorant or more 'open' vowels are directly related to both the height of the first formant and the openness of the front of the vocal tract:

> An attempt to relate these data to articulation was made by Fairbanks [(1950)], who postulated that vowel intensity should be correlated with the anterior opening of the vocal conduit, and demonstrated such a correlation between two sets of published data ... The over-all intensity of a vowel is determined largely by the frequency of the first vowel resonance since the level of that resonance is always greater than that of higher resonances. But the frequency of the first resonance is closely related to the size of the mouth opening ..., and, therefore, the positive correlation described by Fairbanks can be considered to be a consequence of the acoustical theory (1961:314-5).

Intrinsic intensity is related to increased oral aperture in the following way: the frequency of the first formant tends to decrease as the cross-sectional area at some point in the vocal tract decreases--i.e. as the tract becomes more constricted, except when the constriction occurs within a few centimeters of the glottis (as it does in [a]). As F_1 frequency decreases, overall intensity levels decrease, and that means sonority decreases (cf. Stevens and House 1955, 1961; Fant 1962). So constriction decreases sonority, unless the constriction is near the glottis, in which case it increases sonority. As Stevens and House put it,

> ... High first formants [and corresponding high sonority] are associated with a narrow tongue constriction near the glottis and an unrounded, large mouth opening. The first formant is low [and sonority is correspondingly low] when the mouth opening is small and rounded or when there is a narrow tongue constriction near the mouth opening (1955:488).

2.3.1.2.3. Summary and further questions on sonority.

The acoustic correlates of sonority are clearly scalar, although the articulatory correlates--jaw opening, tongue position, pharyngeal constriction, etc.--allow binary expression. The question of scalar vs. binary representation is not one that can be answered in purely phonetic terms. I will reject binary feature representations of sonority,

like [±Open, ±Pharyngeal], [±High, ±Low], or [±Diffuse, ±Compact]--but for phonological rather than phonetic reasons. As McCawley (1971), Chen (1972), and others have argued, such systems are inadequate for the expression of phonological substitutions. In Chapter III I will add to their arguments, giving further evidence that there is a phonological scale of sonority which corresponds to the phonetic one.

A further question of representation--that of how many degrees of vowel height there may be--remains. Clearly, the phonetic correlates are sufficiently numerous, on the articulatory side, and sufficiently continuous, on the acoustic/auditory side, to allow for the expression of as many degrees of height as languages show us. The point is that languages do have to show us--by the phonemic distinctions they make, of course, but also by the number and kinds of distinctions by which they classify more and less sonorant vowels in phonological processing. Questions of this sort--like 'are there more than three possible degrees of vowel height?', and 'does [e] differ from [ɛ] by height or by tenseness?'--will have to wait until phonological evidence that might bear on them has been presented.

2.3.2. Color.

In music, the terms color, tone color, and timbre are equivalent, all referring to 'the peculiar quality of a tone as sounded by a given instrument or voice', and indicating 'the difference between two tones of the same pitch, duration, and intensity if performed on, e.g. a violin and a flute (Apel and Daniel 1961:305). Tone color or quality results from the varying amplitudes of the overtones (sounds at exact frequency multiples of the fundamental frequency). A tone produced by an oboe, for example, has strong fourth and fifth overtones, with the first three overtones very weak; a flute tone has prominent first and second overtones, while the higher ones are nearly absent (ibid. 5).

Vowel quality is similar to, but different in important ways from, musical color or timbre. The different perceptual qualities of vowels like [i, u, a] are due to characteristic formant patterns which result from the damping and amplification of overtones (or sets of overtones) at particular frequencies. The formant patterns depend on the shape of the resonating cavity (which acts as a filter), so that vowel quality can be changed by changing the degree and location of constrictions in the vocal tract, thus changing the shape--and the filtering characteristics--of the cavity.

In vowel descriptions, timbre may have a somewhat narrower meaning (cf. Trubetzkoy 1969:97 ff.): it may refer to vowel quality particularly as a result of the location of constriction in the vocal tract--i.e. to quality as related to what Trubetzkoy calls 'properties of localization'. Timbre is thus to some extent opposed to sonority-- the 'property of aperture'--though these two aspects of quality are of course related. This difference can be related to acoustic properties:

sonority (and aperture) are more directly correlated with the height of the first formant and the intrinsic intensity of the vowel, and timbre is more closely associated with the relationship between the first and second formants, and also with the position and amplitude of the second and higher formants (which give the vowel its characteristic 'brightness' or 'darkness').

The use of color terminology in the description of vowels dates back at least to Stumpf and Jakobson, and probably much further. The ancient Indian grammarians used the term varṇa 'color' in their phonetic treatises (Allen 1953:13-6). Allen's discussion strongly suggests that varṇa was 'color' in the sense of 'sound-quality' especially vowel quality), though he settles on 'letter' as a general translation (for reasons that aren't particularly clear to me).

The use of the term color or coloring to describe a vocalic quality used to mark a consonant (such as palatalization, rounding, or velarization) is traditional and widespread; e.g., Martinet (1955:201-2, esp. note 7) refers to the palatalized consonants of Old Irish as i-colored, and to its labialized and plain consonants as u-colored and a-colored, respectively. Delattre et al. (1952) use color terminology in a similar way.

The way in which I will use the term color compares with the use of the term for consonants. The principal features which I will discuss as colors are palatality and labiality. (Vowels which are neither palatal nor labial--[ɨ, ʌ, ɑ] etc.--will be termed plain or achromatic.)

2.3.2.1. Palatality.

The feature palatal refers, in its positive value, to what are ordinarily called 'front' vowels: [i, e, ɛ, y, ø, œ] and their lax variants. The significant articulatory realization of this feature is the approach of the body of the tongue to the hard palate. This approximation occurs to a greater or lesser degree, and is of course related to the aperture of the vowel; but in all palatal vowels there is some fronting of the tongue body and /or raising of the forward part of the tongue. Even for [æ] and [ə], the front vowels of minimal oral constriction, the body of the tongue is farther forward, and a little higher, than for the corresponding non-palatal [ɑ].

Acoustically, palatal vowels are characterized by a relatively high second formant and a lowered first formant--thus, by a large distance between the two. Because of their high-pitched F_2 (and relatively high F_3 (Fant 1962)), palatal vowels like [i] and [e] are perceived as 'bright' as opposed to 'dark' vowels like [u] and [o]. 'Brightness', in synesthesia and sound-symbolism, is associated with prominent high-pitched overtones--and with high-pitched simple tones in general; and 'darkness' is associated with weak or lower-pitched overtones, and with lower-pitched simple tones (cf. Plomp 1970:402). 'Dark' vowels are

those with low F_2--or with a small difference between F_1 and F_2.

Speakers associate vowel-timbre differences with pitch differences quite readily. Onomatopoeia provides many examples of this (e.g. ding-ding vs. clang-clang vs. bong-bong vs. boom-boom), and bird-song syllabifications many more (peep-peep, birdie-birdie-birdie, bob-white, etc.).

2.3.2.2. Labiality.

The positive value of labial marks the rounded vowels: [u, o, ɒ, y, ø] etc. All labiality or 'lip rounding' involves a narrowing of the mouth opening at the lips. It appears that there is reason to distinguish between two kinds--compression and protrusion, or vertical and horizontal rounding (cf. Ladefoged 1971:71). The former type, compression, or vertical rounding, consists of narrowing the lip opening vertically, without pulling in the corners of the mouth. It may be a secondary type, since many articulatory phoneticians do not mention it at all. The latter type, protrusion, is what is usually referred to as rounding or labialization; here the lip opening is narrowed by pulling in the corners of the mouth and protruding the lips as well as compressing them.

The phonological effects of the difference between compression and protrusion will be noted in the chapter on processes, as evidence arises. Ordinarily, however, languages do not treat the difference as distinctive (although it has been claimed that Swedish is an exception), and the two varieties of labiality have largely similar effects with respect to phonological processing. Therefore, in most of my discussion, no distinction will be made.

Labiality has the acoustic effect of lowering all formants, since it lengthens the vocal tract, and of damping or weakening the higher formants, since it narrows the lip opening. Labial vowels are thus perceived as 'dark' and are associated with lower pitches in sound-symbolism, or with darker colors in synesthesia (cf. Jakobson 1968:82 ff.).

2.3.2.3. Phonological manifestations of palatality and labiality.

As noted above, palatality and labiality have much in common with the 'colorings' of palatalized and labialized consonants. In fact, a great many assimilative processes suggest that they are in fact the same features.

Evidence for the identity of palatality and labiality in vowels and in consonants--and also for a scale of palatality and a scale of labiality--is found in the palatalization or labialization of consonants by palatal or labial vowels, and in the coloring of vowels by consonants as well.

2.3.2.3.1. Coloring of consonants by vowels.

There are, of course, a great many examples of consonant palatalization.

(2.11) In Old Irish, for example, consonants were palatalized before a following palatal vowel (Thurneysen 1946:96ff.). Thus, man was
Voc. sg. fir /f^{i}ir^{i}/, from *wir-e
Gen. sg. fir /f^{i}ir^{i}/, from *wir-I
Nom. sg. fer /f^{i}er/, from *wir-os (Lewis and Pederson 1937:165-6).

This palatalization in Irish occurred only before i and e, not before u, o, or a.

The phenomenon of consonant palatalization has been well studied in a universalist framework. The class of vowels which condition it and the implicational nature of this conditioning are well established, so I will not multiply examples here. Cross-language studies by Chen (1972) and Neeld (1973) have described palatalization in Chinese, Romance, Slavic, Oneida, Hausa, and Korean (to name only a few examples), and both Chen and Neeld point out that higher vowels obligatorily palatalize consonants if their lower counterparts do so, but that lower vowels do not necessarily cause palatalization if their higher counterparts do. Neeld maintains, in addition, that [j] is the most favored palatalizing environment. (The data also suggest that palatalization by lax vowels implies palatalization by the corresponding tense vowels, but not vice versa.)

I do not know of any studies of labialization which compare with the palatalization studies mentioned above, so I will present here a few examples to show the form of the consonant labialization process.

(2.12a) Consonants were labialized as well as palatalized in Old Irish, but labialization affected only consonants before ū and occasionally ŭ, but not before o, a, e, i (Thurneysen 1946:96ff.). Thus; further forms for man, for example, were
Dat. sg. fiur /f^{i}ir^{u}/, from *wir-ū, as opposed to
Nom. sg. fer /f^{i}er/, from *wir-os (Lewis and Pederson 1937:165-6).

Since labialization was regular before ū, occasional befor ŭ, and non-occurring before o, we can say that the process was limited to affecting consonants before high labial vowels.

(2.12b) Labialization occurs before both [u:] and [o:] in Kabardian. According to Kuipers,

Before and in the stressed syllable all consonants are automatically labialized when followed by ū, ō (phonemically a̲w̲, a̲w̲, not followed by a vowel) ... cf. q'aplán 'to look hither(q'a-)' and q'ʷàpɬ'an 'to look behind(q'ʷa) something' and the present tense form q'ʷ'awpɬa (phonet. [q'ʷó:plé] meaning either 'he looks hither' or 'he looks behind it' (Kuipers 1960:24, note 10).

(2.12c) In Nupe, consonant labialization takes place before both /u/ and /o/, and possibly also before underlying /ɔ/ (Hyman 1970). Hyman gives the following derivations (62) (his transcriptions):
/ẽgū/ 'mud' [ẽg$^{w}_{w}$ū] by the labialization rule,
/ẽgó/ 'grass' [ẽg^{w}ō] by the labialization rule,
/ẽgɪ̄/ 'child' [ẽg^{y}ɪ̄] by the palatalization rule,
/ẽgē/ 'beer' [ẽg^{y}ē] by the palatlaization rule, but
/ẽgɑ̄/ 'stranger' [ẽgɑ̄] with no assimilation.
Hyman also posits a controversial segment /ɔ/, which always appears as surface [ɑ], to account for labialized consonants before [ɑ], e.g.
/ẽgɔ̄/ 'hand' [ẽg^{w}ɑ̄]. But whether or not Nupe consonant labialization is caused by underlying /ɔ/'s, the labializing influence of /u/ and /o/ is still apparent.

Like palatalization, then, labialization of consonants seems to be favored in the environment of less sonorant vowels. Both colors thus operate in parallel fashion: the more sonorant vowels are less capable of causing coloration in adjacent consonants, presumably because they are themselves less chromatic.

2.3.2.3.2. Coloring of vowels by consonants.

Further evidence--both for identification of vowel colors with consonant colorings and for a scale of increasing color with decreasing sonority--can be seen in the effects of palatalized or labialized consonants on surrounding vowels. Vowels assume the color of a preceding or following consonant in languages as varied as Middle Irish, Squamish, and Kabardian.

(2.13) In Old Irish, medial unstressed vowels were pronounced like the vowels of stressed syllables, but in Middle Irish, these vowels were merged to a̲ (Lewis and Pederson 1937:72-3). This a̲ appeared between 'plain' (non-palatalized, non-labialized)consonants, but it was assimilated to surrounding palatalized or labialized consonants. Although assimilations took place in both open and closed syllables, the closed-syllable assimilations best illustrate the situation, since in these both the preceding and following consonants play a part.

The effects of adjacent consonants on unstressed vowels may be shown in the following way (C^i is a palatalized consonant; C is plain; C^u is labialized. X/Y means X is found in Early Middle Irish, and Y in Later Middle Irish):

Preceding consonant \ Following consonant	C^i	C	C^u
C^i	i <u>berid</u>	e <u>tuirem</u>	iu <u>imniud</u>
C	i/ai <u>fodil/ fodail</u>	a <u>teglach</u>	o/u <u>denom/ denum</u>
C^u	i/ui <u>manchib/ manchuib</u>	o/u <u>flechod/ fleuchud</u>	u <u>cumung</u>

As the chart shows, <u>i</u> occurred between palatalized consonants, <u>a</u> between plain ones, and <u>u</u> between labialized ones. Thus, <u>i</u> and <u>u</u> appear in the most-palatalized and most-labialized environments, respectively, while <u>e</u> and <u>o</u> appear when only one adjacent consonant is palatalized or labialized.

The objection may be raised that since the spellings of vowels in Irish were conventions for indicating consonant color, they may not represent directly the pronunciations of the unstressed vowels. But even if they are only consonant-spelling conventions, it is extremely revealing that they reflect degrees of color in the way that they do: that <u>u</u> spells a vowel with C^u on both sides, while <u>o</u> spells a vowel with C^u on only one side or the other, etc.

Coloring of vowels also takes place in Squamish--where it is in any case not 'just' a spelling convention. According to Kuipers,

> (2.13b) the vowel /ə/ stands out as being shorter and more variable than /ɑ, u, ɪ/. Its timbre centers around [ʌ] as in British English <u>but</u>, and the deviations *from* this center are determined by surrounding consonants (1967: 27-8).
>
> /ə/ becomes [ɪ] between palatal consonants other than [i̯]; [e] or [ɛ] before or after [i̯] or other palatals, and [æ] between plain (non-labialized) uvulars and dental or palatal consonants. Adjacent labialized consonants produce an [ɔ] quality. Between labials, dentals, and laterals, [ʌ] is heard. And when /ə/ appears between palatalizing and labializing consonants, it may assume an [ø] quality, which reflects both the coloring influences in its environment, since [ø] is both palatal and labial.

Again, the more palatalized or labialized the environment, the more chromatic (and less sonorant) the vowel which appears.

> (2.13c) In Kabardian, two distinct vowels undergo coloring by surrounding consonants. /ə/ and short /ɑ/ become (respectively) [ɪ] and [ɐ] after laterals (which have 'a strongly palatal timbre'), palatalized palatovelars, and jod; [ʊ] and [o] after labialized palatovelars, uvulars, and laryngeals; [ɯ] and (back) [ɑ] after plain uvulars and pharyngeals; and [ɨ] and (central) [ɑ] after other consonants (Kuipers 1960:22).

In the case of Kabardian, the degree of color follows from the original degree of sonority of the underlying vowel, rather than from the environment alone.

In all of the above cases, the vowels which undergo coloring by adjacent consonants are themselves <u>plain</u>, as we see from the plain variants which appear between plain consonants. This suggests that vowels which lack conflicting color are particularly susceptible to assimilative coloring. (This brings to mind 'Hutcheson's Law'--the principle, worked out on consonantal assimilations (Hutcheson 1973), that a segment A is more susceptible to assimilation to an adjacent segment B if A closely resembles B than if A differs sharply from B. This principle applies to vowel-consonant and vowel-vowel assimilations as well, in the cases I have observed.)

Also, in each of these cases, the vowels which undergo coloring are the <u>less sonorant</u> plain vowels of the language. In Irish, only unstressed short <u>a</u>'s (probably phonetic [ə]'s or even [ɨ]'s) are colored; in Squamish, /ə/ undergoes assimilative coloring but /ɑ/ does not; in Kabardian, /ə/ and short /ɑ/ are colored but the more sonorant long /ɑ:/ is not. This suggests that the more sonorant a vowel is, the less susceptible it is to assimilative coloring, and it points out again the conflict between sonority and color.

In summary, the degree of color in chromatic vowels--as measured by their ability to color adjacent consonants--varies inversely with their degree of sonority. The susceptibility to coloring of plain or achromatic vowels varies inversely with their sonority as well. This trading relationship between sonority and color is basic to the phonological behavior of vowels--and it arises in phonetic reality: articulations which increase color decrease sonority, and those which increase sonority decrease color.

2.3.2.4. Color 'collectively'.

It should be clear by now that the use of the term <u>color</u> arises in phonological necessity. In examining substitutions--context-sensitive ones like those in the preceding section (2.3.2.3), and

context-free ones like those to be described in Chapter III--one finds that palatal and labial vowels frequently undergo parallel substitutions or condition substitutions in parallel ways, and that non-palatal non-labial vowels often undergo or condition substitutions that 'chromatic' vowels do not. To simplify the expression of this state of affairs, it helps to have a term which distinguishes vowels which are palatal or labial or both from those which are neither palatal nor labial: chromatic (having color) and achromatic (plain) thus have been and will be used here. (This might be compared to the use of the term chromatic in music to refer to notes which are raised or lowered in comparison to the normal notes or degrees of the scale.)

The distinction between chromatic vowels and achromatic ones is most clearly revealed in context-free phonological processes such as Raising, which applies to chromatic vowels and not to achromatic ones; or Lowering, which applies to achromatic vowels if it applies to chromatic ones. (I will show that Raising is a phonological means of optimizing color by providing a closer articulation which makes increased palatality or labiality possible; and that achromatic vowels--which are free of the oral constrictions associated with palatality or labiality --are especially susceptible to Lowering, which seems to be a phonological means of optimizing sonority.)

In claiming that color is a phonological feature--even a cover feature--I would wish to propose both articulatory and acoustic correlates. If a class of features produce similar phonological effects, there should be phonetic reason for the similarities. I will therefore suggest that color consists of significant anterior oral constriction--in particular, palatal or labial constriction. This ignores the various forms of tongue retraction--but see Sec.2.3.2.5, below.

Stevens and House, quoted earlier, note that F_1 is lowered when the mouth opening is small and rounded or when there is a tongue constriction near the mouth opening. These articulations also affect F_2 and F_3. F_2 becomes higher as the point of constriction moves forward, and it becomes lower as the cross-sectional-area-to-length ratio of the mouth opening decreases (i.e. F_2 decreases when the lips are rounded.) F_3 also increases slightly with forward constriction and decreases with lip rounding (cf. Stevens and House 1955:488ff., and Lindblom and Sundberg 1969). Palatal and labial articulations, then, share the properties of lowering F_1 and strongly affecting F_2 (and F_3).

The difficulty with this proposal on the articulatory nature of vowel color is that [ɨ], the high achromatic, may be said to have an oral constriction which lowers F_1 although it is neither palatal nor labial. This constriction is similar to the palatal and labial constrictions that behave phonologically as color in that it does lower F_1, but it differs from palatality and labiality in that it produces intermediate values (neither especially high nor especially low) for F_2.

Acoustically, one might propose that chromatic vowels are those which show extreme F_2 (or F_2 minus F_1, or averaged F_2 weighted with F_3) positions, and that achromatics are vowels with F_2 (or F_2-F_1) values which occupy a certain middle range. The difficulty with this is that there are bi-chromatic vowels (labiopalatals like [y] and [ø]) whose F_2 (or F_2-F_1) values are intermediate and often rather close to the range which achromatics occupy.

Although it does not seem to be currently possible to give a precise definition of color other than by listing the features which act as colors, it seems to me that the feature is phonologically necessary. At this point, I can only be certain of palatality and labiality, but some forms of retraction (like velarization or uvularization) may turn out to be colors, also. Retroflexion or 'R-coloring' and lateralization or 'L-coloring' should almost certainly be included in a complete discussion of color, since there are a number of respects in which they have the same kinds of phonological effects as palatality and labiality (cf. Semiloff-Zelasko 1973), but I will disregard them here, on the grounds that they are generally more closely associated with consonants than with vowels.

2.3.2.5. Retraction.

Non-palatal vowels--labial or non-labial--are produced without any fronting of the tongue body in the direction of the hard palate. But they may be produced with or without retraction of the tongue body, either toward the velum (as for [u, ɯ]) or toward the rear wall of the pharynx (as for [o, ɔ, ɒ, ɑ]). This feature of retraction, which appears only on non-palatal vowels, may have significant acoustic effects, but it appears to be a secondary color which most often functions to amplify the 'darkness' of labial vowels, exaggerating the low frequency of their second formants and lowering the F_2-F_1 value, and thus increasing their distinctness from non-labial vowels. Unlike palatality and labiality, however, retraction does not conflict with sonority.

Few languages exist in which retraction is distinctive within the class of labial vowels. A well-known exception occurs in Swedish, however, where the back round high vowel /u/ is phonemically opposed by a non-back round high vowel /ʉ/. Although the two vowels are actually diphthongs in the Swedish speech I have observed, the vowel /ʉ/ being realized as something like [ɨw], Paul Kiparsky has demonstrated for me that in the Finnish pronunciation of Swedish, insofar as /ʉ/ is not fronted to [y], it is actually pronounced as a monophthongal central high rounded vowel distinct from [u], and therefore does require us to recognize the existence of oppositions of back/non-back in labial vowels. Similarly, Estonian, Votic, and Livonian have four mid vowels, transcribed [e, ø, ɘ, o] where [ø] may be central rather than palatal and thus opposed to [o] by the retraction of the latter (pers. comm., Ilse Lehiste).

Among non-labial vowels, however, I do not know of any language in which the back/non-back difference is phonemic--speaking, of course, of non-palatal vowels. The difference ([ɯ] vs. [ɨ], etc.) is phonetically controllable, however.

(2.14a) In Texas and some other parts of the American South, [ɤ] is consistently used where northern dialects use [ʌ], as in bug, cup, etc. In reduced syllables, and for some speakers simply in unemphatic speech, the back [ɤ] is centralized, much as palatal vowels are.

Likewise,

(2.14b) Hyman (1973:333) describes the high unrounded vowel of Fe?fe? as [ɯ] 'when articulated carefully', but as [ɨ] 'in rapid speech'.

These parallels seem to support the interpretation of retraction (uvularization or velarization) as a color--or at least, as a 'marked' timbre vis a vis its absence. (That is, we should speak of back/non-back, rather than central/non-central in distinguishing [ɯ] from [ɨ].)

If retraction is to be considered a color--or a set of colors (velarization, uvularization, pharyngealization)--it would differ from palatality and labiality in a significant way: retraction--or, at least, pharyngealization--does not diminish sonority. That is, it does not lower F_1 or decrease intrinsic intensity; on the contrary, it may amplify sonority. The conflict between sonority and palatal/labial color has important consequences in the phonological treatment of vowels; since retraction does not conflict with sonority phonetically, we might expect the behavior of retracted vowels to match that of achromatics more closely than that of palatals or labials. In fact, retracted vowels are rarely distinguished from central ones either in phonemic oppositions or in their effects on the application of phonological processes. I am aware of no evidence that, among either labial or non-labial vowels, back vowels are treated differently from central ones in any systematic way.

Because of this, and because in any event the literature rarely makes a clear distinction between back and central either in labial or in non-labial vowels, the symbols for non-palatal vowels in this work will be used without reference to the difference between back and central, unless otherwise noted. In particular, the symbols [ɨ, ʌ, ɑ] will not ordinarily be distinguished from [ɯ, ɤ, ɑ˖].

2.3.2.6. 'Primary' colors.

The above discussion leaves palatality and labiality as the two colors with which I will be dealing in describing vowel quality and the processes which affect it. The notion 'color' certainly requires

further examination, and I do not mean to claim here that palatality and labiality are the only two colors there are. I think it is quite possible to claim, however, that they are the two most basic, or the 'primary', colors. If a language has any chromatic vowels at all, it will have a palatal (usually /i/). There are a few languages with palatals but no labials, but none, as far as I know, with labials but no palatals (cf. Ruhlen 1976). And if a language has a second color, that color will be labial; I have found no reports of languages with vowel systems like */i, ɨ, ɯ, ɑ/, where /ɯ/ is distinctively back, but non-labial; or */i, ɑ, ᵊ/, where the non-palatal color is retroflexion--and such systems seem quite unlikely to occur.

2.3.2.7. Achromaticity and bichromaticity.

The distinction between chromatic and achromatic vowels is motivated, as I claimed earlier, by the different phonological treatment of chromatics and achromatics: achromatic vowels are not subject to Raising; they are especially susceptible to Lowering; and they do not participate in consonant colorations, like palatalization and labialization. Their principal phonetic characteristics are lack of palatal or labial constriction (i.e. they lack constrictions which severely alter the formants above F_1), and slightly higher sonority (higher F_1 and more intrinsic intensity) than is found in chromatic vowels of equivalent phonological height.

Not only may vowels be achromatic; they may also be polychromatic --having more than one color simultaneously. (I do not know for sure of any vowels with more than two colors, although some varieties of r seem to be palatal and labial, as well as 'R-colored'.) By mixed or bichromatic vowels, I will usually mean labiopalatals, like [y, ø, œ] etc.

Since there is no physiological (or logical) opposition between labiality and palatality (as there would be, say, between [+High] and [+Low]), lip-rounding and tongue-fronting may occur simultaneously. But if they do, they attenuate each other's acoustic effects, so that they are, at least perceptually, less labial than pure labials and less palatal than pure palatals.

They are thus 'marked' or non-optimal; they tend to become monochromatic, and they are consequently rarer in the phoneme inventories of the world than pure labials or pure palatals.

In the event that retraction should be considered a color, the possibility of a different type of bichromatism arises, in which the colors are mutually augmenting (as when tongue retraction and simultaneous lip rounding both lower F_2-F_1), rather than mutually attenuating (as when tongue fronting raises F_2-F_1 and lip rounding simultaneously lowers the value of this same parameter). One might expect differences of phonological behavior between labial, non-palatal, retracted vowels

and labial, non-palatal, non-retracted vowels--but the occurrence of the latter is so rare that no conclusions about such differences can currently be drawn.

2.3.3. Tenseness and laxness.

In discussing tenseness and laxness I will be referring to a vowel quality difference--not a difference of quantity. Tenseness and length are related in many languages, but they are independent features. Vowels may often be long and tense, but they may also be long and lax; and while short vowels are often lax, they are not necessarily so.

(2.15) For example, the Swiss German dialect, Züritüütsch (except in Winterthur) distinguishes between long tense, short tense, long lax and short lax vowels. Keller (1960:37-41) gives the following examples:

	Long	Short
Tense	[i:] blybe 'remain' Zyt 'time' <MHG ī	[i] Side 'silk' <MHG ī, shortened
Lax	[ɪ:] Spiil 'game' <MHG i, lengthened	[ɪ] isch 'is' Chind 'child' <MHG i

The original distinction between tense and lax, or narrow and wide, referred to the tenseness or shape of the tongue. Bell and Sweet distinguished between the 'primary' or 'narrow' vowels and 'wide' ones; wide vowels had a lesser degree of constriction. The terms 'tense' and 'lax' (gespannt and ungespannt) originated with Stumpf (1926), who described laxness as a shift toward the middle of the vocalic triangle, associated with a lower degree of articulatory effort. Raphael (1971) tested this 'effort' hypothesis and found that, for palatal vowels, genioglossus activity was higher for [i, e] than for [ɪ, ɛ]; his results were inconclusive for non-palatal vowels (but he did not measure lip movements).

Acoustically, tense vowels are characterized by more extreme formant positions than the corresponding lax vowels have. Stumpf's notion of shift toward the middle of the vocalic triangle is reflected in the formant values of the acoustical vowel diagram. In a study of the tense and lax vowels of German, Jørgensen (1966) noted that the lax vowels showed higher F_1 values than the corresponding tense vowels. Further, F_2 was higher for tense palatals than for the corresponding lax palatals (suggesting that tense palatals are 'more palatal'), and F_2 was characteristically lower for tense labials than for the corresponding lax labials (suggesting that tense labials are 'more labial'). For the tense/lax /a/ pair, Jørgensen's results were entirely

inconsistent--for F_1 as well as F_2. But among chromatic vowels, the tense vowels displayed greater deviation from the neutral position--i.e. the center of the vocalic triangle--and lower F_1.

A somewhat different aspect of this relationship to a neutral position is suggested by the redefinition of 'tense' and 'lax' vowels for English offered by Lehiste and Peterson (1961):

> 'Lax' vowels, then, are those vowels whose production involves a short target position and a slow relaxation of the hold; for 'tense' vowels the target position is maintained for a longer time, and the (articulatory) movement away from the target position is relatively rapid (274).

The common note in these two views is that tense vowels are characterized by greater deviation from a neutral position or by greater duration of the non-neutral configuration. Both characteristics imply increased muscular effort, and both correspond, for chromatic vowels, to increased intensity of color.

In view of both the phonetic data I surveyed in Miller (1974) and the phonological data I will present in Chapter III, I wish to propose increased intensity of color as a definition of tenseness. In saying that tenseness is intensity of color, I mean that the articulatory, perceptual, and acoustic properties which make a vowel palatal or labial are stronger or more extreme in tense vowels than in the corresponding lax vowels.

The hypothesis that tenseness is intensity of color makes achromatics lax by definition--a definition supported not only by parallels in the treatment of lax and achromatic vowels, but also by the absence of any clear-cut tense/lax contrasts in the achromatic series. In this respect my proposal differs from the peripheral/non-peripheral distinction suggested in Labov et al. 1972, or Lindau 1975.

This is why, when achromatic vowels 'color' (cf. [Donegan] Miller 1973:388ff.), their immediate reflexes are lax. Thus the nucleus of [ɑo̯] in house, sound, when palatalized as in most American dialects, is lax [ɐo̯] (the tense [æo̯] heard in my native Baltimore is a secondary change); and the nucleus of [ɑe̯] as in line, by, when labialized, as in the Outer Banks of North Carolina (personal observation, cf. also Labov et al. 1972, Fig. 41), is lax [ʊe̯] rather than tense [ʊe̯]. Similarly, the delabialized nuclei of snow [ʌu̯] < [ɔu̯] and two [ɨu̯] < [ʊu̯], in various southern and eastern U.S. dialects where these become palatal, are lax [ɛu̯] and [ɪu̯], respectively, not tense [eu̯] and [iu̯].

The absence of tenseness contrasts in achromatics explains the loss of a contrast between /ɑ/ and /ɑ:/ when the long/short contrast in a language is recoded as tense/lax, as when Classical Latin a and ā merge as Vulgar Latin a (Romeo 1968:61); while the distinctions between the other long and short vowels are maintained by being recoded as tense/lax.

Merger of long and short a in languages where vowel distinctions are being so recoded is avoided in many cases by palatalization or labialization of one or both of the achromatic pair: when Middle English short and long a's became palatal in Early Modern English (Jordan 1974: 265, 276) the palatalization of both achromatics allowed a lax/tense distinction to replace the disappearing quantity distinction of short/long pairs like mat/mate.

Similarly, long ā became ō while short a remained a in West Scandinavian (Noreen 1913:113) when, in other vowels, the Common Scandinavian length distinction was being recoded as a tense/lax distinction; the tense/lax difference being inapplicable to ā/a, an alternative quality difference--labial/non-labial--was superimposed on this pair.

It has been suggested (Halle and Stevens 1969, Perkell 1971) that the feature [±Advanced Tongue Root] ([±ATR]) replace [±Tense] in vowel descriptions. The phonetic reasons for identifying [±ATR] with [±Tense] seem to me quite unconvincing, and I will not discuss them here--instead, see Lindau et al. (1972) or [Donegan] Miller (1974). Furthermore, I know of no phonological evidence for identifying advancing with tenseness. There do not seem to be any languages where vowel harmony is based on a tense/lax distinction of the 'European' variety. (Redenberger (1975) suggests a 'tenseness harmony' in Portuguese, however--which might constitute an example of such harmony.) And, as far as I know, there is no relation between the advanced-tongue-root distinction and length (as there is between tenseness and length) in those African vowel-harmony languages which do have a real [±ATR] distinction.

Ladefoged et al. (1972) and Lindau et al. (1972) show that some speakers of English and German may use tongue-root-advancing in producing tense vowels. For such speakers, advancing may serve as a color-amplifying gesture, especially for palatal vowels, that occurs in conjunction with tongue lifting or raising. Tongue-root advancement may be related to tenseness in labial vowels, but the evidence for this is very slight (Perkell 1971). At any rate, advancing is not sufficient to produce tenseness in back rounded vowels, because labial vowels which are [+ATR] in real [±ATR]-harmony systems (like Twi and Dho-Luo) do not have the lowered F_2 which characterizes tense labial vowels (Lindau et al. 1972).

2.3.4. Perceptual aspects of vowel quality features.

In discussing possible articulatory and acoustic correlates of the features used here, I have neglected to mention the considerable work that has been done which attempts to establish how vowels are categorized in perception--e.g. Plomp 1970, Singh and Woods 1971, Pols 1977, Terbeek 1977, Lindblom 1978, etc. (Terbeek 1977, in particular, appears to be a search specifically for the perceptual parameters or features by which speakers of various languages categorize

vowels.) What this work has shown, for the most part, is that the perceptual parameters so far discovered for vowels do not correspond in any very direct way to acoustic patterns or formant structures. Neither do they seem to correspond to articulatory features, as one might expect they would in a motor theory of speech perception (Liberman et al. 1963). Perception may be based, instead, on analysis of the vowel spectrum as a whole, with relationships playing a large part; the degree of dissimilarity as judged by speakers is correlated, according to Lindblom (1978:142-4), with 'spectral distance'--a measure of the differences, integrated with respect to frequency, between the auditory spectra of the two sounds.

One might hope that this notion of spectral distance might ultimately find some interpretation in terms of feature differences--that, perhaps, greater spectral distance would correspond to a greater number of differences in feature specifications--but such a prospect seems remote.

The difficulties of investigating vowel perception are considerable. Vowel perception clearly involves a great number of variables, and standardizing test stimuli--even for duration, overall intensity, fundamental frequency, steady state (vs. diphthongal transition), or consonantal environment (or the lack of it)--risks distorting or eradicating some salient detail. And the kinds of tests used run certain risks as well. Similarity or dissimilarity judgements run into the considerable danger of involving speakers' analysis of sounds (native or foreign) as phonologically, or even orthographically, similar or dissimilar--rather than obtaining judgements based solely on phonetic quality. The use of vowel identification tests carries its own difficulties: the greater intrinsic intensity of more-sonorant vowels makes them more perceptible against noise than less-sonorant vowels (Lindblom 1978:145) and may thus skew the results of tests on vowels in noise; and the use of ultra-short 'clipped' vowels gives results whose relevance is not clear when one considers that identification of vowel qualities in different speakers appears to depend to some extent on dynamic or tempo-related aspects of each speaker's productions (cf. Pols 1977:31). At any rate, the relationship between misidentifications and the acoustic properties of the misidentified vowels in studies which use such tests does not seem to follow, in general, any very clear patterns.

In short, I have found nothing in the limited amount of this literature that I have been able to examine so far to suggest that any of the features I am using here should be ruled out--although, on the other hand, there is little to support them.

The examination of fortition processes is itself--in a very different way--a search for relevant perceptual properties. In their remarkably consistent patterns of phonological substitution under conditions of stress, emphasis, etc., speakers are--without the mediation of test situations--telling us what phonetic properties they consider relevant.

2.3.5. Duration.

The length or duration of a vowel, like that of any speech sound, is determined by a variety of factors--the phonetic properties of the segment itself, the context in which the segment appears, and the systematic or lexical length of the segment--in addition to rate, style, etc. The phonological effects of duration are not related only to lexical length; context-determined and intrinsic duration may be phonologically relevant as well.

2.3.5.1. Intrinsic duration.

Intrinsic duration is 'the duration of a segment as determined by its phonetic quality' (Lehiste 1970:18). Intrinsic duration appears to be correlated with vowel height, tenseness, and color: other things being equal, a lower vowel is longer than the corresponding higher one (ibid.)--e.g. [æ] > [e] > [i], where > means 'is longer than'; a tense vowel is longer than the corresponding lax vowel (Jakobson, Fant, and Halle 1969:38, *cf.* Perkell 1969)--e.g. [e] > [ɛ], [i] > [ɪ], *etc.*; and there is some evidence that a chromatic vowel is longer than the corresponding achromatic (Peterson and Lehiste 1960:701-2; Elert 1964: 182-3)--e.g. [ɛ] > [ʌ], [æ] > [ɑ].

According to Lehiste, it is quite probable that the differences in vowel length according to degree of opening are physiologically conditioned and thus constitute a phonetic universal. The greater duration of low vowels is due to the greater extent of the articulatory movements involved in their production (18-9). About the greater intrinsic length of tense vowels, which also involve more 'complete' or more extreme articulatory movements than do lax vowels, a similar conclusion may be drawn--that 'a longer time would be required to achieve the more complete contraction' (Perkell 1969:64).

With respect to the correlation of openness with duration, Lehiste notes Fischer-Jørgensen's hypothesis (1964) that the motor commands for timing of vowels of different heights are actually the same, and that the longer durations of lower vowels may be due to the extra time required to execute the articulatory movements. This hypothesis may be applied to tenseness and color as well. The motor commands for timing of tense vowels may be the same as for the timing of lax ones, but the more-exaggerated lip and tongue gestures may require more time for execution; similarly, the commands for color gestures may require more time than the commands for achromatic vowels of similar height. But intrinsic duration is not so purely a matter of physical phonetics that it lacks phonological effects.

Intrinsic duration may be phonologically relevant to the distribution of phonemes and to the application of phonological processes. Regarding the former, there are many languages in which the specifications 'long' and 'high' do not co-occur (e.g. Yokuts, with [i, u]

beside [e, o, e:, o:]), or in which 'short' and 'low' do not co-occur (e.g. many Hindi dialects, with [ɑ:] beside [ɛ, ɔ, ɛ:, ɔ:]), and there are also many languages in which 'long' and 'lax' do not co-occur except in low vowels (e.g. Classical Latin, Samoan), and in which 'short' and 'tense' do not co-occur (e.g. Lithuanian, Kurdish, Khasi).

Although differences of intrinsic duration are not phonologically contrastive, since they are by nature derivative, they may affect the application of phonological processes. The additional duration of lower vowels, for example, may affect their susceptibility to processes which are sensitive to length.

(2.16a) For example, in Japanese, vowel devoicing is related to length: long vowels remain voiced, vowels in very slow speech remain voiced, and short /e, o, ɑ/ ordinarily remain voiced; only /i/ and /u/, the short vowels with least intrinsic duration, undergo devoicing (Han 1962: 20-25).

(2.16b) The shortening of Middle Indo-Aryan final vowels (cf.(2.8)), where /ɑ:/ shortened at a later date than /i:, u:/, also points to the relevance of intrinsic length (Pandit 1961:57).

(2.16c) And, conversely, when 'open syllable lengthening' took place in English (cf. (2.7)), it at first affected only the intrinsically longer non-high vowels, a, e, o; i and u, which are intrinsically shorter, were lengthened only later, and only in some areas (Brunner 1963:17).

2.3.5.2. Contextually-determined length.

It is commonly recognized that speech, like other natural human activities (walking, chewing, etc.), is basically rhythmic. The number and the intrinsic durations of the individual segmental articulations which make up speech may to some degree disturb this rhythm, and grammatical factors may also interfere, but it appears that the intended timing of speech, at least, is extremely regular (cf. Kozhevnikov and Chistovich 1965, esp. 104ff.).

When the basic rhythmic unit is an accent group, or 'measure' (cf. Stampe 1973b, 1973c, Donegan and Stampe 1978b), so that there is equal timing between accents, the language is said to be iso-accentual, or stress-timed. When the basic rhythmic unit is the syllable, so that each syllable constitutes an equal prosodic interval, the language is said to be iso-syllabic, or syllable-timed. And when there is a distinction made between short (one-beat) and long (two-or-more beat) syllables, so that each short vowel (or syllable-offset consonant) is mapped onto one 'beat' or time-interval, and each long vowel is mapped onto two, the language is said to be iso-moric, or mora-timed.

Temporal compensation is a matter of mapping different sorts of segmental representations onto the timing patterns set up by the language. In a language with syllables of equal length, for example, the vowel of a closed syllable (CVC) will be shorter than that of an open (CV) syllable, other things being equal. (Prevocalic or 'onset' consonants do not count in the calculation of prosodic value or length.) And in a language with accent-groups of equal length (ideally), the accented vowel of a monosyllabic word (CVC) will, other things being equal, be longer than that of a disyllabic (CVCVC) or trisyllabic (CVCVCVC) word. In many languages, particularly stress-timed languages, these principles may interact, so that there is evidence for both syllable isochrony (with all stressed syllables long and all unstressed ones short) and stress-group isochrony (stressed vowels in polysyllabic accent groups shorten; those in monosyllables lengthen, etc.).

Temporal compensation involves the lengthening or shortening of segments to fit a prosodic pattern--lengthening of vowels in open syllables, or before short or single consonants, or in monosyllables; and shortening of vowels in closed syllables, or before long consonants or consonant clusters, or in polysyllables, etc. It also includes phenomena like 'compensatory lengthening'--usually the lengthening of a vowel to fill the time left open by the loss of a consonant within the same timing unit. (See Donegan and Stampe 1978b for examples.)

Contextually-conditioned length is length that results from temporal compensation of one kind or another. As long as such length is predictable from the phonetic context, it does not function lexically to mark distinctions between morphemes or words. But contextually-conditioned length often functions phonologically to condition processes like diphthongization, palatalization, labialization, etc.--see Chapters III and IV. If a segmental process affects 'long' vowels, it will affect contextually-lengthened vowels as well as lexically long vowels, other things being equal.

(2.17a) Old English ā, which became Middle English ǭ in the South and Midlands, remained ā in Middle English in the North. When this ME ā was palatalized (fronted) to /æ:/ (ǣ), not only the old (lexically long) ā's but also the ă's from OE ă lengthened in open syllables underwent the process (Jordan 1974, 276).

On the other hand, if a segmental process affects only originally-long vowels, or only contextually-lengthened vowels, one must assume that other things are not equal--that the affected and non-affected vowels must differ by some other, qualitative, feature.

(2.17b) Thus, for example, Old English o lengthened in open syllables is lowered to ǭ --thus merging with ǭ (< OE ā), but OE ō is not lowered. This suggests a quality difference between long and short o, since lengthened short o is not treated equivalently to long ō (cf. Brunner

1963, §12). Compare, in this regard, the Züritüütsch long and lengthened vowels of (2.15).

2.3.5.3. Lexical length.

In many languages vowel duration functions as a distinctive, and thus to some degree independent variable, not conditioned by environment. Languages in which vowel length is contrastive or lexical ordinarily distinguish between two lengths, short and long. (A third length, 'overlong', appears in Estonian and in Mixe; for discussion, see Lehiste 1970:41-52.) Long vowels have been variously analyzed linguistically: they may, for example, be regarded either as sequences of two identical short vowels or as single segments marked by a feature of length. The criteria for such analyses are, of course, phonological rather than phonetic.

2.3.5.4. The representation of vowel length.

In articles that appeared concurrently in 1970, M. Kenstowicz and C. Pyle discussed the fact that a long vowel may be represented with a length feature marking a single vowel--as V:, or [+vocalic, -consonantal, +long]--or as a sequence of two identical short vowels--as V_iV_i, or $\begin{bmatrix}+\text{vocalic}\\-\text{consonantal}\\-\text{long}\end{bmatrix}\begin{bmatrix}+\text{vocalic}\\-\text{consonantal}\\-\text{long}\end{bmatrix}$. Kenstowicz drew examples from Lithuanian, and his conclusions regarding the representation of vowel length were that: 1) both the feature representation and the sequence representation are required to describe adequately the phonological treatment of Lithuanian vowels, and 2) the prosodic rules of a language require the sequence representation of vowel length (V_iV_i), and the segmental rules require the feature representation (V:).

Pyle, who drew his data from West Greenlandic Eskimo, agreed with Kenstowicz's first conclusion but disagreed with the second, claiming that the kind of length representation required by a phonological rule could not be predicted on the basis of the function (prosodic or segmental) of the rule, and noting that there are some rules which seem to require both the sequence and the feature representations.

(A similar problem of representation exists for geminate/long consonants, as discussed by Sampson (1973), Saib (1974), Guerssel (1977), etc., but this discussion does not, as far as I can tell, shed much light on the problem of vocalic representation. Consonants involve different features, different processes--and many of the examples used appear to be rules--and, perhaps most importantly, different prosodic values and prosodic settings.)

2.3.5.4.1. Long vowels as V:.

Long vowels are treated as units in many cases: Kenstowicz gives the example of Lithuanian a: becoming o:, and Pyle gives two examples from West Greenlandic: /ɑ:/ → [+round]; and V: → [-high]. The Old English labialization of long ā to ǭ (whence /o:/, as in stone) and the early Middle English tensing of long vowels while the short vowels remained (or became) lax are other changes which require a feature representation of length. Many further examples will appear in Chapter III.

In these substitutions, the long vowels were not being treated as geminate short vowels (which would supposedly constitute the vowel sequence), since short vowels did not undergo the changes. Further, as Kenstowicz and Pyle point out, short vowels frequently undergo substitutions which do not affect long vowels, e.g. Lithuanian o > a; W Greenlandic /ɑ/ → [æ] /__CC; as well as other changes to be described in Chapter III. This too argues that long vowels are not merely sequences of short vowels; if they were, the short-vowel 'halves' of the long vowels would also undergo any change that affects short vowels.

2.3.5.4.2. Long vowels as VV.

Nevertheless, in many cases, long vowels do appear to act as sequences, both in prosodic rules (or processes), as Kenstowicz suggests, and in segmental substitutions. Pyle notes a few instances in which quality changes require a sequence representation, and in Chapter III further examples will be given. In particular, diphthongizations of all types suggest a sequence representation.

2.3.5.4.3. Long vowels as $V\underline{V}$.

It is not sufficient to say, however, that a long vowel is equivalent to a sequence of two identical short vowels. One must specify that the second vowel of the sequence is identical to the first except that the second is non-syllabic (Stampe 1973b,c); thus, a long vowel may be $V_1\underline{V}_1$. To regard both halves of a long vowel as syllabic is to divest the notion 'syllabic' of meaning. Syllabicity is the property that a segment has when it counts as a syllable prosodically--it is the property which distinguishes the [n̩] of lightening [laɪtn̩ɪŋ] from the [n] of lightning [laɪtnɪŋ] (cf. Ladefoged 1971:81). Since a long vowel counts as only one syllable, only one of its constituent vowels may be syllabic; the other must therefore be non-syllabic.

When a long vowel is regarded as a sequence, it is always the second mora that is non-syllabic. There are several reasons for making this claim, as Stampe (1973b, c) suggests. First, in languages which count moras for prosodic purposes, the number of moras--timing units equivalent to a short syllable--is counted by counting the segments in

a syllable, beginning with the syllabic. That is, segments before the syllabic do not count. Thus, VV̯ is two moras, while V̯V is only one. Since in all languages which make a length distinction, a long vowel counts as two moras, V̯V cannot be equivalent to a long vowel.

Second, when a long vowel first becomes a diphthong, it is the second mora which acts as the non-syllabic. In diphthongizations like [ʊ:] → [ʊo̯] → [ɑo̯] → [ɑu̯], this is easy to see; in diphthongizations like [e:] → [i̯e] or [i̯e:], it may be far less obvious, but I will argue in Chapter IV (Sections 4.2.3,and 4.3.2) that the original diphthongization in such cases typically involves a non-syllabic second mora (VV̯) and that only after certain intervening changes is syllabicity shifted to the second element.

Third, when a diphthong undergoes such a shift of syllabicity (cf. Andersen 1972), changing from a falling diphthong VV̯ to a rising diphthong V̯V, it shortens, unless the second element is lengthened to maintain the original length V̯V:.

(2.18) In Frisian 'breaking' (Cohen et al. 1961:118-21), syllabicity shift (VV̯ → V̯V) shortens the vowel of a closed syllable in a disyllabic word, while the long vowel--a falling diphthong--remains in a monosyllable. Thus:

[dɔ̀əs] / [dwɑskə]	doas/doaske	'box/little box'
[bɪəm] / [bjɛmkə]	beam/beamke	'tree/sapling'
[stiən] / [stjɪnən]	stien/stiennen	'stone/stones'
[slʊərə] / [sljʌrkjə]	sluere/sljurkje	'stream/slow stream'
[fuət] / [fwɔ̀tən]	foet/fuotten	'foot/feet'

What is presumably the same segmental representation of each diphthong becomes long (VV̯) in the monosyllabic words and short (V̯V) in the disyllables. In this case, in fact, it appears that the motivation for the syllabicity shift is the change of duration (cf. Sec. 4.3.4). Lehiste (1971) has shown that this kind of temporal compensation takes place in English. If, in diphthongs, a non-syllabic second element makes the vocalism long in this way and a non-syllabic first element does not, the representation of long vowels as VV̯ seems quite reasonable.

But while a long vowel may be, in many languages, the prosodic equivalent of a falling diphthong (VV̯), that does not mean that one can merely represent long vowels as sequences of segments (cf. deChene and Anderson 1978)--or, for that matter, that one can represent short vowels as necessarily uni-segmental. And it is not only the segmental changes affecting long and short vowels differentially--suggesting that long vowels are units--that argue against such representation (Sec. 2.3.5.4.1).

Short vowels may be treated in phonological processing as if they consisted of two parts. Short vowels, as well as long ones, may undergo

processes that affect only one of their 'halves', making two non-identical elements out of a single vocalism. That is, short vowels may diphthongize. Such differential treatment of the 'halves' of a vowel (as, for example, if one half loses its color while the other remains chromatic) is of course far less frequent among short vowels, where temporal limitations favor single articulations, but it does occur.

Moreover, short vowels may become falling diphthongs (cf. 4.1.1):

(2.19) In many American dialects, the lengthened /æ/ of bad or man is diphthongized to [æe̯] or [ee̯]--but in some northern dialects (Detroit, Buffalo, etc.) this diphthongization may be extended to affect the short [æ]'s which appear before voiceless stops or in polysyllables as in that, or Kathy (cf. Labov et al. 1972:Ch.3).

And not only may short vowels become falling diphthongs; falling diphthongs may be, or become, short.

(2.20) For example, the short [ɑe̯] of write is opposed to the long [ɑe̯] of ride even in dialects of English where the two are qualitatively the same,

(2.20b) and the short Faroese [uɣ] of mítt [muɣt:] 'my' or tímdi [tuɣmdɪ] 'liked' differs from the long diphthong of grísur [gruɣ:sur] 'pig' (Lockwood 1955:10).

Since there are both long vocalisms with articulatory and perceptual properties like those of single vowels, and short vocalisms that are clearly bisegmental, it is not possible to do without a prosodic specification of length simply by regarding long vowels as somehow 'double' short vowels--even allowing for the syllabicity difference implicit in a VV̯ representation. It seems to be necessary, after all, to mark vowel length on the entire vocalism. In some languages, this length will depend on context; in others, it will be lexically marked; in still others, there will be interaction between lexical length and length that is conditioned by context.

III - VOCALIC FORTITION PROCESSES

3.0.1. Introduction: Data and method.

A very limited number of natural processes underlie the wide variety of substitutions that occur in children's speech, in synchronic alternation, in stylistic and dialectal variation, and in diachronic change. The notion that children's substitutions, synchronic alternation and variation and historical change are somehow to be understood by the same principles is far from new, of course. Grammont (1965), Baudouin deCourtenay (1895 [1972]), Passy (1890), Martinet (1955), Jakobson (1968) and others have attempted classifications and explanations which would include the sorts of substitutions attested in all these areas of phonological evidence--although, of course, the principal attentions of each of these scholars may have been directed toward one area or another.

The assumption which underlies the identification of one type of substitution with another is that all substitutions are phonetically motivated. If a child is found to make a substitution like one that occurs in the adult speech of a particular language or dialect (cf. Major 1976), and if both the child and the adults are assumed to have a phonetic purpose in making the substitution, it is reasonable to assume that they have the same purpose, insofar as their substitutions are subject to similar constraints or occur under similar conditions.

The processes to be described in this chapter are consequently based on the various kinds of data noted above; I share with Jakobson and others the conviction that the similar substitutions which occur in these various circumstances are to be identified--and identified causally or teleologically. As the processes in child speech and in synchronic alternation and variation turn out to share with the processes of diachronic change the same phonetically motivated implicational conditions on their application, they themselves offer their own confirmation of this view.

Although I have attempted to gather examples from as many languages and language families as possible, the data I have examined falls short of a corpus for which I can claim true universality. Many language families are neglected, and it might be argued that others (especially Romance and Germanic) have been overemphasized. The accessibility and clarity of language descriptions have of course been important factors in determining my data base, but it is hoped that the non-European examples I will cite will show that the processes I am describing are not limited to particular language families. Where

some particular phenomenon does appear to characterize a particular family (as one might say that diphthongization characterizes the Germanic languages), I have attempted to show that phonetic, rather than merely genetic, factors are at work, in ways that suggest that one might find similar instances elsewhere.

Most of the examples I will cite are examples from adult speech--diachronic change, and synchronic variation and alternation--rather than from child speech; but I have included examples from the speech of a handful of children whose substitutions I have been able to study, when their substitutions parallel adult substitutions. Although Dressler (1974) suggests that children's substitutions frequently fail to parallel diachronic changes, I have found no non-parallel examples to add to those he cites. In my observation, children's vowel substitutions--in monophthongs, in diphthongizations of monophthongs, in diphthongs, and in monophthongizations of diphthongs--rarely fail to correspond to possible (i.e. occurring) diachronic changes, and in some cases, the parallels are quite striking (e.g. Major 1976).

Once the data have been decided on and collection of examples begun, the question of how to classify the substitutions arises. Given 'similar' substitutions, one may use a number of criteria to determine that they represent the same process.

The first and most important criterion is <u>similarity of effect</u>. It is fairly easy to see what is meant by this, at least in most of the cases I will deal with: [ʊ] → [ɑ], [o] → [ʌ], [u] → [ɨ], and [y] → [ɪ] are all examples of Delabialization. And [ʊ] → [o] and [o] → [u] both involve the addition of one degree of height, or Raising. The natural and reasonable impulse is to group the first four substitutions together, and to group the latter two also.

Once substitutions have been classified by effect, the various applications of probable processes--like Raising and Delabialization--must be compared to see if patterns of substitution indicating a common process emerge. One indicator that substitutions with similar effects constitute a common process is <u>frequent co-occurrence</u>. For example, [ʊ] is raised to [o] and [o] is raised to [u] in the English vowel shift and in that of São Miguel Portuguese. Since the pair of substitutions have similar effects, their concurrent applications in these cases further suggest that [ʊ] → [o] and [o] → [u] both result from the same processes.

Co-occurrence alone, however, is not as clear an indicator of process identity as is <u>direct implicational relationship</u>: For example, the context-free raising of [ɛ] to [ɪ] co-occurs with the raising of [æ] to [e] (as in the early stages of the English vowel shift) but--more importantly--the raising of [e] to [ɪ] never seems to occur unless an [æ] in the system is, under similar circumstances, concurrently raised to [e]. That is, [e] → [ɪ] implies [æ] → [e]. The implication is unilateral: [æ] may be raised while [e] remains, as in the later stage

of the English shift, when a new [æ] (from lengthened [ɑ]) became [e], while [e] was only optionally raised to [i]. This unilateral implicational relationship between the two substitutions suggests strongly that they are related as subparts of a single Raising process which is especially applicable to low vowels.

Sometimes substitutions have similar effects and do co-occur, as do raising of palatal vowels and raising of labial vowels in the English vowel shift, in Colloquial Czech, and in Old Prussian--where ē's become ī and ō's become ū, but there is no direct implicational relationship between them: [e] → [i] does not imply [o] → [u], for example, and [æ] → [e] does not imply [ɒ] → [o] or [o] → [u]. In cases like this, the substitutions may be said to represent the same process if there are shared implicational hierarchies. In the raising of palatal vowels, for example, a low vowel must be raised if the mid vowel is raised; the condition for raising labial vowels is the same. Thus, palatal and labial Raising share the implicational condition ! lower (read 'especially lower'); i.e., lower vowels of both colors are especially susceptible to Raising. Palatal and labial raising may thus be regarded as subparts of the same process. (And further, the raising of labiopalatals may be regarded as a subpart of the same process that raises labials and palatals, because [ø] → [y] appears to imply [œ] → [ø].)

As noted earlier, any attempt to understand the individual substitutions and the processes they represent requires an attempt to discover the phonetic motivations for the processes one describes. To do this, one looks first at what happens in the substitutions; The first indicator of similar motivation is similar effect or similar change. The next step is to determine which segments undergo the change and which do not undergo it to see if the possible process inputs give a clue to the motivation for the substitution. For example, labial, palatal, and labiopalatal vowels undergo fortition Raising, but achromatic (non-labial, non-palatal) vowels do not, This suggests that there is more to Raising than the mere decrease of sonority (or addition of height); in each case, the process also increases the color of the subject vowels, since labiality and palatality increase as sonority decreases. The absence of Raising as a fortition (in stressed syllables, long vowels, etc.) in vowels without color suggests that the motivation for Raising is the increase of color.

Like the absolute conditions on process application, relative or implicational conditions may also provide clues to process motivation. For example, the process which delabializes vowels is especially applicable to lower or more sonorant vowels. Thus, the less labial a vowel is, the more susceptible it is to loss of labiality. This reflects the articulatory and perceptual difficulty of maintaining the attenuated labiality of vowels marked by a large mouth opening and a high degree of sonority: it also reflects the tendency apparent in all fortition processes to increase in a segment a property which it already possesses to a high degree--a tendency that I will refer to as

the 'rich-get-richer' principle (e.g., the more sonorant of two labial vowels is the one that will be more apt to increase its sonority by losing its labiality)--cf. 3.1.1.4, for further explanation.

Besides the effects of a process and its possible sets of input segments, the conditions under which a change is apt to occur must be considered. Such conditions, both suprasegmental and segmental, must be considered even with so-called 'spontaneous' or 'unconditioned' changes, because substitutions are in fact rarely completely unconditioned. Speech style (casual, deliberate, emphatic, etc.) may influence such substitutions, and accent and timing frequently play an important role in influencing process application. For example, the various sorts of diphthongization often affect only stressed and/or long vowels--but never only short or unstressed vowels. Compare this with vowel reduction, which ordinarily affects only unstressed vowels. Both kinds of processes might be considered 'context-free', particularly as they may be interpreted in historical changes, where the suprasegmental conditions may subsequently be obscured, but stress and duration certainly affect their applications. Hyperarticulate styles increase the domains of the processes associated with diphthongization, by increasing the stress and length factors which promote such changes. Such styles reflect an increase in the degree of attention paid to speech, which also increases the domains of fortition processes. Hypoarticulate speech styles often involve shortenings and decreased stress levels, and they reflect decreased attention to speech; both of these factors promote the application of lenition processes like vowel reduction.

3.0.2. Fortition and dissimilation.

The conditions under which particular substitutions occur include the segmental environments of the substitutions, too, of course. In assimilative changes, where the role of context is most obvious, the phonetic motivations for the substitutions are often most obvious also. In dissimilative changes, the superficial role of context may be apparent, but the function of a substitution in a dissimilative environment may be somewhat obscure. Finding the phonetic motivations for dissimilative changes requires comparison of such changes with the context-free changes they so often resemble. Comparison of the effects, the inputs, and the conditions on dissimilations of adjacent segments with those of context-free fortition processes has led me to believe that dissimilations are ordinarily to be identified with fortitions.

In the following sections, I will discuss the principal fortition or 'strengthening' processes which govern the segmental phonology of vowels. Since fortition processes are those which optimize or maximize phonetic features of individual segments, their typical application is 'context-free' although, as noted above, their application may be influenced by suprasegmental factors and they also frequently apply dissimilatively.

The dissimilative application of a fortition process has the same teleology as its context-free application--the maximization or optimization of a particular phonetic property of a segment. But because phonetic properties often conflict, so that a segment represents 'compromise' or intermediate values for two (or more) properties, the maximization of one property often entails the attenuation (or loss) of another. For example, raising [e] to [i] represents an increase of palatality and a reduction of sonority; lowering [ɪ] to [ɛ] represents an increase in sonority but a reduction of palatality.

Fortition processes apply more freely in dissimilations because in dissimilations the property which is lost or reduced in the segment which undergoes change is preserved in the environment: the [ɪ] of [ɪi̯], for instance, is more susceptible to Lowering than simple [ɪ], because the palatal quality that Lowering weakens is preserved in the [i̯] of the environment. As the processes to be described will show, the more intensely present in the environment the property-to-be-weakened in the changing segment, the more suitable the environment is for conditioning dissimilation--e.g., the more palatal a palatal vowel's environment is, the more susceptible that vowel will be to fortitions which increase some other property at the expense of its palatality.

In this view, 'dissimilation' itself does not actually motivate the substitution; an environment which maintains the property being lost or reduced is not the cause of the substitution, but only the occasion for it. The cause or motivation is the increase of a phonetic property, as in parallel context-free fortitions.

Fortition processes, both context-free and dissimilative, are particularly applicable in hyperarticulate speech and to segments in 'strong' positions, probably because such styles provide (and such positions represent) the suprasegmental conditions which favor their application. It is important to keep this in mind because fortition processes may have 'lenition counterparts'--processes which appear to cause the same substitutions but which apply under very different conditions, often with different input classes, and--most importantly--with different motivations.

3.1. Tensing and Laxing.

Changes in the degree of color of palatal and labial vowels may be accomplished by the processes of Tensing and Laxing. Tensing imparts greater color, for a given phonological height; Laxing attenuates color, but imparts, for a given height, greater sonority (cf. 2.3.3). Tensing and Laxing are relatively simple processes, and they often interact with other phonological processes, particularly in context-sensitive applications, so they will be discussed here first.

3.1.1. Tensing.

The Tensing process can be represented thus:

$$\left[\begin{array}{l} V \\ \alpha\text{palatal} \\ \beta\text{labial} \\ +\text{long} \\ \text{higher} \\ /\left[\begin{array}{l} V \\ -\alpha\text{palatal} \\ -\beta\text{labial} \end{array}\right] \end{array}\right] \rightarrow \quad [\text{tense}]$$

Condition: α and/or β has the value +.

If tenseness is intensity of color, then Tensing is limited to palatal, labial, or labiopalatal vowels; plain vowels cannot tense because they have no color to increase. This difference between plain and chromatic vowels appears in various occurrences of Tensing:

(3.1a) When the length distinction of Classical Latin was reinterpreted as a tense/lax distinction in Vulgar Latin (Allen 1970,47), the long and short plain vowels--a and ā--fell together.

When a length distinction is reinterpreted as a tense/lax distinction in other languages, it is often the case that one or both of the a-quality vowels will be palatalized or labialized so that a quality difference may replace the length difference that is being eradicated.

(3.1b) Chromatic and achromatic vowels are also treated differently by Tensing in the Quiché dialects (e.g. in Cantel, near Quezaltango) which neutralize the tense/lax contrast among chromatic vowels but retain /ɑ/ and /ɑ:/--as [ʌ] vs. [ɑ] (Campbell 1977:15). This shows that the [ʌ] vs. [ɑ] difference is not one of tenseness, but rather one of height.

Of course, an [ʌ] vs. [ɑ] or [ɑ] vs [ɑ:] difference appears in many languages (e.g. Standard Hindi, Panjabi, Pashto, Standard German) in parallel with the tense/lax distinction, and this difference is sometimes attributed to tenseness. But in fact, neither the phonetic properties nor the phonological behavior of [ʌ] vs. [ɑ] parallel [ɛ] vs. [e] or [ʊ] vs. [u]. Phonetically, lax chromatic vowels are more sonorant than their tense counterparts, but [ʌ], supposedly the lax member of the [ʌ]/[ɑ] pair, is less sonorant than [ɑ]; and the examples just noted are among the indicators of the phonological differences. The [ʌ]/[ɑ] difference is one of height; the [ɑ]/[ɑ:] difference is one of length. Identification of [ʌ]/[ɑ] as a tenseness distinction is sometimes made because the susceptibility of plain vowels to Lowering when they are long (see 3.2.1.4) parallels the susceptibility of

chromatic vowels to Tensing when they are long.

3.1.1.1. ! Long

Long vowels are especially susceptible to Tensing. Examples of tensing of long vowels are plentiful:

(3.2a) Historically, the long chromatic vowels [i:, u:, e:, o:] became tense in English (cf. Sweet 1891, Kurath 1964),

(3.2a) and in many German dialects--e.g. that of Berne (Keller 1961:90ff.), and that of Zürich (2.15),

(3.2c) in the various Scandinavian languages (Haugen 1976:254),

(3.2d) in Classical Latin (3.1a),

(3.2e) and in Hindi (Pattanayak 1966).

(3.2f) Synchronically, long chromatic vowels are tensed in Hungarian (Fonagy 1966, cited in Lehiste 1970:121),

(3.2g) and in Kalispel (Vogt 1940:15);

(3.2h) and chromatic vowels lengthened by position in open syllables are tensed in Palestinian Arabic (Abdul-Ghani 1976).

3.1.1.2. ! Higher.

In some languages, only the mid vowels vary between tense and lax. The high vowels are always tense because, ceteris paribus, tensing is especially applicable to higher vowels. The following are some examples of differential tensing which depend on vowel height:

(3.3a) In Bengali (Pattanayak 1966), mid vowels are tense if they are also long, but high vowels--short and long--are always tense.

(3.3b) In Tojolabal (Supple and Douglass 1949) the high vowels /i, u, i:, u:/ are tense, but the non-high vowels /ɛ, ɔ, ɛ:, ɔ:/ are lax.

(3.3c) In Sardinian (Rohlfs 1946:44-6), the Latin high vowels became tense: $\breve{\text{I}}$, $\bar{\text{I}}$ → /i/, $\breve{\text{u}}$, $\bar{\text{u}}$ → /u/; but the non-high vowels were laxed: $\breve{\text{e}}$, $\bar{\text{e}}$ → /ɛ/, $\breve{\text{o}}$, $\bar{\text{o}}$ → /ɔ/.

3.1.1.3. Dissimilative Tensing.

Tensing may also apply context-sensitively; vowels often tense dissimilatively. The tensing of vowels in hiatus (/__V) may be in part a matter of tensing the 'unchecked' (lengthened) vowels of open syllables, but this process suggests that dissimilation is also a contributing factor.

That Tensing in the environment of another vowel is indeed dissimilation is confirmed by the particular susceptibility of vowels to Tensing when the adjacent vowel is lax or achromatic. A vowel is especially apt to increase its color by Tensing when it appears adjacent to a vowel with no color, with weak color, or with the 'opposite' color. The adjacent vowel need not be syllabic (so a hiatus position for the vowel being tensed is not required), although syllabicity in the adjacent vowel is especially conducive to Tensing.

(3.4a) In American English, lax vowels often develop achromatic offglides when lengthened by context. In some southern dialects the lax syllabics become tense when achromatic offglides follow: bid [bɪɪ̯̈d] → [bï̯d], bed [beə̯̈d] → [beə̯̈d], etc.

(3.4b) In Faroese (Lockwood 1955:9-12) a, æ are pronounced [a] when short, [ɛä̯] when lengthened in open syllables; maður [mɛä̯vur] 'man', spakari [spɛä̯kari] 'quieter', lag [lɛä̯] 'position'. But before syllabic [a], this /a/ is lengthened (as in all open syllables) and is then raised and tensed to [e:]: baða [be:a] 'to bathe', hagar [he:ar] 'hither'. Thus, the first half of lengthened [a:] (= [aä̯]) is raised before nonsyllabic [ä̯], but the entire lengthened [a:] is raised and tensed before syllabic [a].

3.1.1.4. The function of Tensing.

The phonetic motivation for Tensing is the increase of color. (This is not quite as tautological as it might appear. Since vowels also lose sonority when they are tensed, another motivation for tensing is at least possible.) Only chromatic vowels are tensed because achromatics have no color to increase. Long vowels are especially susceptible to Tensing because their greater duration allows time for the tongue and lip gestures to reach the more extreme positions associated with their articulation. Tense vowels are, of course, intrinsically longer than the corresponding lax vowels. It is because of this that when a tense/lax opposition is superimposed on a long/short, it is the long vowel which tenses; and it is also for this reason that when tense/lax chromatic vowels coexist with long/short plain vowels--as appears to be the case in Standard German-- it is the long /ɑ:/ which patterns prosodically with the tense vowels.

Higher vowels appear to tense more readily because they are already highly chromatic and (for vowels) weakly sonorant. There seems to be, in fortitions, a general principle, mentioned briefly earlier, that 'the rich get richer and the poor get poorer': the vowel which is more susceptible to increase of a given property is the one which already posseses that property to a higher degree. Thus, the more-chromatic [ɪ] is more susceptible to tensing, other things being equal, than the less-chromatic [ɛ].

Although I cannot propose this principle as a universal in the strict sense, it does appear to be one of the basic principles by which fortition processes operate. When a vowel is to be 'strengthened' --when it is to undergo increase or intensification of some phonetic property--the property selected for enhancement is likely to be one that the vowel already has to a relatively high degree. Thus the vowels which are particularly susceptible to a process are those which possess to a higher degree the property it increases. Correspondingly, when the increase of one property entails the loss of another, it is typically the case that the vowel most susceptible to the loss is that which possesses the property to a weak degree.

3.1.2. Laxing.

Laxing is, of course, the process with the opposite effect from Tensing; Laxing increases sonority and decreases palatality or labiality for a given degree of phonological height. The implicational conditions on Laxing are, like its effects, just the opposite of those of Tensing:

$$\left[\begin{array}{l} V \\ \quad \alpha\text{palatal} \\ \quad \beta\text{labial} \\ ! \ -\text{long} \\ ! \ \text{higher} \\ ! \ /\left[\begin{array}{l} V \\ -\ \text{palatal} \\ -\ \beta\text{labial} \end{array}\right] \end{array}\right] \rightarrow [\text{lax}]$$

This applies by virtue of the definition of laxness, if both α and β have the value -.

Tensing and Laxing frequently appear in parallel, and it is often difficult to determine which is the active process (e.g. Tensing of high vowels or Laxing of non-high vowels or both) since we only rarely know if the vowels before Tensing/Laxing were lax or tense. Thus, the examples which illustrate the ! -long and ! lower conditions on Laxing are the same as those which illustrate the ! +long and ! higher conditions on Tensing ((3.1a) through (3.6b)).

Because Laxing is particularly applicable to short vowels, which often undergo reductions that do not affect long vowels, and because Laxing has a 'lenition counterpart' which may affect unstressed vowels, the idea that Laxing may apply as a fortition may appear dubious at first. It is the role of Laxing in diphthongization which first suggests it is a fortition; and the fact that Laxing may also apply context-free, affecting all the vowels of a language, short and long--as in Yokuts (pers. comm. Greg Lee), Diegueño (Langdon 1970), Sarsi (Hoijer and Joël 1963), etc.--supports this notion. Laxing does increase sonority, and sonority is the vocalic property par excellence, so it is not unlikely, after all, that some languages should forego the intensified color of tense vowels in favor of the intensified sonority of lax vowels--particularly if the language does not have a large number of vowel distinctions to maintain.

3.2. Lowering and Raising.

Two fortition processes, Lowering and Raising, govern changes of vowel height, the feature which is the most direct manifestation of sonority. Lowering increases sonority by decreasing the height of vowels by one degree. Like Tensing and Laxing, Raising and Lowering have opposite implicational conditions as well as contradictory effects.

3.2.1 Lowering.

Lowering makes high vowels mid and mid vowels low:

$$\left[\begin{array}{l} V \\ n\ \text{high} \\ !\ -\text{chromatic} \\ !\ -\text{tense} \\ !\ \text{long} \\ !\ /\left[\begin{array}{l} V \\ \left[\begin{array}{l}\text{same color} \\ -\text{syllabic}\end{array}\right] \end{array}\right] \end{array}\right] \rightarrow \quad [n - 1\ \text{high}]$$

3.2.1.1. ! Achromatic.

The ! -chromatic condition on Lowering means that plain vowels like [ɨ] and [ʌ] are especially susceptible to Lowering: if a palatal or labial vowel is lowered, the corresponding non-palatal non-labial vowel must be lowered, too--i.e., [ɪ] → [ɛ] or [ʊ] → [ɔ] entails [ɨ] → [ʌ], and [ɛ] → [a] or [ɔ] → [ɑ] entails [ʌ] → [ɑ]. The lowering of a plain vowel, however, does not imply lowering of any chromatic vowel. Thus,

(3.5a) Many children lower the English achromatic [ʌ] but do not lower the corresponding chromatic vowel [ɛ]. Joan

Velten, for example, said [had] for hug, [nat] for nut, etc., but no such general lowering affected [ɛ] in her speech (Velten 1943:88f.).

(3.5b) In the history of English, the lax (from old short) vowels [ʊ] as in hut and [ɔ] as in hot unrounded in many dialects. The reflexes of this delabialization were lowered to [ʌ] and [ɑ] respectively. But where these vowels remained labial [ʊ] and [ɔ], as in push, off, etc., they were not lowered--nor were the corresponding palatal vowels [ɪ] and [ɛ], as in hit, bet.

(3.5c) The Dravidian language Kolami has a five-vowel system: /i, e, a, o, u/, short and long, plus /ə/ and /ə:/, which occur only in Marathi loans. These non-low achromatics are sometimes lowered to [ɑ] and [ɑ:], respectively (Emeneau 1955:7). (Kolami ə = ʌ, as used here.)

(3.5d) Elsewhere in loan phonology, [ɑ] is a common substitute for [ʌ]. Japanese, for example, has /mafu/ muff, /rɑNtʻi/ lunch, etc. (Lovins 1974:241).

(3.5e) I have also observed the substitution of [ɑ] for [ʌ] in foreign-accented English--for example, in a Greek speaker's pronunciations of lucky as [lɑkɪ], mother as [mɑðr̩], while chromatic vowels were unaffected by Lowering.

3.2.1.2. ! Lax.

The condition ! -tense on the Lowering process means that, just as achromatic vowels are more susceptible to Lowering than chromatics, so weakly chromatic vowels are more susceptible to Lowering than strongly chromatic or tense ones. Thus lax vowels may lower with no implications for their tense counterparts, but if a tense vowel lowers, the corresponding lax vowel must also lower.

(3. a) In Sacapultec, a dialect of Quiché, for example, lax vowels are optionally lowered: ɸ'i? ~ ɸ'e? 'dog', uɸ ~ oɸ 'good', teleb ~ talab 'shoulder', kox ~ kax 'lion, cougar' (Campbell 1977:16ff.)

(3. b) In Eastern Ojibwa, short /ɪ/ and /o/ (usually [ɪ] and [ʊ]) are lowered (and the latter unrounded) to [ɛ] and [ʌ] in final position, as in enini 'man', ekkito 'he says so'. Long /ɪ:/ and /o:/, which are tense, do not lower Bloomfield 1956:4ff).

(3. c) In the current American speech of Detroit, Buffalo, and Chicago, Labov et al. find examples of systematic lowering of lax--but not tense--palatal vowels, where [ɪ] becomes a mid vowel and [ɛ] a low vowel. (Although Labov

et al. do not mention lowering of the achromatic vowel [ʌ], their acoustical vowel diagrams (esp. Fig. 23) strongly suggest that it is lowered also.) (1972:121ff.).

(3.6d) Lowering may also affect lax vowels in children's speech: Sylvia Major pronounced words like bit and foot as [bɪt] ~ [bɛt] ~ [bɛ̝̈t] and [fʊt] ~ [fɔ̝̈t] (Major 1976:34). (The pronunciations with [ë̝] were especially emphatic and long; lax vowels often develop a schwa-like offglide when they are lengthened (cf. Sec. 4.4.1).)

(3.6e) Only lax--and not tense--vowels were affected in the General Romance change whereby Latin lax (formerly short) i and u were lowered (and then tensed) to merge with tense (formerly long) e and o. Thus Cl. Lat. verus > Italian vero, mĭnus > meno, hora > ora, mŭltum > molto (Grandgent 1933:22).

(3.6f) Lax-vowel lowering also occurred as part of the change that Anglists call 'open-syllable lengthening'. In early 13th-century English, the lax (formerly short) vowels e and o, when lengthened by position in open syllables, lowered, ultimately merging with ē̞ and ō̞. Thus OE mete > mē̞te 'meat', nosu > nō̞se 'nose', etc. (Though a lengthened, merging with ā where ā had not been labialized (2.17a), ā could not, of course, lower.)

Later in the 13th century--and in more southerly areas, only in the 14th--i and u were also lengthened and lowered, ultimately merging with ē̝ and ō̝. Thus gif, gē̝ves; mękil, mikelness; wood(e) < wudu (Jordan 1974:47ff.).

Just as plain or achromatic lowering does not imply lowering of chromatics, so the lowering of lax vowels has no implication for tense vowels. Clear examples of lowering of tense vowels are hard to find. Their absence could represent an absolute restriction, but, since there are cases where both short and long vowels lower and their tenseness is indeterminate, it seems more justifiable to claim only an implicational restriction and say that if a tense vowel lowers, then its lax counterpart lowers, too.

The parallel behavior of lax and achromatic vowels with respect to Lowering supports the notion that laxness is attenuated color and tenseness is augmented color.

Although both palatal and labial lax vowels are lowered in most of the examples cited above, it is not always true that Lowering affects vowels of both colors equally:

(3.6g) In Dagur, for example, Altaic *u has become o (Poppe 1955:31). Cf. also (3.6c) above and (3.7c) below.

3.2.1.3. ! Mixed.

The lowering of bichromatic vowels while pure-colored vowels retain their height is only rarely attested, but it is nevertheless consistent with the attenuated color of these vowels:

(3.6h) In Kentish and other southern dialects of English, y̆ and ȳ unrounded to ĕ and ē during the Old English period (Wright 1928:49,57); both had apparently lowered before unrounding (or lowered simultaneously with unrounding) since they merged with the short and long mid rather than the short and long high vowels.

3.2.1.4. ! Long

Long vowels--of whatever quality--are more susceptible to Lowering than their short counterparts: i.e., a long vowel may lower while its short counterpart remains unchanged; but if a short vowel lowers, its long counterpart must lower too, other things being equal. In the Middle English 'open syllable lengthening' (3.6f), for example, it was the lengthened lax vowels, not their short counterparts, that lowered: thus we have wēkes but wic (< OE wicu 'week'), and wōdes but wud (< OE wudu 'wood'). There are many other examples:

(3.7a) In some dialects of Icelandic, Einarsson (1945:11) notes a similar tendency to lower lengthened i [ɪ:] and u [ʏ:] to e [ɛ:] and o [ɔ̈:] synchronically. (Modern Icelandic has no [ʊ:].)

(3.7b) In West Greenlandic Eskimo, long vowels are lowered, so that i, u alternate with e:, o: (Pyle 1970:133),

(3.7c) and in Alaskan Eskimo, /u/ becomes [ɔ:] when stressed and long in final syllables: /kuɬtsú́uq/ 'little creek' → [kuɬtʃɔ:q]; /uqxsú́u/ 'his hat' → [uqxsɔ́:] (Mattina 1970: 38ff.).

(3.7d) In Yokuts, vowels lower when lengthened, so that [ɪ] and [ʊ] alternate with [ɛ:] and [ɔ:] (Kuroda 1967:11; according to G. Lee, these vowels are lax).

(3.7e) Such a lowering of long high vowels is also suggested by the Pashto vowel system, since its short chromatic vowels are /i/ and /u/ and its long chromatic vowels are /e:/ and /o:/ (Shafeev 1964:34).

(3.7f) Lowering also selects the long vowel in Delaware, where short /ɛ/ is lowered when lengthened, so that [ɛ] alternates with long [æ:] (Voegelin 1946:136).

(3.7g) Similarly, Proto-Central Algonquian *e: has historically become [æ:] in Menomini, while its short counterpart *e has lowered only irregularly in that language (Bloomfield 1946:86).

(3.7h) Proto-Mayan **/ə:/ underwent a historical lowering whereby it merged with **/ɑ:/ as Proto-Quichean */ɑ:/. Short **/ə/ did not lower; in fact, short **/ɑ/ appears to have been raised (Campbell 1977:72).

(3.7i) Proto-Indo-European *ē and *ō became /ɑ:/ in Sanskrit, while *e and *o became /ɑ/ ([ʌ]). It may be, of course, that *ē and *ō became *[ʌ:], and that this vowel became [ɑ:], but it is nevertheless true that the long vowels, chromatic or achromatic, lowered while the corresponding short ones did not (Burrow 1965, §20; cf. Allen 1953:58).

There are some apparent counter-examples to the ! +long constraint on Lowering--some cases where the short vowels seem to lower and the long vowels stay:

(3.8a) The lowering of Latin ĭ and ŭ to merge with ē and ō as e, o in Vulgar Latin is one example--cf.(3.6e).

(3.8b) The lowering of stressed short vowels in Chinautla (a dialect of Pokoman, a Quichean language) is another; here uk' 'louse' > ok', pĭš 'tomato' > pĕs, isoq 'woman' > isaq, etc. (Campbell 1977:22).

But Campbell says that the Pokoman short vowels that lower in Chinautla are lax, and Allen (1970:47-50) argues from Latin spellings and contemporary descriptions that the long and short Latin vowels differed in quality (and at least partly in degree of aperture), and suggests that ĭ, ŭ differed from i, u as lax versus tense. Thus, in both Latin and Chinautla--and as we would presumably find in other such cases--the short vowels which lowered were lax, and the lowerings may thus be based on laxness rather than on length.

Here the question may arise of whether these claims about the implicational conditions on Lowering are verifiable. Since long vowels often are (or become) tense, and length and tenseness have different effects on the susceptibility of vowels to Lowering (and to other processes), the claim could be made that I am calling a single feature 'length' when it conditions Lowering and 'tenseness' when it does not (or when it conditions Raising, as I will claim that tenseness does).

Although this kind of question may seem to cast some doubt on certain historical examples, it does not really represent a problem with synchronic data, since tenseness and length are observably different properties--one a matter of quality, the other a matter of quantity--in speech. And in the directly observable cases (e.g. (3.6a-d), (3.7a-d,f),

and others to follow), length and laxness do favor Lowering, and tenseness inhibits Lowering and favors Raising.

It seems altogether reasonable to me to extrapolate from such observations to historical cases like that of Latin, and various kinds of evidence support this step. The modern reflexes of old short vowels may be lax and those of old long vowels tense. Or the patterns of subsequent diphthongization may suggest that an earlier tense/lax distinction arose from a long/short distinction, since tense vowels often seem to become 'tensing', 'up-gliding', or 'out-gliding' diphthongs ([i:] → [ɪi̯] or [ei̯] or [ɨi̯]), and lax vowels often become 'down-gliding' or 'in-gliding' diphthongs ([ɪ:] → [ɪɛ̯] or [ɪɨ̯]). Or there may be evidence of the sorts of timing changes that characteristically accompany--or may even be said to cause--shifts from a length to a tenseness distinction. (These timing changes and diphthongization patterns will be discussed in Chapter IV.)

3.2.1.5. Dissimilative Lowering.

In the cases cited above, Lowering applies as a context-free fortition process, conditioned only by accent, length, and the qualities of the affected segments themselves--not by segmental environment. Certain segmental environments, however, do affect the application of Lowering; this fortition process, which is especially applicable to achromatic, long, or lax vowels, is especially applicable when such vowels appear adjacent to vowels that are chromatic, non-syllabic (and thus short), and tense. In brief, Lowering is especially applicable if it applies as a dissimilation.

(3.9a) Children may lower vowels dissimilatively. Sylvia Major lowered the nuclei of English /i/ and /u/--diphthongs in many American dialects--to [ɛ] and [ɔ], so that me was [mɪi̯] ~ [mɛi̯], and boot was [bʊu̯t] ~ [bɔut]. It's great! was occasionally, in exaggerated speech, [ɪts gra̯ɨt], showing lowering of the syllabic of the /e/ diphthong as well (Major 1976:33).

(3.9b) Elizabeth Stampe lowered [ʌ] to [ɑ] when it occurred adjacent to [ɪ]; (peanut) butter, usually [bʌdɪ] or [bʌrɪ], underwent Flap Deletion for a time and was sometimes pronounced [bɑɪ] (~[bʌɪ]). Elizabeth also lowered [ʌ] to [ɑ] before [u̯] under emphasis, as in no! [nʌu̯] ~ [nɑu̯].

Elizabeth ordinarily lowered only the plain vowel [ʌ] before a chromatic vowel or glide, while Sylvia lowered chromatics before chromatic glides of the same color. Both children's lowerings were especially likely to occur under strongly emphatic or emotive conditions.

Examples of dissimilative Lowering abound in historical phonology:

(3.9c) Sommerfelt notes that '/eɪ/, which has been monophthongized in many eastern Norwegian dialects, has been differentiated into /aɪ/ in several dialects of a more archaic type in the mountain valleys and the west' (1968: 499).

(3.9d) The syllabics of diphthongized ī and ū lowered in the English vowel shift, to become ultimately the [ɑ]'s of modern English [ɑɐ̯] and [ɑo̯]: thus mīs [mi:s] → [mɪ̝s] became [mɑ̝s], now ordinarily [mɑɐ̯s]; and mūs became [mɑʊ̯s], now, in many dialects in the U.S., [mɑo̯s] or [mæo̯s].

(3.9e) A dissimilative lowering of syllabics before non-syllabics of the same color has also occurred in the Swiss-German dialect, Züritüütsch (Keller 1961:42). In hiatus, and when compensatorily lengthened by the loss of n before a fricative, Züritüütsch has:
[eɪ̯] from MHG ī, in frei 'free', feischter 'dark';
[oʊ̯] from MHG ū, in troue 'trust';
[øɪ̯] from MHG iu [y:], in nöi 'new', föif 'five';
[æɪ̯] from MHG ei, in Stäi 'stone', räise 'travel';
[æʊ̯] from MHG ou, in Äug 'eye', au 'also';
[œɪ̯] from MHG öü [øʏ], in Frœid 'joy', Bœim 'trees',
in Keller's transcriptions.
The high syllabic of each diphthong arising from a MHG high vowel has been lowered one degree to mid; and the mid syllabics of the MHG diphthongs have been lowered one degree to low (and delabialized and palatalized in the case of ou > [æʊ̯]. Since ī and ei, ū and ou, iu and öü have not merged in this dialect, we must assume that either the mid-vowel lowerings were first, or the mid and high syllabics lowered simultaneously.

(3.9f) Similar lowerings occurred in Standard German, but here the diphthongizing MHG high vowels ī, ū, iu merged with the MHG diphthongs ei, ou, öu (eu)--with the syllabics of ī, ū undergoing Lowering twice (cf. English ī and ū (3.9d)):
MHG ī, ei > StdG [ɑɪ̯], in Eis 'ice', Geist 'ghost',
MHG ū, ou > [ɑʊ̯], in Haus 'house', Baum 'tree',
MHG iu, öü/eu > [ɔɪ̯], in deutsch 'German', Bäume 'trees' (Wright 1907:58-62).

Although there are many more examples of such lowerings in German dialects, dissimilative Lowering is by no means limited to Germanic languages.

(3.9g) In Cham, a Malayo-Polynesian language, /ə/ becomes [ɑ] before /w/ or /ɟ/: /pəṭəw/ → [pəṭɑw] 'stone' (David Blood 1967, cited in Dyen 1971:204). This synchronic process continues an earlier change which also involved dissimilative Lowering: Proto-Malayo-Polynesian *u and *i, when compensatorily lengthened by loss of a following word-final *h, became in Cham /ew/ and /eɟ/: *batuh > /pəṭêw/ 'stone', *bəlih > /pieɟ/ 'buy' (Doris Blood 1962, cited in Dyen 1971:207). (/ə/ = my /ʌ/.)

(3.9h) In Sinhalese, the achromatic vowel /ʌ/ is morphophonemically lowered to /ɑ/ before any other vowel--e.g. /hondʌ/ 'good', /hondɑ/ 'it is good' (Coates and deSilva 1960: 173).

(3.9i) In Breton, vowels are lowered synchronically before long (perhaps the requirement is tautosyllabic) like-colored glides: /kɨ: + es/ → [keɟ:ɛs] 'dogs'; [go:] 'mole', but [gɒw:əṭ] 'moles'; [Row:ə] 'king', cf. [Ruɞ:nəs] 'kings' (Dressler and Hufgard 1975:171).

(3.9j) Further synchronic Lowerings before like-colored glides include Cockney English, where [ɛi̯] varies with [ɑi̯] in words like make (Sivertsen 1960:56-7), with the initial element closer in unstressed and non-final positions: day by day [dɛi̯ bɑi̯ da:i̯],

(3.9k) and the American dialect of McCaysville, Georgia, whose speakers I have observed to lower palatal vowels before palatal non-syllabics: we [wɛi̯], meat [mɛi̯ṭ], stay [stɑi̯], etc.

(3.9L) In a more-general application of Lowering, all vowels are lowered before like-colored glides in the diphthongizations in the Malmö dialect of Swedish (Bruce 1970: 8ff.). The first 'half' of each 'long' vowel is lowered one degree, while the second, non-syllabic half retains its height. In Bruce's transcriptions:

/ɪ:/ → [e͡ɪ] /ʏ:/ → [ø͡ʏ] /ʉ:/ → [o͡ʉ]
/e:/ → [ɛ͡e] /ɯ:/ → [ɤ͡ɯ] /o:/ → [ɛ͡o]
/ɛ:/ → [æ͡ɛ] /ø:/ → [œ͡ø] /ɑ:/ → [æ͡ɑ], [æ͡o].

As these transcriptions suggest, Bruce regards the e/ɛ difference as one of height--and indeed /ɛ:/ does undergo a change which affects, for the most part, tense (formerly long) vowels. The back vowels undergo other changes in addition to Lowering; their syllabics delabialize and palatalize as well. The /ɑ:/ vowel seems to retain more labiality than the [æɑ] transcription suggests, to judge from Bruce's spectrographic data; and, Bruce notes that it is traditionally described as [ɑu̯]--

though this is surely an exaggeration. But a change of [ɑu̯] to [ɑo̯], [æo̯], [æo̯] or [æø̯] is certainly possible--cf. [hɑo̯s] 'house in U.S.English → [hɑø̯s], [hæø̯s] in some southern dialects.

Similar synchronic lowerings of one or more vowels occur in Old Prussian (Schmalstieg 1964:216ff.), Colloquial Czech (Kučera 1955: 579ff.), Fox (Jones 1911:746), Boston schoolchildren's English (Andersen 1972:24), and in many languages.

The languages and dialects cited thus far show dissimilative Lowering of the first, or syllabic, moras of diphthongs. In other cases, however, it may be the second mora which lowers and the first which retains its height.

(3.10a) Certain Icelandic dialects have a process which lowers the second mora of lengthened lax vowels:
i [ɪ:] → [ɪɛ:] u [ʏ:] → [ʏö:]
e [ɛ:] → [ɛæ:] ö [ö:] → [öö:] o [ɔ:] → [ɔø̯]
(Einarsson 1949:11 (his transcriptions)).

(3.10b) In a dialect of southern Lappish, a similar process also applies: ii → ie, uu → uo, üü → üö,
ee → eä, oo → oa (McCawley 1971:8).

Lowering of the second, non-syllabic half of a VV̯ diphthong is apparently less common than Lowering of the first or syllabic half. However, if syllabicity is shifted to the second element, that vowel often undergoes Lowering. A number of examples of such 'syllabicity shifts', with and without Lowering, will be discussed in Chapter IV (Sec. 4.3.2), so I will give only a brief example here:

(3.11) French oi (< ei < ę) and oi (< ui) fell together in the 13th century as ue or we [ue̯], so that, for example, envoit rhymed with ait (Pope 1934, 519). This [ue̯] has become [wa] in Modern French.

3.2.1.6. The function of Lowering.

The function of Lowering is to make vowels more sonorant. By decreasing height, Lowering increases intrinsic intensity and thus increases audibility (given a constant degree of articulatory effort). Lowering thus increases the suitability of a vowel for its functions as syllable nucleus, as principal locus of intonational or accent-associated pitch, etc.

In reviewing the implicational hierarchies which constrain the application of Lowering, we note that the 'rich-get-richer' principle (cf. Sec. 3.1.1.4) seems to apply here also. Other things being equal, the more sonorant (and less chromatic) of two vowels is the more apt to increase sonority by Lowering. Since achromatic vowels are relatively

sonorant, and since they have no color to lose and no other salient property to increase, they are particularly favored in Lowering. Lax vowels, more sonorant and less chromatic than their tense counterparts, are correspondingly more susceptible to Lowering.

The particular susceptibility of more-sonorant, less-chromatic vowels to Lowering suggests that an ! lower implicational condition on Lowering is to be expected--i.e. that lowering of mid vowels may occur without lowering of high vowels, but that the lowering of high vowels should imply lowering of their mid counterparts--but I cannot substantiate such a condition at this time.

Long vowels are more susceptible to Lowering than their short counterparts because the greater intrinsic length of lower vowels can apparently be more satisfactorily realized in long vowels, which are highly sustainable (cf. Lehiste 1970:36), than in short vowels, which have more strictly limited duration. Dissimilative Lowering results in the polarization of sonority and color: a segment is particularly susceptible to Lowering, which entails some loss of labiality or palatality, when the labial or palatal quality is preserved in an adjacent segment.

3.2.2. Raising.

Raising increases vowel height by one degree:

$$\begin{bmatrix} V \\ n\ high \\ +chromatic \\ !\ +tense \\ !\ lower \\ !\ /\begin{bmatrix} V \\ -chromatic \\ -tense \end{bmatrix} \end{bmatrix} \rightarrow [n + 1\ high]$$

3.2.2.1. +Chromatic

The fortition process of Raising appears to affect only palatal, labial, and labiopalatal vowels, not plain ones. This restriction seems to be absolute rather than relative: various lenitions, like vowel reduction and vowel harmony, may raise achromatic vowels, but context-free raisings like [ɑ] → [ʌ] in accented syllables only (where fortitions are most favored) do not seem to occur.

Childres's substitutions often illustrate this:

(3.12a) Joan Velten raised the mid chromatics [e, ɛ] to [i, ɪ] and [o, ɔ] to [u, ʊ] through her 42nd month, all the while lowering the mid plain [ʌ] to [ɑ] (Velten 1943:87f).

In the vowel shifts that involve Raising, it is, again, only the chromatic vowels that are raised.

(3.12b) In the English vowel shift, for example, (early stage): $\bar{e}_{\downarrow}$ → [i:]: teeth, sleep, and $\bar{o}_{\downarrow}$ → [u:]: shoe, tooth, $\bar{e}_{\downarrow}$ → [e:]; leave, heat, and $\bar{o}_{\downarrow}$ → [o:]; stone, road (< $\bar{a}$), but $\bar{a}$ (< lengthened $\breve{a}$), as in tale, make, was not raised to [ʌ:]. This $\bar{a}$ was ultimately raised, but only after it had acquired a palatal color. (Cf. Luick 1964:554ff.)

(3.12c) Correspondingly, in Scots dialects where OE $\bar{a}$ had not been labialized to $\bar{o}_{\downarrow}$, $\bar{a}$ was not raised, as it was in the southern dialects where it had been labialized (3.12b) (Wright 1928:28).

(3.12d) In American dialects which raise the syllabics of the diphthongs that arise from lengthened /æ/ as in mad and /ɔ/ as in law ([æə̯] → [ɐə̯], [ɔə̯] → [oə̯]), the /ɑ/ of god, rod, etc. is never raised to [ʌ]. (Cf. Labov et al. 1972: 47ff. et passim).

Raising does not always affect all chromatic vowels, however. (In some dialects, the raising noted in (3.12d) affects only the palatal vowel.) Raising may be limited to palatals only or to labials only:

(3.13a) In a later stage of the English vowel shift, [æ:] (from lengthened a) as in place, mate became [e:]; and [e:] (from raised $\bar{e}_{\downarrow}$ (3.12b) as in sea, leave was--at first only optionally and dialectally--raised to [i:], while the non-palatal vowels remained.

(3.13b) In Old Gutnish, palatals and labiopalatals were raised one degree: OG veria, OSwed. værja 'to defend, support'; OG lengr, OSwed. længr 'longer'; OG mēla, OIce. mǽla 'to speak'; OG nētr, OIce. nætr 'nights'; OG sīa, OSwed. sēa, ODan. sē 'to see'; OG yx, OIce. øx 'axe'; OG brȳþr, OIce. brøþr 'brothers' (Noreen 1913:sec. 140-141, 149-150).

(3.13c) In São Miguel Portuguese, only the labial vowels are raised: [ɔ] > [o] in agora, carrossa, etc., and [o] > [u] in povo, arroz, etc. São Miguel [ɑ] is labialized to [ɔ]--not raised to [ʌ]; palatal vowels are not affected (Rogers 1948:13ff).

(3.13d) And in the South Biguden dialect of Breton (Cornouaillais dialect), the stressed long (and tense) palatal $\bar{e}$ and labial $\bar{o}$ become $\bar{I}$ and $\bar{u}$ (in certain environments), but the labiopalatal $\bar{ø}$ remains mid: [kwi:n] 'supper', elsewhere [kwe:n]; [mu:ni] 'money', literary moneiz (Dressler and Hufgard 1977).

3.2.2.2. ! Tense.

Almost all the examples of Raising cited in 3.12 and 3.13 above apply only to tense vowels. Judging from their modern reflexes, the vowels which underwent Raising in the historical examples were almost certainly tense, and those which failed to undergo it almost certainly lax. And in the contemporary examples, e.g. the American raising of low chromatic vowels (3.12d) or the Breton dialectal raising of pure chromatic vowels (3.13d), the input vowels in dialects or contexts where raising occurs are observably tense. Only in Joan Velten's child speech (3.12a) does it become clear that lax vowels can also be raised, and here, of course, the corresponding tense vowels are raised as well. Thus Raising clearly exhibits the implicational hierarchy ! Tense.

The parallel effects of color and tenseness are thus evident in Raising as well as in Lowering: only chromatic vowels are raised, and of these, those with intense color are more susceptible to Raising than those with weak color.

Discussions of vowel shifts, particularly those of English and other Germanic languages, ordinarily refer to the raising of 'long' vowels. But on close examination, it seems clear that the raising of long vowels may occur without raising of the corresponding short vowels only when the long vowels are tense in distinction to the short vowels. The raising is dependent not on length, therefore, but on tenseness. Tenseness is often superimposed on length, especially (according to a pattern of development to be discussed in Chapter IV) when timing changes threaten the preservation of a vowel quantity opposition in a language. Therefore it is not surprising that in historical examples the distinct roles of length and tenseness should have been confused.

3.2.2.3. ! Lower.

It appears that lower vowels are especially susceptible to Raising. The raising of English ē (ɛ: from lengthened a) while ē (e:) optionally remained (3.13a); the raising of Old Gutnish æ generally while e was raised only before vowels (3.13b); and the raising of English ɔ as in dog, Br. yacht to o in Japanese borrowings--doggu, yotto (Lovins 1974:241) all suggest that low vowels can be raised in the absence of mid vowel raising. I know of no context-free examples of mid-vowel raising where low vowels in the system are not also raised.

The rarity of vowel systems with /i/ and /æ/ but no /e/, or with /u/ and /ɔ/ but no /o/, also argues against the possibility of raising /e/ or /o/ without raising /æ/ or /ɔ/ as well.

There are, however, examples of dissimilative raising of mid vowels without dissimilative raising of the corresponding lower vowels,

which cast some doubt on the ! lower condition, so that its status is less firmly established than that of most other hierarchies cited here.

3.2.2.3. Dissimilative Raising.

Like Lowering, Raising often applies dissimilatively; a vowel is especially susceptible to Raising when it precedes or follows another vowel. Thus the 'halves' of a long vowel (cf. Sec. 2.3.5) are particularly susceptible to Raising. Either of the two vocalic components of a long vowel may be raised. When the vowel which acts as the first time unit(mora) of a long vowel is raised, that is 'first-mora raising':

(3.14a) Such raising occurred in Finnish, where in initial (i.e. accented) syllables, *ee > ie, *oo > uo, *öö > üö : *veeras > vieras 'stranger', *soomen töömees > Suomen työmies 'the Finnish worker', etc. (Hakulinen 1961:21ff). This raising is extended in some Eastern Finnish dialects to ää (> eä) and, with labialization, to aa (> oa) (McCawley 1971:8; and pers. comm. Leena Hazelkorn).

(3.14b) First-mora raising also appears in the history of French, where Vulgar Latin e̯ and o̯ in accented open syllables (i.e. when lengthened) became Old French ie and ue ([ɛɛ̯] → [iɛ̯]; [ɔɔ̯] → [uɔ̯] → [uə̯] → [uɛ̯]): pĕdĕm > pe̯:de > pieθ; sŏrŏr > so̯:ror > suor > suer (Pope 1934:103ff.).
The vowels of accented open syllables in Spanish and in central Italian dialects also underwent this change.

(3.14c) The Finca Valparaiso dialect of Pokomchí, Quichean language, has a first-mora raising, too: e: > ie, and o: > uo : te:w > tiew 'wind', me:ɣ > mieɣ 'eyebrow', k'o:x > k'uox 'mask', po:m > puom 'copal/incense'(Campbell 1977: 23).

(3.14d) The raising of Pre-Old High German *ē² and *ō to OHG ie and uo (Rauch 1967:89-91) also appears to have been a matter of first-mora raising. (The widespread spellings ea, ia for ie,and oa, ua for uo suggest an intermediate stage in their development in which the second mora was lax or achromatic--cf.(3.14b).)

There are also many examples of the raising of the second mora of a long vowel:

(3.15a) In English, the tense mid vowels have undergone dissimilative raising: /e:/ → [eɪ̯] (→ [ɛɪ̯]); /o:/ → [oʊ̯] (→ [ɔʊ̯]). In some southern U.S. dialects--e.g. in Smoky Mountains speech--this diphthongization is extended to /æ/ and /ʊ/, which become [æə̯] or [ɛə̯] and [ʊo̯] or [ɑo̯], at least, in lengthening environments. Thus calf [kæə̯f],

moths [moǫz] diphthongize in parallel with way [weɪ̯], no [noʊ̯] (cf. Hall 1942:22f., 31f.).

(3.15b) In Old French, the tense mid vowels e̯ and o̯ were diphthongized (when lengthened in open syllables or in monosyllabic words) by raising of the second mora:

e̯: > eɪ̯ (> ʌi > oi)	mẽ > me̯: > mei (> moi)	'me'
	bĭbĭt > be̯:bet > beit (> boit)	'drinks'
o̯: > oʊ̯ (> ʌu > eu)	sōlum > so̯:lu > soul (> seul)	'alone'
	gŭla > go̯:la > goule (> geule)	'throat'

(Pope 1934:103ff.)

In the above examples, an adjacent identical vowel increases a vowel's susceptibility to Raising (the short counterparts of these long or lengthened vowels are not raised), but vowels appear to be even more susceptible to Raising when the adjacent vowel is achromatic.

(3.16) In many urban U.S. dialects, for example, the vowels /æ/ and /ɒ/ are raised, as documented by Labov, Yaeger, and Steiner (1972:179-80 et passim), who propose that the schwa-like 'in-glides' associated with the raised variants develop after the raising. But no examples of raising without 'in-gliding' are offered, and there are many American dialects (apparently unnoticed by Labov et al.) in which the lax vowels in general are followed by such in-glides, without raising or tensing of the syllabics: e.g. bid [bɪɻ̯d], bed [bɛə̯d], good [gʊɻ̯d], etc. We may conclude then, that these raising dialects develop inglides after low or lax vowels (i.e. after vowels of relatively weak color) just as many non-raising dialects do, and that the syllabics of these in-gliding diphthongs are then tensed and raised, increasing their color in dissimilation to their achromatic off-glides. (Cf. the dissimilative tensing of (3.4a) in other U.S. dialects, and that of (3.4b).)

3.2.2.4. The function of Raising.

As the function of Lowering is the increase of sonority, so the function of Raising is the increase of palatal or labial color. This is why achromatic vowels do not undergo Raising--they have no color for this fortition to increase.

The functions of Raising and Lowering are displayed most clearly when the two processes interact in diphthongizations, which are very often step-by-step polarizations of sonority and color (cf. Stampe 1972). When these two incompatible properties appear in sequence, each may be increased to a degree impossible to attain when they are simultaneous: when [o:], with simultaneous intermediate degrees of sonority and color, becomes [oɣ̯], both sonority and labiality are increased. In diphthongizations of this sort, one half of the vowel becomes the

color-bearing element, and the other half becomes the sonority-bearing element. Subsequent changes may lower the sonority element and/or raise the color element. The segment which is lowered--the sonority 'pole' of the polarization--often loses its color entirely; but the element that is raised--the color 'pole'--always keeps its color. In the color-sonority polarizations governed by Raising and Lowering, vowels are raised to increase their color, then, and lowered to increase their sonority.

3.2.3. Degrees of vowel height.

The phonological evidence from Raising and Lowering favors a scalar feature for vowel height rather than a combination of binary features. There are many instances in which vowels of two different heights are each raised (or lowered) one degree--e.g. low → mid, and mid → high. To claim that height is specified by two binary features, like [±Low, ±High], or [±Constricted Pharynx, ±Open], would be to claim that the raising of low vowels to mid and the raising of mid vowels to high are two different processes (and that Lowering consists of two separate processes as well).

There is some evidence that application of mid-to-high raising implies the application of low-to-mid raising; if the two raisings were separate processes, this would mean that the two processes were related implicationally. There do not seem to be any other such inter-process implicational relationships.

The implicational conditions ! lower and ! higher even more clearly suggest a scalar height feature. These conditions apply not only to Laxing and Tensing, respectively, but also to Bleaching (Sec. 3.3) and Coloring (Sec. 3.4) and to other processes, like vowel nasalization and consonant palatalization as well (cf. Chen 1972, Neeld 1973, Schourup 1973).

It might be suggested that a hierarchy like ! lower could in fact consist of two hierarchies, ! +low and ! -high, which would be the same in effect as the scalar hierarchy, while ! +high and ! -low would have the same effect as ! higher. But the absence of any processes with the specification ! -high, ! -low (i.e. ! mid) is further indication that the scalar conditions are better representative of the phonological situation.

The evidence for a maximum number of degrees of vowel height, however, is not so clear. In categorizing vowels as high, mid, and low, I have assumed a maximum of three heights, and I have attributed the e/ɛ difference, for example, to tenseness rather than to height. However, I do not know of any a priori reasons to believe that there cannot ever be languages with four vowel heights, and there is some evidence--like the diphthongizations of Malmö Swedish (3.14L) to suggest that the e/ɛ difference may be interpreted as a height

difference, i.e. that there can be four heights in one vowel series, like [ɪ, e, ɛ, æ]. While allowing for this possibility, I wish to note that the bulk of the evidence suggests a three-height limit. There are possible critical cases, like Marshallese (Bender 1971) and Car Nicobarese (Critchfield 1966), which are reported to have four achromatic vowels--and thus, four-height systems with no involvement, by definition, of tenseness. These languages deserve further phonetic and phonological study in this regard, as does the entire question of degrees of vowel height.

3.3. Bleaching and Coloring.

Bleaching and Coloring are the processes that remove and add color--palatality or labiality--directly, without changing vowel height. They are functionally parallel to Laxing and Tensing, respectively, and they consequently share with Laxing and Tensing many of their implicational hierarchies of applicability.

3.3.1. Bleaching.

Bleaching eliminates either labiality or palatality, and may thus be represented:

$$\begin{bmatrix} V \\ !\ \text{lower} \\ !\ \text{-tense} \\ !\ \text{mixed} \\ !\ /\begin{bmatrix} V \\ \text{+labial} \end{bmatrix} \end{bmatrix} \rightarrow [\text{-labial}] \qquad \begin{bmatrix} V \\ !\ \text{lower} \\ !\ \text{-tense} \\ !\ \text{mixed} \\ !\ /\begin{bmatrix} V \\ \text{+palatal} \end{bmatrix} \end{bmatrix} \rightarrow [\text{-palatal}]$$

In fact, Bleaching appears to consist of two subprocesses, delabialization and depalatalization. Each may apply independently, and there is no implicational relationship between them: delabialization does not imply depalatalization, and depalatalization, though it seems to be the rarer of the pair, does not imply delabialization.

Delabialization and depalatalization have similar effects, share identical hierarchies of applicability, and frequently co-occur, but their effects, while similar, are not identical, and their co-occurrent applications are sometimes differently constrained (e.g, delabialization may affect all vowels while depalatalization affects only non-high vowels). It seems best, then, to regard the two as independent subprocesses belonging to a single class.

The unity of the class is confirmed by the merger of Middle Welsh /ʏ/ with /ɨ/ (Morris Jones 1913:13-4):

(3.17) When /y/ > /ɨ/, both /i/ and /u/ also existed in Welsh. Since no merger with either /i/ or /u/ occurred, /y/'s loss of labiality must have been simultaneous with its loss of palatality.

This is a highly unusual example, since it represents a phonological change (substitution) which requires that two features be changed at once. Most phonological substitutions--even those like [ɑ] → [e], which appear to change two features--can be interpreted as orthogonal, changing single features, rather than diagonal (cf. Donegan and Stampe 1978a). For example:

	+palatal		-palatal
-low	e	←	ʌ
	↑		↑
+low	æ	←	ɑ

represents the ordinary course of such changes, but in Welsh,

	+palatal	-palatal
-labial	i	ɨ
+labial	y	u

.

The peculiarity of this Welsh change is to some extent alleviated if we regard the two simultaneously-actuated feature changes as arising in related processes. The relative rarity of such a substitution as [y] → [ɨ], in spite of the acoustic similarity of the two sounds involved, corresponds to the rarity of such simultaneous actuation of independent processes in historical change. (For a discussion of simultaneous application of processes synchronically, see Donegan and Stampe 1978a.)

When I refer to Bleaching, then, I will be referring to one (or more) of a small set of processes, comprising delabialization and depalatalization--and perhaps also delateralization, de-rhotacization, etc. Here I will deal only with the first two--I only wish to suggest that a broader understanding of the term is possible.

Full-scale context-free application of Bleaching--both depalatalization and delabialization--like full-scale application of any fortition process, occurs relatively rarely in adult languages, but it does appear to constrain the phoneme inventories of certain Northwest Caucasian languages, where /ɨ, ʌ, ɑ/ systems are reported for Adyghe and Kabardian and /ɨ, ɑ/ for Abkhaz, Abaza, and Ubykh (Catford 1977: 294), and also the inventories of Higi (Mohrlang 1971) and Gude (Hoskison 1974), which may be analyzed as having only /ɨ, ʌ, ɑ/. Total application may be less rare in children's speech. Bleaching applies in the early speech of children who pronounce all vowels as [ɑ] (cf. Jakobson 1968:47); and D.K. Oller (1972, ms.) reports a child named Curt whose only vowels were [ɨ] and [ɑ].

Although many of the clearest examples of Bleaching and the conditions which constrain its possible applications appear in context-sensitive dissimilations, the conditions can all be confirmed from its context-free application. Bleaching, of course, affects only palatal or labial vowels; plain vowels have no color to bleach.

3.3.1.1. ! Lower.

The lower a vowel is, the more susceptible it is to Bleaching; if a higher vowel is delabialized or depalatalized, the corresponding lower vowel(s) are delabialized or depalatalized also.

(3.18a) The Sanskrit merger of Indo-European *e and *o with *a (Burrow 1965:103ff.) is an instance of bleaching of mid vowels. Sanskrit ă was [ʌ]; thus *e, *o > [ʌ] (Allen 1953:58). The Indo-European high vowels *i and *u did not undergo this bleaching.

(3.18b) Bleaching affected only the low palatals when Old English æ became a in the 12th century, as in appel 'apple', blak 'black', etc. (Jordan 1974:54).

(3.18c) Bleaching is limited to low (or non-high) labials in Lardil, where /u/ lowers (as does /i/) and is delabialized in word-final position: e.g. /ŋuku/ 'wife' → uninflected [ŋukɑ], beside non-future [ŋukun] (/ŋuku + n/) (Hale 1973:422, note 26).

(3.18d) The greater susceptibility of lower vowels to Bleaching may be reflected in the chronology of phonological change as well: Old English ø was delabialized to e before y was delabialized to i (Campbell 1959:77, 132). Campbell notes that both oe and e spellings for ø occur in early West Saxon, but that y is hardly ever written with i until late West Saxon.

The unrounding of /u/ to [ɨ] in Japanese (cf. Han 1962:10ff) immediately suggests itself as a counterexample to this ! lower condition, since Japanese /o/ does not delabialize. It may be that the quality of labialization provides an explanation in this case (and in possible similar cases). Bloch (1950) refers to Japanese /u/ and /o/ both as 'weakly rounded', but in observing Japanese speakers I have noticed that for some speakers, at least, pronunciations of /u/ that are labialized involve a lip opening that may be quite wide in the horizontal dimension but very narrow in the vertical dimension. That is, the /u/ may be produced with compression, while /o/ is usually produced with the lips slightly protruded (with the corners of the mouth brought in slightly). In this regard, it should be noted that /h/ → [Φ] before this /u/, suggesting that /u/ is not altogether without labiality in Japanese.

It may be that high vowels, which have a narrower vertical lip opening than their lower counterparts, are more susceptible to the substitution of compression for protrusion rounding than lower vowels, and that compression-labial vowels are more susceptible to Bleaching than are protrusion-labial (rounded) vowels.

3.3.1.2. ! Lax.

Lax vowels are more susceptible to Bleaching than their tense counterparts; there is even a possibility that the restriction of Bleaching to lax vowels may be absolute. Since tense vowels are never bleached while their lax counterparts remain chromatic ([i] → [ɨ] implies [ɪ] → [ɨ]), and since the implicational conditions on Laxing and Bleaching are parallel, an intermediate laxed stage will ordinarily be possible when tense vowels are bleached. The difficulty with this view is that it would require tense [y], if delabialized, to become [ɪ] (via [ʏ]) rather than [i] (or if depalatalized, to become [u] rather than [ɯ]). I know of no reason to believe that this occurs, so I will regard the ! lax condition as implicational, not absolute.

Some examples of bleaching of lax but not tense vowels:

(3.19a) In American English, lax /ʊ/ and /ɔ/ (< ŭ and ŏ) are lowered and delabialized to [ʌ] and [ɑ], as in but, not, etc., but tense /u/ and /o/ (< ū and ō) remain labial.

(3.19b) In Chinautla, a dialect of Pokoman, when lax (and short) stressed vowels lower, [ɔ] and [ɛ] become [ɑ], while [o:] and [e:] remain: [šɔhṭ] 'comal' > [šɑhṭ], [ɪšɔq] 'woman' > [ɪšɑq] (Campbell 1977:22). (No examples are provided for [ɛ].)

(3.19c) In Sacapultec, a dialect of Quiché, [ɛ] and [ɔ] optionally become [ɑ] when (lax) [ɪ] > [ɛ] and [ʊ] > [ɔ]: [tɛlɛb'/tɑlɑb'] 'shoulder', [kɔx/kɑx] 'lion, cougar', [k'ɛl/k'ɑl] 'chocoya (bird)' (ibid. 16f).

(3.19d) In Southern and Western Swedish, beginning in the 15th century, ĭ and ў were lowered to ĕ and ӧ: thus fesk 'fish', möcke 'much', versus Central Swedish fisk, mycke (Haugen 1976:258).

3.3.1.3. ! Mixed.

Mixed vowels--in Martinet's sense of 'mixed', i.e. labial and palatal, rather than in Sweet's less felicitous sense, central--are especially susceptible to Bleaching. If a pure-colored vowel is delabialized or depalatalized, a corresponding mixed vowel is delabialized or depalatalized as well: [i] → [ɨ] entails [y] → [u], and

[u] → [ɨ] entails [y] → [i].

In addition to the English delabialization of [y] and [ø] (3.18d), there are many other examples of delabialization of mixed vowels while the corresponding pure labials remain:

(3.20a) y (< IE *u) has become [i] in Modern Greek (probably before the 10th century), while u (< o) remains labial (Sturtevant 1940:41-7).

(3.20b) In Lithuanian Yiddish, the y and ø vowels were delabialized: MHG ü > i, as in mil 'mill', MHG ö > e, as in hernr 'horns', MHG iu [y:] > *[i:] > ai, as in haizr 'houses', MHG oe [ø:] > [e:] > ę, as in šęn 'fine' (Sapir 1915:259f.)

(3.20c) The same change occurred in the German dialects of Darmstadt: MHG ü > [ɪ], as in Glick 'luck', MHG ö > [ɛ], as in Drebbsche 'drop', MHG iu [y:] > *[i:] > [aị], as in Haiser 'houses', MHG oe [ø:] > [e:], as in schee 'beautiful' (Keller 1961:167ff.),

(3.20d) and Alsatian: (here [i:] < [y:] did not diphthongize) MHG ü > [ɪ], as in Glick 'luck', MHG ö > [ɛ], as in Lecher 'holes', MHG iu [y:] > [i:], as in Hyser 'houses', MHG oe [ø:] > [e:], as in bees 'wicked' (ibid. 125f.),

and in Upper Austrian (ibid. 209ff.) and Luxemburgish (257ff.), and in other German dialects as well.

Depalatalization of mixed vowels appears to be rarer, but there are examples:

(3.21a) Monguor ö > o and ü > u ; Monguor has bodono for Written Mongolian bödöne < *bödene 'quail', cf. Urdus bödönö, Kalmuck bödnö; Monguor uge for Written Mongolian üge 'word' (Poppe 1955:49ff.).

(3.21b) In the 'Iranized' Turkish dialects of Özbek, ö > o and ü > u, as in kŏrsatilgan 'shown' < kör-sä-t-il-gän; or tušunaman 'I am thinking (now)' < tüs-ün-ä-män (Menges 1968:80).

(3.21c) Depalatalization of [y] also occurs in the infant speech of 'Y', as described by Pupier: lune [lun] ~ [lyn], plus [pu] ~ [py] (1977:81).

Simplifications of mixed-vowel colors appear to share the same implicational hierarchies as bleaching of pure colors (! lower, !lax, etc.).

3.3.1. Dissimilative Bleaching.

Vowels are particularly susceptible to Bleaching when they appear in like-colored environments--i.e., labials are particularly susceptible to bleaching before or after labials, and palatals are particularly susceptible to depalatalization before or after palatals. Dissimilative applications of Bleaching are subject to the same implicational conditions as context-free applications:

(3.22a) Delabialization of a low vowel before a labial glide apparently occurred in certain English dialects in the development of Middle English ū to Modern English [aʊ̯]. Thomas Batchelor appears to have pronounced ME ū as [ʊ̯] (1809:55); the [ʊ] of this [ʊ̯] has since been delabialized, yielding [ɑ̯]. In other dialects, this delabialization appears to have applied while the syllabic of the diphthong was still mid, so that [ɔ̯] (<ME ū) became [ʌ̯] --and then became [ɑ̯] by Lowering (cf. Wolfe 1972).

(3.22b) In the history of Icelandic, West Scandinavian ǭ merged with ā, and their subsequent development to Modern Icelandic /au/ suggests that they merged as [ɒ:], though the spelling á was used. Merger as [ɑ:] would leave unexplained the source of the labial element in the modern diphthong. Then the low vowels of Old Icelandic diphthongized: [æ:] → [æ̯] or [æi̯],
[ɒ:] → [ɒ̯] or [ɒ̯],
and the [ɒ̯] underwent bleaching of its low syllabic (before its labial glide), becoming modern /au/ (cf. Benediktsson 1959:291-9).

(3.22c) Mid labial syllabics have unrounded before high labial glides (i.e. before [ʊ̯]) in Cockney English; and high syllabics before such glides may unround as well (Sivertsen 1960:34, 81 et passim). Jespersen notes, interestingly, that Sweet attributed pronunciations like [nʌ̯] or [nɑ̯] for no to 'the habit of speaking with a constant smile or grin' (1964:278). The low vowel [ɒ] does not occur before [ʊ̯], so the ! lower condition holds here--and is confirmed by the apparently more frequent delabialization of the mid vowel as compared with the high.

(3.22d) /ou/ and /u:/ come to have delabialized syllabics in many other British and U.S. dialects, too. Labov et al. cite New York dialects with [ʌ̯] for [ɔ̯], and the dialects of Bethnal Green in London (as in (3.22c)), Norwich, the

North Carolina Outer Banks, and Sheffield, Texas with [ʌ̯] for [ɔ̯] and [ɨ̯] for [ʊ̯] (1972). I have heard these substitutions in Baltimore, Maryland and Columbus, Ohio as well.

(3.22e) A similar delabialization appears to have occurred in Old French, when ou (< ō) in open syllables became *ʌu (subsequently eu > ø): sōlum > *sǫ:lu > soul > *sʌul > seul. Delabialization also appears to have affected non-syllabic ǫ after the syllabic u of uǫ (< ǫ in open syllables): uo > *uʌ > ue (> ø): sŏrōr > *sǫ:ror > suor > *suʌr > suer (cf. Pope 1934:104ff.).

Depalatalization before or after palatal glides also occurs:

(3.23a) In Icelandic, æi (< æ) became ai, merging with ai from a + g [ɣ] (Benediktsson 1959:298).

(3.23b) The development of ę in French parallels that of ǫ, and thus includes an instance of Bleaching: ę (in open syllables) > ei > *ʌi (> oi); thus mē > *mę: > mei > *mʌi > moi (cf. Pope 1934:104ff.).

(3.23c) In the English vowel shift, [ɛi̯] (< ME ī) became [ʌi̯], and then [ɑi̯] (cf. Wolfe 1972).

(3.23d) In coastal North Carolina and Texas dialects observed by Labov et al. (1972), Modern English [ɛi̯] as in paid, way, fate becomes [ʌi̯]. High syllabics may also be depalatalized: [ɐi̯] → [ʌi̯] and [ɪi̯] → [ɨi̯].

(3.23e) In Lardil, /i/ becomes [e] word-finally. This [e] is bleached and lowered to [ɑ] after palatals (including palatal consonants): (in Hale's transcriptions)
/paɣi/ → non-future payi-n, uninflected paya;
/tuntʲi/→ non-fut. tuntʲi-n, uninfl. tuntʲa 'junior wife's brother' (Hale 1973:422 note 26).

In Icelandic, in French, in the English Great Vowel Shift (some dialects), and in the U.S. dialects mentioned, delabialization and depalatalization co-occur, producing symmetrical changes. Variation in Australian English is especially illustrative of this symmetry.

(3.24) The speech of Australian adolescents was studied by Mitchell and Delbridge (1965); they grouped their speakers into three categories: 'cultivated'--closest to RP, 'general'--without conspicuous accent, and 'broad'--typically Australian. The substitutions which differentiate the 'general' from the 'cultivated' variants illustrate both context-sensitive depalatalization and context-sensitive delabialization:

Cultivated		General			Cultivated
[ɪi̯]	⟶	[ɨi̯]	[ɨu̯]	⟵	[ʊu̯]
[ɛi̯]	⟶	[ʌi̯]	[ʌu̯]	⟵	[ɔu] ~ [ou]

(Elliott:1977:57).

The 'broad' dialect is marked by Lowering of achromatics and some other changes to be discussed below.

3.3.1.5. The function of Bleaching.

Although the most obvious effect of Bleaching is the removal of palatal or labial color, the real function of this fortition process is to increase sonority. (Fortition processes always act to increase phonetic properties of segments.) Because of the conflict of sonority and color discussed in Chapter II, the loss of palatality or labiality results in increased sonority (increased F_1, increased intensity).

The ! lower condition on Bleaching reflects the difficulty of maintaining both a color and a high degree of sonority, and it also exemplifies the 'rich-get-richer' principle, since it means that a vowel with higher sonority and weaker color will undergo increase in sonority in preference to one with weaker sonority and stronger color.

Bleaching in mixed vowels reflects the incompatibility of palatality and labiality as well as that of color and sonority. Delabialization or depalatalization of mixed vowels actually increases--or, at least, optimizes vowel color: palatality is optimized by delabialization, which raises ($F_2 - F_1$); and labiality, by depalatalization, since depalatalization lowers ($F_2 - F_1$).

Dissimilative Bleaching frequently applies as a step in the polarizations of color and sonority that are common in diphthongization. When the non-syllabic element of a long vowel (VV̯) is tensed or raised (e.g. [ee̯] → [ei̯]), increasing its color, the syllabic element is often bleached, increasing its sonority ([ei̯] → [ʌi̯]). Note that Laxing and Lowering, which also increase sonority, are also favored in such circumstances , and that they often affect the same vowels that Bleaching does (as when [ei̯] → [ɛi̯] → [ʌi̯] → [ɑi̯]). And conversely, when the non-syllabic is bleached (e.g. [ee̯] → [eʌ̯]), it is the syllabic that is often tensed or raised ([eʌ̯] → [iʌ̯]), and this bleached non-syllabic is not uncommonly made syllabic by 'syllabicity shift' ([iʌ̯] → [i̯ʌ] or even [jɑ])--cf. Sec. 4.3.2.

Like other dissimilative fortition processes, Bleaching is especially applicable to segments which appear in environments capable of preserving the feature that the fortition incidentally weakens or removes in increasing another (conflicting) feature. So delabialization is especially applicable to vowels before or after labials, and depalatalization is especially applicable to vowels before or after palatals; an adjacent labiopalatal may promote bleaching of either color. As with other processes, the hierarchical conditions on the

susceptibility of vowels to Bleaching exactly reverse those on the environments for Bleaching: the less chromatic the vowel, the more susceptible it is to Bleaching, but the more chromatic the environment, the more apt it is to condition Bleaching. The strongly chromatic environments which are the 'best' ones for Bleaching are those which are most capable of preserving the color Bleaching removes from the adjacent vowel.

3.3.2. Coloring: Palatalization and Labialization.

Coloring, like Bleaching, is in fact a class of two processes, palatalization and labialization:

$$\begin{bmatrix} V \\ -\text{labial} \\ !\ \text{higher} \\ !\ /\begin{bmatrix} V \\ +\text{labial} \end{bmatrix} \end{bmatrix} \rightarrow [+\text{palatal}] \qquad \begin{bmatrix} V \\ -\text{palatal} \\ !\ \text{higher} \\ !\ /\begin{bmatrix} V \\ +\text{palatal} \end{bmatrix} \end{bmatrix} \rightarrow [+\text{labial}]$$

Since the two are parallel processes, with parallel implicational conditions of application, they will be discussed together.

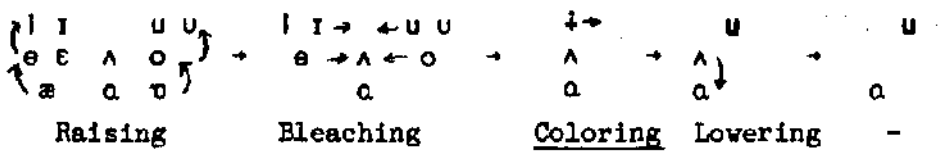
The coloring processes ordinarily apply only to achromatic vowels --most importantly, to vowels which lack the 'opposite' color--in fortitions. This condition--that chromatic vowels like [u] and [i] do not spontaneously add a color--is due to the function of fortitions; addition of a second color would weaken the original labiality or palatality of a chromatic vowel, not strengthen it. Apparent cases of context-free color mixing will be discussed below, in Section 3.3.3.

3.3.2.1. ! Higher.

The applicability of Coloring varies directly with vowel height; a higher vowel always colors if its lower counterpart does, other things being equal. This ! higher condition on Coloring is, of course, exactly opposite to the ! lower condition on Bleaching.

Children often color higher vowels while their lower vowels remain achromatic.

(3.25a) Joan Velten, during her two-vowel stage, labialized her high vowel and left her low vowel achromatic. In Joan's speech, adult /e, ɛ, o, i, ɪ, u, ʊ/ became [u], and /æ, ɒ, ʌ, ɑ/ became [ɑ], apparently by the following series of processes: (cf. Velten 1943)



(3.25b) Hildegard Leopold's substitutions were much like Joan's at first, except that her high (from high and raised mid) vowels became [ɨ] rather than [ʊ], her Coloring process being palatalization rather than labialization (cf. Leopold 1939).

Achromatic vowels also palatalize or labialize historically, or dialectally, and such colorings preferentially affect higher vowels:

(3.25c) /ɨ/ has become /ɪ/ in Southern Welsh, but /ɑ/ has not been similarly palatalized (Bowen and Jones 1960:12).

(3.25d) /ɨ/ becomes /ɪ/ in Northern Irish as well (Sommerfelt 1968:495),

(3.25e) and in Common Mongolian (Poppe 1955:33),

(3.25f) and in Özbek dialects of Turkic (/ɨ/ → [ɪ], merging with /ɪ/.) (Menges 1968:79).

(3.25g) Black Lahu /ɨ/ and /ʌ/ have merged with /ɪ/ and /e/ in Yellow Lahu (Matisoff 1973:12). Here both high and mid achromatics are palatalized, but the low vowel /ɑ/ remains non-palatal.

(3.25h) Palatalization may affect all vowel heights and thus include low vowels; ā became ą̄ ([ɑ:] > [æ:]) in Classical Greek (Allen 1974:70).

(3.25i) West Germanic a became æ in Old English (unless OE ǣ, ē were direct retentions from Primitive Germanic ā) (Campbell 1959:52f.). This change applied dissimilatively as well as context-freely: W Gmc *au >*æu (> *æo > æa).

Context-free labialization is less common than palatalization, but it does occur, and it appears also to follow the ! higher condition on colorings:

(3.26a) The epenthetic or 'enunciative' vowel of Dravidian, elsewhere /ɨ/, becomes [ʊ] in Kannada and Telugu, thus merging with original or underlying /ʊ/ (Bright 1975:41).

(3.26b) Gutob-Remo *i̇ has become u in the Mundlipada dialect of Remo (Zide 1965:44).

3.3.2.2. Dissimilative Coloring.

Dissimilative palatalization 'fronts' a plain vowel adjacent to a labial; dissimilative labialization 'rounds' a plain vowel adjacent to a palatal. Unlike the processes dealt with up to now, which, in dissimilations, polarize color and sonority, dissimilative coloring

polarizes tonality--i.e., it produces in two adjacent vocalic elements a maximal difference of color. By this process, in the environment of a labial, an achromatic vowel becomes not only non-labial but palatal; or in the environment of a palatal, the achromatic becomes not only non-palatal but labial.

As with context-free coloring, high vowels are especially susceptible to dissimilative coloring (e.g. [ʌu̯] → [ɛu̯] entails [ɨu̯] → [ɪu̯]).

(3.27a) In a number of U.S. dialects, the high achromatic syllabic of [ɨu̯], which arises when /u/ undergoes diphthongization and dissimilative Bleaching, is palatalized, yielding [ɪu̯] for /u/, as in <u>two</u> [tɪu̯]. (Labov et al. report this change in the Outer Banks of North Carolina (1972, figs. 40, 43); I have observed it there, in Waco, Texas, and elsewhere in the South.)

(3.27b) Mid achromatics also undergo dissimilative palatalization. In much Baltimore, Maryland speech, /u/ retains a labial syllabic ordinarily ([ʊu̯]), but /ou/ often becomes [ʌu̯], and its bleached syllabic is often palatalized, giving [ɛu̯], as in <u>home</u> [hɛu̯m], <u>road</u> [rɛu̯d].

(3.27c) Mid achromatics underwent a similar dissimilative palatalization in the history of French, when *<u>ʌu</u> (< <u>ou</u> < <u>o͂</u>) became <u>eu</u> (eventually <u>ø</u>) (Pope 1934:104ff.)--cf. (3.22e).

At about the same period in French, a dissimilative labialization also occurred, changing *<u>ʌi</u> (< <u>ei</u> < <u>e͂</u>) to <u>oi</u> (eventually [ɥɛ], then [ɥɑ] (ibid.)--cf. (3.23b).

(3.27d) Low syllabics have been palatalized dissimilatively in many dialects of Modern English: /ɑu/ → [æu̯] in RP (Jones 1964:107-9), and [æu̯] or [æɒ̯] in most U.S. and Australian dialects (Labov et al. 1972, and Mitchell and Delbridge 1965, respectively). In some of these dialects, /ɑi/ undergoes dissimilative labialization to [ɒi̯] or [ɒɐ̯]; areas where this labialization parallels the palatalization include coastal North Carolina, certain London and Norwich dialects (Labov et al. 1972), Worcester and the South Country (Wright 1905:127), and Australia (Mitchell and Delbridge 1965).

(3.27e) Dissimilative labialization may occur in loan phonology, too, as in the Lithuanian substitution of [ui̯] for Russian [ɨi̯]: Lith <u>muilas</u> 'soap', <u>tuinas</u> 'fence' from Russian <u>mylo</u>, <u>tyn</u> (Andersen 1972:23).

In the above examples, it is the syllabic, initial element of a V̯V diphthong that undergoes dissimilative coloring. If the second

element, the glide, is an achromatic, it may be dissimilatively colored as well. Such colorings often occur--or become apparent--when the vowel being colored comes to be the syllabic and receives an accent.

(3.27f) The diphthongization of o: to uo in Romance is followed, in some languages, by the change of this uo to ue--apparently a matter of Bleaching: uo > uA; Coloring: uA > ue; and Syllabicity shift: ue > ue, in some cases. Such a sequence appears to have occurred in French: sŏrŏr > so:ror > suor > suAr > suer (cf. Pope 1934: 104ff.), and in Spanish: nova > no:va > nuova > nuAva, nueva (cf. Menendez Pidal 1926:122ff).

As with other processes which apply dissimilatively, the hierarchical conditions on the dissimilating environments are the reverse of those on the processes' potential inputs.

3.3.2.3. The function of Coloring.

Unlike the other processes discussed in this chapter, Coloring does not, strictly speaking, increase a phonetic property in a segment --*instead, palatalization and labialization each assign to segments a* property they previously lacked. The properties they assign, palatality and labiality, make vowel height differences more audible, since chromatic vowels differ in degree of color as well as in height; we should thus expect Coloring to increase the perceptibility of height differences.

The ! higher condition on Coloring reflects the incompatibility of color with sonority. Higher vowels are more susceptible to Coloring because they have less sonority for the color to conflict with, and because color will intensify their relative lack of sonority, since coloring decreases intrinsic intensity. (Achromatic vowels are more sonorant than their chromatic counterparts, other things being equal.)

The conditions that specify against color-mixing (-labial on palatalization; -palatal on labialization) reflect the incompatibility of palatality and labiality, an incompatibility that became apparent earlier from the high susceptibility of mixed vowels to loss of one or the other color.

The dissimilative conditions which catalyze Coloring processes show that Coloring functions in polarizations of palatality and labiality as Raising does in polarizations of color and sonority. Color polarization produces diphthongs of changing tonality. Such changing tonalities may increase perceptibility in something like the way that changing fundamental frequencies appear to be more perceptible than constant or 'steady-state' fundamental frequencies (cf. Lindblom 1978: 146-8).

3.3.3. Interactions of Bleaching and Coloring.

As the examples of (3.22-24) and (3.27) suggest, Bleaching and Coloring together account for changes which take place in diphthongizations of tonality, the polarizations of palatality and labiality which do not affect vowel height. While maintaining the same hierarchies of applicability as seen in their context-free applications, Bleaching and Coloring often apply in sequence, producing progressive dissimilations like [ʊu̯] → [ɨu̯] → [ɪu̯].

Laxing and Tensing often play a part in these dissimilations, of course. Laxing may create from a monophthong the lax/tense diphthong to which Bleaching applies, and Tensing may cause further dissimilation by intensifying the newly-added color, so that the complete sequence becomes: [u: → ʊu̯ → ɨu̯ → ɪu̯ → iu̯].

Such sequences may be followed by assimilations, which may eventually re-monophthongize the now-bichromatic sequence, producing a bichromatic vowel. The creation of bichromatic vowels from monochromatic ones--usually [y] from [u] or [ø] from [o], in languages like French, Yiddish, Faroese, Greek, and some Portuguese, German, and English dialects--is problematic if, as the usual long and/or accented environments suggest, such 'frontings' are to be regarded as fortitions. Since such changes produce less-optimal vowels like [y] or [ø] from more-optimal ones like [u] or [o], they run counter to the basic phonetic causalities of fortition processes, which apply to make segments phonetically optimal. I wish to suggest, instead, that most, if not all, such palatalizations of labial vowels (and corresponding labializations of palatal vowels) are the results of diphthongizations of the color-dissimilating variety, with subsequent re-monophthongization.

In many languages, the 'fronting' of [u] is preceded by unrounding of an early [y], and the fronting is described as part of a chain shift, but the phonetic motivation for a change of [u] to [y] is not thus established. The delabialization of [y] may, however, be related to delabialization of the syllabic of [u:], and the change of [u:] to [y:] is thus begun:

	u:	y(:)
Laxing (! dissimilative)	u: → ʊu̯	y: → ʏy̯
Bleaching (! dissimilative, ! mixed → -labial)	ʊu̯ → ɨu̯	ʏy̯ → ɪi̯, y → i
Palatalization (! dissimilative)	ɨu̯ → ɪu̯	
Tensing (! dissimilative)	ɪu̯ → iu̯	
Palatality Assimilation	iu̯ → iy̯	
Labiality Assimilation	iy̯ → yy̯	

The u-to-y change may be paralleled by o-to-ø, if the mid vowels undergo these processes as well:

uu̯ → ʊu̯ → ɨu̯ → ɪu̯ → iu̯ → iy̯ → yy̯
oo̯ → ɔo̯ → ʌo̯ → ɛo̯ → eo̯ → eø̯ → øø̯.

Such patterns are not always entirely parallel, of course; another process, like Lowering, may intervene and interrupt the parallel development, or differential application of one of the processes may cause one of the vowels to travel only part way along the path described.

Below are a number of examples showing how color-mixing changes allow diphthongal interpretations. Various kinds of evidence for diphthongal analyses are discussed.

(3.28a) In Lithuanian Yiddish (cf. Sapir 1915), the Middle High German labiopalatals ü and iu delabialize, merging with their palatal, non-labial counterparts i and î. Long û and ô are diphthongized, with subsequent labialization, palatalization, and mutual assimilation:

	û	ô	ou	ei
Diphthongiz'n (Laxing)	ʊu̯	ɔu̯	-	-
Delabializ'n (! dissim.)	ɨu̯	ʌu̯	ʌu̯	-
Palataliz'n (! dissim.)	iu̯	eu̯	eu̯	-
Palatal and Labial Assim.	yy̯	øy̯	øy̯	-
Monophthongiz'n (Height Assim.)	-	øø̯	øø̯	ee̯

The [ø:] (< ô, ou) is subsequently unrounded to [e:], and the new [y:] (< û) is diphthongized to [ʊi̯] by the same processes which change [i:] (< î, iu) to [ɑi̯]. In Yiddish, the parallel development of ou with ô and the monophthongization of ei are consistent with the notion that the 'frontings' occurred via diphthongization, then monophthongization; although it is of course possible that the merger of ô with ou occurred as a monophthongization of ou.

(3.28b) The development of u to [y] and o to [ø] in French (Pope 1934:104) may be viewed as having taken the same path. In French, there is also concurrent labialization of the palatal e (to oi). Briefly--cf. (3.22e, 3.27c):

	u	o	e
Diphthongization	ʊu̯	ɔu̯	ei̯
Bleaching (! dissim.)	ɨu̯	ʌu̯	ʌi̯
Coloring (! dissim.)	iu̯	eu̯	oi̯
Labial Assim. (/_ labial)	yu̯	øu̯	-
Palatal Assim. (/_ pal'l__)	yy̯	øy̯	-
Monophthongization	y	ø	-

The eu stage for o and the oi stage for e are attested in French rhymes and spellings, but there seems to be no rhyme or spelling evidence for the high vowel as a diphthong. Further, the change of u to [y] in closed and even in countertonic syllables, where o and e did not diphthongize, suggests that this instance of color-mixing may need to be otherwise explained.

(3.28c) The change of v [u] to [y] in Attic (Allen 1968:65ff.) may also have occurred via diphthongization. Although it would be difficult to prove this outright, it is

interesting that 'for reasons that are not in all cases clear, initial υ̯ is always aspirated (ὑ̯)' (ibid.). Buck, in fact, suggests that original [u] first became [i̯u], since initial [i] or [ɟ] is one source of aspiration in Greek: ὑ̔δωρ, Skt. udan-; ὑ̔στερος, Skt. uttaras (Buck 1933:134).

This possibility is quite consistent with the proposed sequence u̯u̯ → i̯u̯ → i̯u, requiring only the addition of syllabicity shift in word-initial position. But Allen rejects Buck's suggestion, partly because this initial aspiration appears also in dialects like Boeotian, where υ̯ remains [u]. But Boeotian and other dialects (e.g. Tsaconian) show palatalization of dental consonants before [u] (< υ̯), and such palatalization is in fact more likely to have been caused by a following [iu̯] or [i̯u], the results of diphthongization, than by a following [y], the result of 'fronting'. If diphthongization and consonant palatalization occurred in these dialects and then palatality was lost from the resulting [i̯u] or [iu̯] or [y] in the 'non-fronting' dialects (cf. (3.23e), (3.21a-c), and also English dialects where [tʃi̯uzdɛi̯] Tuesday → [ʧuzdɛi̯], or [li̯ut] lute → [lut]) then both the initial aspiration and consonant palatalization can be explained.

(3.28d) In Northern dialects of English, Old English ō (Middle English ǭ) becomes ȳ (Brunner 1965:19ff.), apparently via [ø:] (Jordan 1974:86). It is possible to assume a sequence: ǭ [oǫ] → [ʌǫ] → [eǫ] → [øø̨] → [yy̨] to account for this development. Although spelling evidence is lacking, there is some indirect evidence for the critical [eǫ] stage, since ǭ plus w̯ (< ɣ̯) remained ew. I have suggested that ǭ > [eǫ] and tautosyllabic [eǫ] became [ø:], then [y:]. But the sequence [eǫ.w] (< ǭɣ̯) may have become [e.w] by glide absorption (as eo.w > e.w in ME spewe(n) 'to spew' < OE speowian) and this ew remained, e.g. in ME bowes, Northern bewes, OE bōgas 'boughs'.

Color-mixing by diphthongization and monophthongization is most apparent when there remain diphthongal reflexes of the palatalized or labialized vowels, when intervening changes give evidence for the intermediate diphthongal stages, or when the changes are synchronic, with variation between diphthong and monophthong. The history of Faroese provides a particularly obvious case of diphthongization and subsequent color-mixing, since it meets the first two of these conditions.

(3.28e) In Faroese, old long ú, ó and í, ý (the latter pair identical, since ý was delabialized) were diphthongized. Each of the three diphthongs has developed into two sounds in the modern language, a short and a long variant:

	short:	long:
ú	[ʏ]	[ʏɣ]
ó	[ø]	[eɣ], [oɣ]
í, ý	[ʊɣ]	[uɣ]

é, which had undergone 'breaking' to [i̯e], was not affected by these changes, but there is some evidence that ei, now [ai̯], may have participated in the shift. If we may ignore some vowels for the moment in order to simplify somewhat, these remarkable changes may be seen as the results of early bleaching and dissimilative coloring, followed by later assimilations, with the assimilations more complete in the short variants:

	ú	ó	í,
Diphthongization	ʊɣ	ɔɣ	ɪi̯
Bleaching (! dissim.)	ɨɣ	ʌɣ	ɨi̯
Labializ'n (! dissim.)	-	-	ʊi̯
Palataliz'n (! dissim.)	ɪɣ	ɛɣ	-
Labiality Assimil'n	ʏɣ	(øɣ)	ʊɣ
Palatality Assimil'n of Glide (when V is shortened)	ʏ	ø	-
Tensing (! dissim. of Syllabic (when V is long))	yɣ	eu̯	uɣ

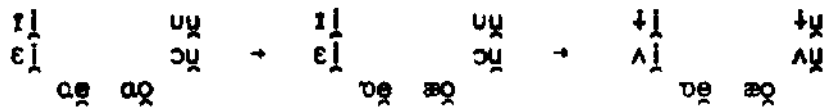
The diphthongal intermediate stages in Faroese are revealed by additional changes which affected the non-syllabic elements of diphthongs, 'stranding' certain of the syllabics midway in their development. Certain glides were 'sharpened' to homorganic affricates: ɣ > gv, i̯ > ǰ (Rischel 1968:103), and others were 'absorbed' by tautosyllabic homorganic consonants (examples from Lockwood 1955:10ff.):

kúgv	[kʏgv]	'cow'	tíggju	[tuǰ:ʊ]	'ten'
sjóvur	[šɛgvʊr]	'sea'	nýggjur	[nuǰ:ʊr]	'new'
frískur	[frʊškʊr]	'healthy'	lívga	[lug:a]	'enliven'.

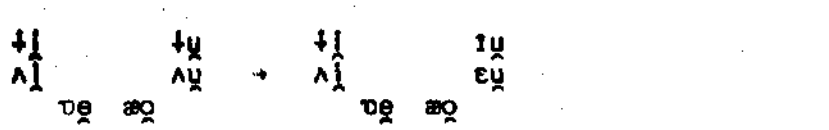
The quality of the vowel before each new consonant shows the quality of the syllabic of the earlier diphthong.

Bleaching and Coloring interactions of the sort proposed for the above historical changes can be observed in a number of contemporary dialects of English.

((3.28f) Australian dialects (Mitchell and Delbridge 1965:34-5) are marked by dissimilative coloring of the (low) syllabics of the diphthongs [ɑɐ̯] and [ɑɑ̯] to [ʊɐ̯] and [æɑ̯]. Then there is bleaching of the syllabics of diphthongs with like-colored glides: [ɛi̯], [ɪi̯] → [ʌi̯], [ɨi̯], and [ɔu̯], [ʊu̯] → [ʌu̯], [ɨu̯].



(3.28g) There are dialects in the United States (e.g. the North Carolina Outer Banks, as documented in Labov et al. 1972) which share this pattern of changes, but which add a dissimilative palatalization of the high and sometimes also the mid achromatic syllabics of [ɨ̯] and [ʌ̯], producing (variably) [ɪ̯] and [ɛ̯] (for /u/ and /ou/):



One or both of the palatal syllabics may remain palatal while Bleaching and Coloring affect the labials in this dialect and in others.

There are certain British dialects (e.g. London, Norwich, etc. --cf. Labov et al.) which share these changes. In some dialects, the /u/-to-[ɪ̯] change goes even further: Palatality Assimilation may change [ɪ̯] to [ɪ̯], and there exist speakers with [ɛ̯] for /ou/, apparently by the same series of processes, since [ɛ̯] varies with [ɛ̯] and [ʌ̯]. Or the assimilations may go to completion, resulting in monophthongal [y]: I have heard [y] varying with [ɪ̯] in a single Texan speaker, for example.

Bleaching and coloring thus produce a wide variety of patterns which include diphthongizations, 'frontings', 'backings', etc. One or more of the high chromatic vowels may diphthongize, and this diphthongization may be accompanied by that of one or more mid chromatics. Although changes in palatality often accompany changes in labiality, it should be clear that such parallels are not required by the nature of the processes--i.e., depalatalization and delabialization may apply in concert, but neither implies the other. Thus, the palatal and labial series may be affected differently.

(3.28h) A final example to illustrate the varying patterns which the independence of processes (particularly diphthongizations of palatals and labials) can cause comes from the insular Portuguese dialects described by Rogers (1946, 1948a, 1948b).

In Porto Santo, stressed i̯ may become [ø̞]:

[i̯ → e̞ → ʌ̞ → o̞ → ø̞].

In Madeira, this i̯-to-[ø̞] substitution is more general, though again not universal; [ø̞] here varies with [o̞] and with [e̞]. Here also, u̯ becomes [y] in stressed syllables. Thus, diphthongizations are suggested:

[i̯ → e̞ → ʌ̞ → o̞ → ø̞]
[u̯ → → ɨ̯ → ɪ̯ → y̯ → yɣ].

In São Miguel, the u-to-[y] change has occurred while i remains [i]. But in São Miguel, the change of u was accompanied by a parallel change of ou (now merged with ô in the standard language) to [ø], which occasionally varies with [øu̯]. (The fact that only ou, and not ô, 'fronted' suggests that diphthongization was a factor.) Further, in São Miguel, ê irregularly becomes [ø], oi ordinarily becomes [øi̯] or [ø], and ei becomes ê [e], as well:

[uu̯ → ɨu̯ → iu̯ → yu̯ → yɣ]
[ou̯ → ʌu̯ → eu̯ → øu̯ → øø]
[eu̯ → ʌu̯ → ou̯ → øu̯ → øø]
[oi̯ → øi̯ → øɣ → øø]
[ei̯ → eu̯].

It should be clear from this and other examples that the high and mid (and low) series may be differently affected, as well. In some languages--e.g. Attic (3.28c), only the high labial becomes a (labio-) palatal. In others--e.g. Faroese (3.28e), both the high and mid labials do so. In still others--e.g. Northern English (3.28d), only the mid labial becomes labiopalatal. In the cases I have observed, such variable patterns are readily reconciled with the implicational conditions on individual processes. In the Northern English case, ū may be diphthongized and bleached to [ʌo̯], then becoming [eo̯ → ø: → y:], while u remains because the lower syllabic is more susceptible to Bleaching, and the still-labial syllabic of [uu̯] or [ou̯] is not susceptible to the palatalization which makes [ʌo̯] → [eo̯]. But if both ū and u̯ are diphthongized and bleached to [ʌo̯] and [ɨu̯], then [ɨu̯], whose syllabic is more susceptible to coloring, may become [iu̯] while [ʌo̯] remains; subsequent monophthongization would then show the results of the diphthongization as [y:] (< [iu̯ < ɨu̯ < u:]) versus [o:] (< [ʌo̯ < o:]).

I have attempted to establish here that all--or most--cases of 'spontaneous' palatalization of labial vowels and labialization of palatal vowels may be the results of diphthongization and monophthongization, where a second color is introduced onto a bleached diphthongal element and then 'spreads' by assimilation onto the element which retains the original color. In some of the historical cases I have discussed, the evidence is subject to other interpretations than those I have presented, but these other interpretations claim that a conflicting color is added to an already chromatic vowel. (Other writers do not use these terms, of course, but it is generally agreed that [y] is a more 'marked' or less optimal vowel than [u].) Thus, while it may seem more direct or simpler to claim that [u] becomes [y] directly, to do so requires the assumption of a substitution for which it is very hard to see a phonetic motivation, either articulatory or acoustic/perceptual. In a theory which requires a phonetic explanation for phonetic change, this is a major problem.

Wood (1975) proposes that [u] is palatal as well as velar and labial, and that 'fronting' of [u] to [y] is simply a matter of loss of velarity. While this could be a start at explaining palatalization of [u] without diphthongization, [o] could not be treated in parallel fashion, and changes like Northern English $\bar{o} > \bar{\phi} > \bar{y}$ (3.28d) would remain unexplained. Further, it remains to be shown that [u] is ever treated phonologically as a palatal vowel by other processes.

Earlier attempts to explain such changes as u-to-y or o-to-ø have aimed at phonological explanation, and they have been based on the notion that such fronting 'relieves overcrowding among the back vowels --more specifically, four degrees of height' (Labov et al. 1972:211; cf. Haudricourt and Juilland 1949:21ff.). This explanation falls short phonologically for a number of reasons:

a. It suggests that the 'overcrowded' back vowels should be more susceptible to merger than the front vowels (which have more 'space' per vowel), but I do not know of any attempts to show that mergers are more common among back vowels than among front vowels--and my own study of vowel processes has not given me the impression that this is the case.

b. It requires the assumption that a and o differ in phonological height--which is possible--but it also implies that they differ only in height and disregards the difference of lip rounding.

c. It does not explain the frequent co-occurrence of 'fronting' with diphthongization (as in French, in Portuguese dialects, in Scandinavian, in Yiddish, etc.).

d. It leaves the occasional labialization of front vowels unexplained.

Moreover, the corresponding attempt to give the phonological problem a phonetic basis has not been much more successful. Haudricourt and Juilland (1949:22-3) claimed that the back vowels are subject to overcrowding because of the (front-to-back) asymmetry of the vocal tract. It would seem that this explanation is based on a too-literal conception of the tongue-arching model of vowel articulation (cf. Wood 1975). Further, it ignores the question of why u (and/or o) is palatalized to y (or ø), rather than delabialized to ɨ (or ʌ) in the shifts they describe. With this insufficient phonetic explanation, the direct change loses some of its obvious appeal. And if one considers that contemporary context-free 'frontings' of labial vowels all seem to involve diphthongization, the proposed relation between color-mixing and diphthongization seems quite reasonable, although in many cases it cannot be proven.

3.3.4. Palatality and Labiality.

Haudricourt and Juilland were surely correct in noting the frequent asymmetries in the phonological behavior of 'back' and 'front' vowels. For like reasons, on a number of occasions in this discussion of Bleaching and Coloring, I have suggested that delabalization is more common or frequent than depalatalization, and that palatalization is more common or frequent than labialization. This amounts to saying that palatality is somehow a 'stronger' color than labiality--i.e. that palatal vowels display to a greater extent the kinds of phonological behavior associated with chromatic vowels--that they are more likely to keep or increase their color, to impart this color to adjacent vowels or consonants, etc.

Although I have done no statistical study of this matter, I offer the following phonological reasons for believing that palatality is in this sense a 'stronger' color:

a. Achromatic vowels appear to palatalize more often than they labialize: e.g. ɨ → i in Welsh, Irish, Mongolian, Turkic dialects, Lahu, etc.; but ɨ → u far more rarely--cf. (3.25-6).

b. Further, while palatalization may perhaps extend to labials (if u → y without diphthongization, as may have been the case in French), all examples of labialization of palatals (e.g. i → öi in Madeira (3.28h)) involve diphthongization; therefore labialization affects only achromatics.

c. Labiopalatals appear to be delabialized more frequently than depalatalized. y → i in Greek and in many Germanic languages and dialects--cf. (3.18d), (3.20a-d); but I have found only a few examples of y → u (Monguor, Özbek, the child 'Y'--(3.21a-c)).

d. The extraordinary stability of i-vowels in some languages which undergo extensive vowel changes is not paralleled, as far as I know, by any similar stability of u-vowels: e.g. in Romance vowel systems, the Latin Ī has been maintained to the present day despite far-reaching changes in the phonetic values of other vowels; and in Greek, i has remained unbudgeable in spite of changes affecting other vowels, so that Modern Greek /i/ is the reflex not only of Classical i and Ī, but also of u, ū, ē, ei, and oi; but I know of no similar cases for u or ū.

e. There are vowel systems with palatal vowels but no labial vowels--e.g. Manambu, with /i, ɑ, ɑ̃ / (Allen and Hurd 1972); Tillamook, with /ɪ, æ, ʌ, ɑ/ (Thompson and Thompson 1966); and Ixil, with /i, ɛ, ɑ, ɯ, ʌ/ (Eliot 1960)--but there do not seem to be any languages with labial vowels but no palatal vowels.

f. There are many languages in which the extreme palatal vowel is high and tense /i/, but the extreme labial vowel is lower or

lax /ɔ/ or /ʊ/--e.g. Nahuatl (Puebla), with short and long /ɨ, e, o, a/ (Robinson 1969); Oneida, with short and long /ɨ, e, o, a/ (Lounsbury 1953); Seediq (Terowan), with /ɨ, ʌ, o, a/ (Dyen 1971); or Wik-Munkan, with /ɨ, e, a, ɔ, ʊ/ (Sayers 1964). Since Raising and Tensing favor vowels with higher degrees of color, and Lowering and Laxing favor vowels with less color, these systems suggest that palatals are somehow more strongly chromatic than the corresponding labials: in the processes which constrain or create the system, [e] is raised and [o] is not, or [ɨ] and [e] are tensed and [ʊ] and [ɔ] are not, or [ʊ] is lowered or laxed and [ɨ] is not, etc.

It should be emphasized, however, that this asymmetry of palatality and labiality does not have strict implicational consequences and is only a matter of probability; Raising or Lowering may affect only palatals or only labials, achromatics may labialize or palatalize, labiopalatals may delabialize or depalatalize, etc.

This apparent difference in degree of color between palatal and labial vowels of the same height, tenseness, etc. requires an explanation which may only come with a better understanding of the phonetic realizations of the color features.

3.4. Vowel Shifts.

In giving examples of the application of the processes described here, I have used a number of substitutions which occur as parts of larger patterns of vowel substitution--i.e. in vowel shifts. Any of the processes may apply in this way, as part of a larger pattern, but I wish to note here that each process is independent. A process may, of course, depend on another process to provide certain of its inputs, but, granted that there exist some appropriate segments in appropriate environments for it to apply to, a process may apply--or fail to apply --independently of the application of any other process. In other words, there are no implicational relationships between processes--only within processes.

For example, in English, the diphthongization of high tense vowels by dissimilative Laxing and Lowering was accompanied (or followed) by Raising of tense mid vowels: $\underline{\bar{I}}, \underline{\bar{u}} > \underline{ai}, \underline{au}$ (cf. (3.9d)) $\underline{\bar{e}}, \underline{\bar{o}} > \underline{\bar{I}}, \underline{\bar{u}}$ (cf. (3.12b)). In English, Diphthongization and Raising co-occur, but in Standard German, a similar diphthongization of $\underline{\bar{I}}$ and $\underline{\bar{u}}$ was not followed by Raising of $\underline{\bar{e}}$ and $\underline{\bar{o}}$, but instead by monophthongization of ie and uo. And in later English, when $\underline{\bar{\varepsilon}}$ (< $\underline{\bar{e}}$, as in meat) was raised to $\underline{\bar{I}}$, $\underline{\bar{I}}$ (< earlier $\underline{\bar{\varepsilon}}$ as in meet) did not diphthongize; instead original $\underline{\bar{e}}$ and $\underline{\bar{\varepsilon}}$ merged.

But in spite of the independence of individual processes, there are nevertheless certain characteristic patterns of vowel change that have been noted (Sweet 1888:19f., Labov et al. 1972 Ch. IV) for their

frequent occurrence:

A. Tense or long vowels are raised.

B. Lax or short vowels are lowered.

C. Back vowels are fronted.

The processes I have proposed, with their implicational hierarchies of applicability, are consistent with principles A and B, insofar as lax vowels are concerned: tense vowels appear to be raised more often because tense vowels are implicationally favored by Raising, and lax vowels are implicationally favored by Lowering. My claim (3.2.1.4) that long vowels are especially susceptible to Lowering runs counter to both A and B, but lowerings of long vowels (3.12a-i) are too common to be dismissed as 'isolated' counter-examples. On the other hand, raisings of long vowels can, in all cases that I know of, be attributed to tenseness--because the raised reflexes are tense, because they subsequently become 'upgliding' diphthongs (as tense vowels often do), or because other aspects of the language give evidence of a reinterpretation of the length distinction as tense vs. lax--cf. Sec. 3.2.1.4, and Chapters IV and V.

It should be clear from Section 3.3.3 that I also think that principle C is in need of some revision. Many discussions of the vowel shifts which illustrate C have ignored symmetrical, though perhaps incomplete, changes that affect the front vowels while the back vowels 'front'. For example, except in Rogers' own paper (1948), I have never seen a discussion of the São Miguel vowel shift (3.28h), in which u > ü, ô > u, ó > ô, and á > ó, which mentions that ê may become ö or that ou may become ő. Similarly, in discussions of the fronting that occurred in French, the parallel development of ę to oi and ǫ to eu is sometimes disregarded. In suggesting that labial vowels front via diphthongization, and in noting the asymmetry of color 'strength' which allows labials to undergo dissimilative delabialization more frequently than palatals undergo dissimilative depalatalization (and which also suggests the more frequent palatalization than labialization of achromatics), I offer an alternative view to C.

Vowel shifts have been conceptualized, by Jakobson and Martinet and their followers, as typically chain-like in form (a → b, b → c, c → d, etc.); and the theory that such chain-like forms reflect the causality of the shifts (a 'pushes' b, and b 'pushes' c; or d 'drags' c, and c 'drags' b, etc.) is widely accepted--along with its corollary that phonetic change occurs for phonological reasons. Since such 'chains' result from the way processes apply--in sequence or simultaneously, iteratively or non-iteratively, in a given order or without extrinsic order, etc.--they will be discussed in Chapter V. I will note here, however, that vowel shifts are by no means universally chain-like, with one vowel 'filling in the space' that another has vacated; for example, the vowel shifts of Faroese (3.28e), Yiddish

(3.28a), Madeira, Australia, and Coastal North Carolina (3.28f-h) are not like chains at all. It should also be noted that many patterns that are thought of as chains (e.g. French and São Miguel Portuguese) are in fact parts of larger patterns that may not be chain-like. While the notion of chain shifts is of considerable interest and will receive further discussion, the independence of individual processes--due to their individual phonetic, not phonological, motivations--must be emphasized (cf. Stampe 1969, 1972).

IV - DIPHTHONGIZATION

4.1. Kinds of diphthongs.

A diphthong is a two-part vocalism that constitutes a single syllable peak. Since, in a diphthong, two vowels are mapped onto a single syllable, one of them must be non-syllabic. Falling diphthongs are those with the first vocalic element syllabic and the second non-syllabic, symbolized V$\underset{\downarrow}{V}$. Rising diphthongs have the non-syllabic element first, symbolized $\underset{\uparrow}{V}$V.

4.1.1. Falling diphthongs--V$\underset{\downarrow}{V}$.

Falling diphthongs are themselves of two types, up- or out-gliding diphthongs (like [e$\underset{\downarrow}{\text{i}}$], [a$\underset{\downarrow}{\text{u}}$], [ɨ$\underset{\downarrow}{\text{ɪ}}$], etc.), where the glide is higher, tenser, or more chromatic than the syllabic, and in- or down-gliding diphthongs (like [e$\underset{\downarrow}{\text{ɛ}}$], [ɪ$\underset{\downarrow}{\text{ɛ}}$], [o$\underset{\downarrow}{\text{ɔ}}$], etc.), where the glide is lower, laxer, or less chromatic than the syllabic. In up-/out-gliding diphthongs, the second element may be raised or tensed, as in early French, where the tense mid vowels e and o became ei and ou (cf. (3.15b)). Or the first element, the syllabic, may be laxed or bleached or lowered, as in the southern U.S. dialects of English where /ɪ/ becomes [ɜ$\underset{\downarrow}{\text{ɪ}}$] or even [ɨ$\underset{\downarrow}{\text{ɪ}}$] (cf. (3.23d)), or the speech of Boston children who pronounce [ɐ$\underset{\downarrow}{\text{ɪ}}$] for /ɪ/ in words like me (cf. Andersen 1972:24).

As pointed out by Stampe (1972:583f.), diphthongs of this type frequently result in the polarization of color and sonority within the vocalism. The syllabic is given the role of sonority-bearer and it is lowered and often bleached to maximize this sonority, while the non-syllabic, which retains its color, is raised and tensed to intensify this color. This is what happens when [ɪ:] (= [ɪ$\underset{\downarrow}{\text{ɪ}}$]) has its syllabic laxed and lowered and bleached: [ɪ$\underset{\downarrow}{\text{ɪ}}$] → [ɜ$\underset{\downarrow}{\text{ɪ}}$] → [ɛ$\underset{\downarrow}{\text{ɪ}}$] → [ʌ$\underset{\downarrow}{\text{ɪ}}$] and, often, lowered again: [ʌ$\underset{\downarrow}{\text{ɪ}}$] → [a$\underset{\downarrow}{\text{ɪ}}$], as in the histories of English and Standard German, where parallel changes also affected [u:], so that [ɪ:s] > [a$\underset{\downarrow}{\text{ɪ}}$s] 'ice' and [hu:s] > [hau$\underset{\downarrow}{\text{s}}$] 'house' in both languages.

But sonority-color polarizations are not the only ones that occur in this type of diphthong; palatality and labiality may also polarize. The bleached syllabics of up-/out-gliding diphthongs sometimes color dissimilatively: in many American English dialects, /au/ becomes [ɐu] or [ʚu], and in some /ai/ also dissimilates to [ʊ$\underset{\downarrow}{\text{ɪ}}$] or [ʊ$\underset{\downarrow}{\text{i}}$] (cf. (3.28g)). In these dissimilations, the two colors or tonalities are polarized. Such tonality polarization is even more obvious in developments which do not include Lowering, like the Faroese changes

of i̯ to [ʊi̯] and u̯ to [ʏu̯] (cf. (3.28e)).

In contrast to these diphthongs of the ai/au/iu type are the in-gliding or down-gliding diphthongs like [i̯ɛ], [uo̯], [ee̯], etc. In this second type of falling diphthong, the non-syllabic second element is laxed, or lowered, or bleached, as in the Lappish dialects where [i:] becomes [i̯e], [u:] becomes [uo̯], [ø:] becomes [eæ̯], etc. (cf.((3.10b)), or as in American dialects where lengthened lax vowels acquire centering off-glides: bid [bɪ:d] → [bɪi̯d], bed [bɛ:d] → [bɛe̯d], etc. Or the syllabic first element may be raised or tensed, as when Germanic *ē2, *ō became MHG ie, uo; or as in the Middle Atlantic and other U.S. dialects where original lax [a:] as in bad, etc. becomes [æa̯] or [ee̯] (cf. (3.16). That is, in- or down-gliding diphthongs involve loss of color on the second element, while the syllabic may increase its color dissimilatively.

In in-gliding diphthongs, as in out-gliding ones, an achromatic element--here, the non-syllabic which loses its original color--may color dissimilatively, as when Gallo-Roman uo̯ (< Vulgar Latin o̯) became uʌ̯ and then Old French ue̯ (cf. (3.27f)). Such changes may be said to make out-gliding diphthongs from in-gliding ones.

Sometimes up-/out-gliding diphthongs become in-gliding ones, too. If the chromatic non-syllabic loses its color, the result is an in-glide. Such changes may be assimilative, as when the [ʊe̯] of coin, or the [æo̯] of house, or the [ɑe̯] of wide become [ʊo̯], [æa̯], [ɑa̯], with loss of color in the glide if that color is not shared by the syllabic. Changes like this appear in the southern Appalachians--e.g. Georgia, North Carolina, Tennessee--and they appear to be stages in the monophthongizations of these diphthongs, since the offglides readily assimilate to the syllabics.

4.1.2. Rising diphthongs: V̯V.

In rising diphthongs, the first of the two vocalic elements is the non-syllabic and the second is syllabic--V̯V. Such glide-vowel sequences are in some ways more like consonant-vowel sequences than they are like the vowel-vowel sequences that form 'true' (falling) diphthongs and are equivalent to long vowels. Since the length or 'weight' of a syllable is reckoned from the start of the syllabic, falling diphthongs are counted together (as two moras) in speech timing, but in rising diphthongs, the non-syllabic counts as part of the syllable-onset--which means, in most languages, that for prosodic purposes it doesn't count at all: V̯V is no longer than V, and V̯V: is no longer than V:. Further, falling diphthongs function as units in rhyme: paid [pɛi̯d] and raid [rɛi̯d] rhyme, but paid [pɛi̯d] and red [rɛd] do not. But rising diphthongs do not act as units in rhyme; the pre-syllabic glide does not 'count': feud [fi̯ud] rhymes with mood [mud] and cooed [kud] as well as with mewed [mi̯ud]. (Significantly, there may be disagreement about this in dialects where feud,

mewed are pronounced with [i̯u] rather than [i̯u]; for such speakers, feud [fi̯ud] and mood [mud] do not rhyme.)

The up-/out-gliding versus in-/down-gliding distinction that can be made among falling diphthongs has no counterpart in rising diphthongs. As far as I have been able to discover, all rising diphthongs have a non-syllabic element that is at least as high and at least as chromatic as the second, syllabic element. That is, there are rising diphthongs like [i̯ɑ, i̯e, e̯æ, u̯ɑ, u̯o, o̯ʌ, i̯u, u̯i, o̯e], but I have never seen any phonetic or phonological evidence offered for diphthongs like *[e̯i, ʌ̯o, o̯e, ɨ̯i, o̯u], etc. Such diphthongs are sometimes proposed as intermediate historical stages (Menendez Pidal 1926, Schmitt 1931), but their absence in synchronic phonetic descriptions argues against such intermediate stages. They may also be proposed as part of the phonological representations of lengthened vowels (Grundt 1976), but pre-syllabic glides--chromatic or achromatic--do not serve to represent length, since on-glides do not count prosodically.

In rising diphthongs, then, it appears that the second element is always the sonority element in any polarizations, and is thus especially susceptible to processes which intensify sonority, and the first element is especially susceptible to processes which increase color. Such processes increase the consonantal properties of the glide in its consonant-like syllable-onset position. And because the non-syllabic first element of a rising diphthong not only lacks the vocalic function of syllable bearing but also occupies an optimal consonantal position in the syllable onset, it may lose sonority and increase color to such an extent that it actually becomes a consonant.

(4.1) In Spanish, for example, word-initial glides become voiced spirants: huéle [ɣʷele] '(it) smells', yema [ʝema] 'yolk' (Harris 1969:21-7).

The kinds of diphthongs I will refer to may be summarized thus:

	Falling: VV	Rising: VV
Up-gliding	e.g. [ei̯, ou̯, æo̯]	e.g.
Out-gliding	[ɨi̯, ʌo̯, ɨu̯]	[i̯ɑ, u̯ɛ, i̯u, o̯ɑ]
In-gliding	[ii̯, ee̯, ɑo̯]	
Down-gliding	[iɛ̯, uo̯, eæ̯]	

4.2. Sources of diphthongs.

Diphthongs may arise from vowel-plus-consonant (or consonant-plus-vowel) combinations when consonants are vocalized or become glides, they may arise in combinations of vowels, and they may arise from single vowels.

4.2.1. Glides from consonants.

In the Spanish example above, non-syllabic vocalics become consonantal. Consonants can, of course, in opposite fashion, become vocalic. Typically, this happens when a syllable-final consonant is lenited, creating a falling diphthong. For example:

(4.2a) Syllable-final Latin l [ɬ] was vocalized to [u̯] in Old French: illos > ellos > eus (> øs > ø) Mod Fr eux 'them'; and Old French palatal l (from Latin kl) has become [i̯] in Mod Fr: parikulum > pareklu > parej > paRej (= pareil) 'same, similar' (Pope 1934:154, 239).

(4.2b) In late Old English, 'palatal g' after [æ, e, i] became [i̯]: OE dæg > ME dai 'day', OE weg > ME wei, wai 'way'. 'Velar g' (ɣ), which appeared after [ɑ, o, u], became [u̯]: OE maga > ME mawe 'maw', OE boga > ME bowe 'bow' (Brunner: 1965:18-20).

(4.2c) Modern English /r/ in syllable offsets has become [ə̯] in Received English and in many other dialects, British and American: ear [ɪə̯], pair [pɛə̯], oar [ɔə̯], cured [kj̯uə̯d], etc. (Jones 1964:108-13).

Although such consonant lenitions ordinarily affect postvocalic consonants, prevocalic consonants--usually non-initial ones--may also be vocalized:

(4.2d) Vulgar Latin prevocalic l was lenited to [i̯] in Italian: bianco 'white', fiore 'flower', from Latin blanco, flore, etc. (Rohlfs 1949:296ff.).

In fact, the vocalization may lack environmental conditions altogether, as when Polish ł becomes [u̯] in all positions.

4.2.2. Diphthongs from vowel combination.

Many diphthongs also arise in the juxtaposition of two vowels. If one of two juxtaposed vowels is (or becomes) non-syllabic--i.e. if the two vowels are mapped onto a single syllable--a diphthong arises. This combination of two full vowels into a single syllable can result in a rising diphthong, which parallels the CV syllable and thus forms an optimal syllable, or it can result in a falling diphthong, which remains the prosodic equivalent of two (short) vowels. Thus, two vowels may become V̯V if open syllables are favored, or VV̯ if their original two-mora length is to be maintained.

(4.3a) The former principle appears to be at work in Sanskrit; when two high vowels are adjacent, the first loses syllabicity: madhu + iva → madhviva 'honey-like', vi + usti → vyusti 'daybreak' (Whitney 1960:44-5).

The assignment of syllabicity to one of two adjacent vowels may also depend on the qualities of the adjacent vowels. If they differ in sonority, the less sonorant of the two typically becomes the non-syllabic, so that, for example, i + a would become [ja], but a + i would become [aj], with the less-sonorant i becoming non-syllabic regardless of its order in the two-vowel sequence.

(4.3b) This also happens in Sanskrit. When a high vowel (or r) is followed by a lower vowel, a rising diphthong is formed; e.g. iti 'thus' + āha → ityāha, vadhu 'bride' + āi 'name of Shiva' → vadhvāi. And when a low vowel is followed by a higher vowel, a falling diphthong results (these falling diphthongs, ai and au, become e and o--both long--respectively): raja 'king' + indra 'Indra' → rajaindra → rajendra; hita 'advantageous' + upadeçah 'instruction' → hitaupadeçah → hitopadeçah (cf. Whitney 1889:43-4).

In languages which assign stress and then desyllabify certain vowels, stress is a condition on desyllabification. Vowel sequences typically remain bisyllabic if both vowels are stressed.

(4.3c) Thus, in English, syllabicity may be lost from the unstressed /u/ of do in phrases like How do I look? [haudɣaj‖ʊk], or Do eagles eat fish? [dɣ‖gl̩zi‖fɪ], but the stressed /u/ of Did they do it? or Do eat some pie may not reduce to [ɣ]: *[dɪdðe‖dɣɪt], *[dɣ‖tsʌmpaj].

(4.3d) Similarly, in Spanish, the unstressed /i/ of y 'and' in cantó y bailó 'he sang and danced' reduces to [j]: [kanto‖baj‖o], but the stressed /i/ of himnos 'hymns' in cantó himnos [kantoimnos] 'he sang hymns' remains syllabic (cf. Saporta 1956 [1963:404]).

The matter of stress is relative. Stress need not be primary to prevent desyllabification; often, a secondary stress will suffice to keep a vowel syllabic. But on the other hand, stress need not be entirely lacking to allow desyllabification, especially in hyperarticulate styles; a weakly-stressed vowel may desyllabify if it is adjacent to a very strongly stressed one: Did they do ánything? [dɪdðe‖dɣénɪθɪŋ].

When two vowels are combined into a single syllable, then, several considerations determine whether the result is a rising or a falling diphthong (assuming that neither vowel is deleted or completely assimilated to the other):

a. Preferred syllable structure: V̂V more closely adheres to the CV syllable canons preferred--or required--by many languages;

b. The requirements of timing: VV maintains the same prosodic quantity as V.V, while V̌V represents a shortening;

c. The relative degrees of sonority of the two vowels: the more sonorant is the preferred syllabic;

d. The relative stress or accent levels of the two vowels: the less-stressed or unstressed vowel is the one that will desyllabify.

4.2.3. Diphthongs from single vowels.

A single vowel is usually said to become a diphthong when it changes in quality over part (very roughly speaking, half) of its duration. Once a single vowel has become a diphthong, the factors cited above strongly influence its development, determining how the syllabic and non-syllabic 'halves' will change (the non-syllabic may become less sonorant, for example), whether syllabicity will remain on the original syllabic or be shifted, etc. The original diphthongization of a simple vowel, however, typically produces a falling diphthong: V(:) → VV̯. Some exceptions to this generalization are only apparent exceptions,

(4.4a) like the development of Common Norse é (long e) to ié or jé in Old Icelandic (Mod.Ice. [jɑ:]) fié (fé) 'livestock', miér (mér) '(to) me' (Noreen 1913,§94). It may be argued that é went through an intermediate stage as an in-gliding or down-gliding falling diphthong, like [eɛ̯] or [iɛ̯], since é becomes īe, ie, ea (also ēi, ei) in other Scandinavian languages (Haugen 1976:256), and especially since other falling diphthongs in Icelandic become rising diphthongs (cf. (4.5b), below).

Others seem to be the result of a requirement for CV syllable structure (especially word-initially), and thus may be a special set of cases.

(4.4b) For example, Andersen (1972:29) cites the use of prothetic [i̯] and [u̯] before originally-initial vowels in many Polish dialects: igła [i̯ɨgwa] 'needle', Ewa [i̯eva] 'Eve', owies [u̯ovés] 'oats', etc. This change occurs in other Slavic languages as well, e.g. in Russian vosem' vs. Serbo-Croatian osam 'eight'.

(4.4c) Andersen also cites cases of diphthongization of syllabic consonants, noting that l(:) becomes lu(:) in Czech: compare Slovak tlstý 'thick', tĺk 'pestle', and Czech tlustý, tlouk (with /ou/ < /u:/) (p.34).

These are exceptions to a more general rule, however; a great majority of diphthongizations result in falling diphthongs--sequences of vowels in which the syllabic is first.

In the usual case of diphthongization, when the diphthongizing vowel is long or lengthened, a falling diphthong is the exact result one would expect, because a falling diphthong maintains the bimoric prosodic value of the original vowel. But in the relatively rarer case of diphthongization of short vowels, the result may still be a falling diphthong (cf. 2.3.4.4).

Diphthongs may also arise from single vowels, especially lengthened vowels, by assimilation to an adjacent consonant.

(4.5) In some American dialects, especially in the South, palatal vowels become diphthongs by assimilation to the height of certain palatal consonants: e.g. [mæ:ʃ] mash → [mæɐ̯ʃ], [kræ:ʃ] crash → [kræɐ̯ʃ], [bæ:ɡ̟] bag → [bæɐ̯ɡ̟], etc.

Such diphthongs do not ordinarily undergo fortition processes, which would continue the differentiation that assimilation to consonants incidentally begins, unless they are reinterpreted as diphthongs (as [lɛi̯ɡ̟] leg and [ɛi̯ɡ̟] egg, which arise by the same process from [lɛɡ̟] and [ɛɡ̟], are reinterpreted as having the same vowel as bake, laid). (Cf. Donegan and Stampe 1978a, Sec. 3.2.1.)

4.2.4. 'Insertions'.

In closing this sketch of the sources of diphthongs, I wish to point out that there does not seem to be any reason to believe that diphthongs arise by insertion of glides (or vowels), as is sometimes suggested. Diphthongs originate in segments that already exist, as when two vowels become adjacent and one loses syllabicity, when a consonant adjacent to a vowel vocalizes, or when one 'half' of a single vowel undergoes a change in quality so that the two halves are no longer identical.

Diphthongs formed from a vowel and a vocalized consonant, or from two juxtaposed vowels, start out from two dissimilar elements, so the question of insertion does not ordinarily arise in such situations. Diphthongs from single vowels, on the other hand, seem to start out as one segment and end up as two, so here the question does arise, especially when the equivalence of long vowels with vowel-glide sequences is ignored.

But even if it is maintained that the monophthong from which a diphthong arises is a single segment (cf. 2.3.4.4), it seems wrong, for several reasons, to claim that in diphthongization a vowel--syllabic or

non-syllabic--is inserted. First, such a claim confuses prosodic with segmental changes. Diphthongization itself is a change in vowel quality, not a change in timing; note that the insertion of a glide of identical quality with the vowel it followed would be a way of describing a timing change but would not be considered a diphthongization. Diphthongization is not necessarily connected to timing change. Although it often follows upon (or even seems to co-occur with) lengthening, it may also be related to shortening: diphthongization of lexically (distinctively) long vowels--as in the histories of Faroese and English--may occur just when those long vowels are about to be shortened in certain contexts (apparently a 'prophylactic' change to prevent merger with their short counterparts). Second, proponents of the notion that diphthongs arise by insertion do not seem ever to address the question of why the 'inserted' element is always only minimally different from its environment at the onset of diphthongization, though the ultimate difference between the two elements may be extreme (as when [i:] becomes [ai], for example).

Both of these problems can be avoided by regarding lengthening and diphthongization as separate phenomena, one prosodic, the other segmental. Lengthening is the temporal extension of an element that is already present. Diphthongization is the change in quality of part of a (more or less extended) single element by ordinary segmental processes applying dissimilatively; since this single element is originally homogeneous, the initial difference between the parts will be minimal, though the ultimate difference may be extreme, because each phonological process makes minimal changes.

4.3. The development of diphthongs.

The basic fortition processes which affect vocalic elements in diphthongs are identical with those that affect simple vowels, as described in Chapter III. A few further comments on their application, specifically in the development of diphthongs, follow.

4.3.1. Dissimilation.

Once a diphthong has arisen--whether by consonant vocalization, by desyllabification of a vowel, or by dissimilative application of a fortition process to one 'half' of a vowel--fortition processes may apply--given appropriate conditions of accent, duration, etc.--to both of its parts. As noted earlier, fortition processes increase one phonetic property at the expense of another. These processes apply most freely in dissimilations because here the weakened feature may be preserved in the environment, so no information is lost.

In diphthongs, since the vocalism consists of two parts, the incompatible properties of sonority and color can be assigned to different segments. In the strong positions which favor the application

of fortitive processes, each 'half' of the diphthong is granted sufficient articulatory effort and perceptual importance to allow it to increase its suitability for its function, so dissimilation results when the color-bearing element becomes more chromatic (via Tensing and/or Raising) and the sonority-bearing element becomes more sonorant (via Laxing, Bleaching, and/or Lowering).

This dissimilative or polarizing principle accounts for the fact that, in diphthongs, vowels often lose the properties which are most strongly present in an adjacent segment and acquire or increase properties which are weak or absent in an adjacent segment. The contextual conditions on Bleaching, for example, suggest that the syllabic of [æe̯] is more susceptible to Bleaching than that of [ææ̯] ([æ:]), but less susceptible than that of [æi̯] because, other things being equal, [æ] is more susceptible to <u>loss</u> of palatality in environments which are more capable of <u>preserving</u> palatality, and because [æ] is more susceptible to increase of sonority in environments which are (relatively) weakly sonorant. In similar fashion, this compensation aspect seems to be a factor in the tensing and raising of in-gliding diphthongs; if the second part of a vowel loses color, the first becomes especially susceptible to processes which increase its color.

But sonority and color are not the only incompatible properties which mark vowels. Diphthongs like [iu̯] and [oe̯], in which neither element is highly sonorant as compared to the other show that increasing sonority while maintaining color is not the only motivation for dissimilation in diphthongs. It may be that diphthongization begins in the polarization of color and sonority, but such developments as the delabialization and depalatalization (respectively) of the two halves of a bichromatic vowel, as in [y] → [iu̯] or [iu], or dissimilative coloring and tensing as in [ɨu̯] → [ɪu̯] → [iu̯] show that dissimilations may occur which do not continue a sonority-color polarization, but which instead polarize the incompatible colors of palatality and labiality, perhaps in the interest of achieving a more perceptible, because dynamic, tonality. A lowering of the [ɨ] of [ɨu̯], for example, would produce a more optimal, because more sonorant, syllable nucleus--one which is better suited to its vocalic functions (cf. Sec. 2.2) as voice-bearer, consonant-bearer, etc. The coloring of the [ɨ] of [ɨu̯] ([ɨu̯] → [iu̯]) produces instead a more optimal, because more differentiated, diphthong; it thus reflects the functions of vowels as distinctive elements.

4.3.2. Syllabicity shift.

Another important aspect of the development of diphthongs is the matter of which of the two vocalic elements is syllabic (that is, which of the two falls under the accent, or on the beat, for timing purposes). The falling diphthongs which are the typical result of diphthongization of single vowels may become rising diphthongs by syllabicity shift, in which the property of syllabicity is transferred

from the first vocalic element to the second: V̥V → V̥V. Syllabicity shift is also known as accent shift or intensity shift. The factors which determine whether syllabicity will shift from the first to the second element of a diphthong are nearly the same as those which determine the initial assignment of syllabicity (cf. Sec. 4.2.2):

a. the relative degrees of sonority of the two segments,

b. the syllable-type preference, and

c. the timing system of the language.

As Andersen (1972) notes, intensity--syllabicity-- is normally assigned to the element of a complex nucleus that is closest to the vocalic optimum; that is, the more sonorant element is or becomes the syllabic. Thus, if the non-syllabic second element is lower and thus more sonorant than the syllabic--as in a diphthong like [i̯e], The more sonorant vowel may become the syllabic ([i̯e]), so that the accent peak can coincide with the segment of greatest intrinsic intensity. Simultaneously, this will cause the more chromatic vowel to become non-syllabic; the shift thus selects the less sonorant, more consonant-like element of the diphthong for the consonantal function of onset glide.

Syllabicity shifts with this motivation often affect down-gliding or in-gliding diphthongs. For example:

(4.6a) Daniel Jones (1940:58, note 11) remarks that in the pronunciation of English [ɪə̯] (from /ɪr/) it is 'not uncommon to meet with Southern English speakers who in many words do not give sufficient force to the ɪ to make it predominate over the latter part of the diphthong. Instead of pronouncing dear dɪə̯, they say dɪə (which is nearly the same as dɹə:). Some even pronounce dɹə:.'

(4.6b) A similar shift appears to have occurred in Old Icelandic, where syllabicity was shifted from the first to the second element of the following diphthongs:
ea > ja *dearfr > djarfr 'bold, daring';
eo > jo > jǫ *eofurr > jǫfurr 'prince';
éa, ía > já séa > sjá 'see', fíande > fjándi 'enemy';
éu, íu > jú *deupr > djúpr 'deep', *hiwu > hjú 'household';
eu > éo > jó *beuðan > *béoða(n) > bjóða 'offer, invite, challenge' (Gordon 1957:274).
éa, ía > já represents contraction of disyllabic sequences, but it seems reasonable to believe that the contraction occurred before the syllabicity shift; otherwise we would have to assume the desyllabification of the long vowels é and í. This Old Icelandic shift

seems also to have affected long ē, which became [je:] (cf. (4.4a)).

In cases in which an apparently lower first element becomes non-syllabic, it seems reasonable to assume that the first element is raised either before or when it loses its syllabicity, so that its color increases as it becomes the color-bearer of the diphthong.

(4.6c) Midlle High German ie (< *ē²), which elsewhere became standard New High German ī (as in bieten, diep, tier), became je in some words with relatively weak sentence stress, like iegelicher, ieman, ietweder, iezuo (> jeglicher 'everyone', jemand 'someone', etc.) (Priebsch and Collinson 1934:151).

(4.6d) Andersen (1972:23-4) cites the shift of earlier English [ɨu̯], still current in New England and eastern England new, few, to [ɻu:] as evidence that syllabicity is better borne by low-tonality vowels.

Andersen's suggestion that this shift is based on tonality would be better supported if he also gave examples of syllabicity shift in the other direction that made the lower-tonality vowel syllabic--i.e. shifts from rising to falling diphthongs, like [u̯i] → [uɻ] or [o̯e] → [oe̯], for example. He does not, and I know of no such examples myself. And one must also remember that tonality is not entirely independent of sonority; low-tonality vowels are, ceteris paribus, more sonorant (more intrinsically intense) than high-tonality vowels (cf. Fant 1956: 52-3), and are thus closer to the 'vocalic optimum'.

This last shift brings to mind other syllabicity shifts, which appear to go against the principle that syllabicity is most typically shifted to a more-sonorant element. There are cases in which adjustments of sonority co-occur with the shift of syllabicity (and do not necessarily precede it) that suggest that the motivation for syllabicity shift is not always based on differences of relative sonority.

(4.7a) The development of Old French oi to ue, from which comes Modern French [u̯a] or [wa], as in moi [mwa] < mue < moi < me:, or toit [twa] < tuet < toit < tectus (Pope 1934:194-5) suggests the transfer of syllabicity to a less sonorant segment (a palatal vowel of equivalent height) even if we assume that the second half of oi lowered before the shift.

(4.7b) In Yorkshire English, there is an occasional shift of [uɪ] or [uɻ] to [u̯ɪ] or [wɪ:]: cushion [ku̯ɪʃn] or [kuɻʃn]--with an intrusive palatal glide before the palatal [ʃ] as in many dialects--becomes in Yorkshire [kwɪʃn̩] or [kwɪ:ʃn̩] (Kolb 1966:350).

(4.7c) In some southern U.S. dialects where [ɒ̯ɐ̯] becomes [ɔ̯ɐ̯] in boy, coin, etc., an occasional syllabicity shift produces the rising diphthongs of [bo̯ɑ] boy, [go̯ɑn] goin' (← [go̯ɐ̯n]), etc.

It must be noted that, at least in the cases of French and Southern U.S. English, these syllabicity shifts are closely associated with a strong preference for open syllables. In later Old French and early Middle French, both falling diphthongs and closed syllables were systematically (though not entirely) eliminated (Pope 1934:191 et passim). The Southern U.S. preference has had less drastic results, but it is in part responsible for many of the differences between 'general Southern' and 'general Northern' U.S. dialects. (Note the southern monophthongization or near-monophthongization of the falling diphthongs of buy, bough, boy, the southern syllable-division of Billy [bɪ.lɪ] vs. northern [bɪɬ.l̩], etc. (cf. Bailey ms.).)

(4.7d) Shevelov and Chew (1969) point out that similar phenomena also mark the development of Japanese: Old Japanese iu > yu: and eu > yó: at about the same period in which ei > e:, ou > o:, and au > o:.

In all three of thses cases, monophthongizations, syllabicity shifts, and loss of syllable-final consonants co-occur as manifestations of a tendency to open all syllables. When syllabicity shift occurs as part of such a pattern, syllable-opening is surely involved in its motivation.

In French, the tendency to open all syllables had the effect of making all syllables equally long: V̯V were eliminated either by monophthongization or syllabicity shift, no vowel length distinction existed, and few closed syllables survived. As C(V̯)V became the (principal) syllable form, syllable length was equalized; and there is reason to believe (Stampe 1973c) that a shift to syllable timing was the unifying force behind a wide variety of changes at this period.

In Japanese, on the other hand, a vowel length distinction did exist, and, just as length was maintained in monophthongization (ei became e:, not e), length was also maintained in syllabicity shift: iu became yu: (not yu), and eu became yo: (not yo). This is what one would expect to happen in a mora-timed language (Stampe 1973c). Note that this shift is perfectly straightforward if understood prosodically: what starts out as two moras ends up as two moras. The shift would seem far less natural--involving gemination of the second element or insertion of a non-syllabic third element--if one insisted on a purely segmental explanation.

As noted in the brief discussion of the Frisian syllabicity shift described in Chapter II (2.18), lengthening (or shortening) may also be a motivating factor in determining syllabicity assignment. A diphthong which appears as V̯V in a lengthening environment (a stressed, open

syllable, or a monosyllabic word) may appear as V̯V in an environment which favors shortening (an unstressed or closed syllable, or a polysyllabic word). Here a longer (2-mora) falling diphthong, VV̯, alternates with its shorter (1-mora) rising counterpart, V̯V, as in doas/doaske [doa̯s]/[dwɑskə], etc. There are similar cases of alternation.

(4.8a) In the Lappish dialect of Jukkasjärvi, 'the diphthongs with rising sonority [these are /ɐɛ, ɔɔ, uo/] have the main stress on the second component when they are comparatively short (prosodically equivalent with the shorter grade of etymologically long vowels...), but the main stress on the first component when they are comparatively long (prosodically equivalent with the longer grade of etymologically long vowels)' (Collinder 1940:23). The dialect thus has the falling diphthongs [eɐ̯, oɔ̯, uo̯] in 'long' positions--in open initial (i.e. stressed) syllables--and the rising diphthongs [e̯ɛ, o̯ɔ, u̯o] in 'short' positions.

It is notable that in Frisian, as well as in Lappish, the alternation between short vowel, rising diphthong, and long vowel affects only diphthongs 'with rising sonority'--i.e. those in which the second element is no higher than the first: in-gliding or down-gliding diphthongs. The other Frisian diphthongs [ɑi̯, ɛi̯, ʌy̯, oi̯, ɔu̯]--all up-gliding or out-gliding--do not undergo the shift. In both languages, apparently, the requirements of shortening and lengthening do not override the sonority and color characteristics of the individual elements of the diphthongs.

(4.8b) A further syllabicity shift appears in Modern Vietnamese. Canh (1974) reports that the in-gliding diphthongs ia, ɯ̯a, ua [iɐ̯, ɯɐ̯, uɐ̯] occur syllable finally, while iê, ɯ̯ɔ̯, uô [ie̯, ɯɣ̯, uo̯] occur non-finally.

Here the allophonic distribution of diphthongs serves to equalize the length of syllables, making all syllables consist of at least two moras.

4.4. *Length, lengthening, and diphthongization.*

As I have noted in various places in this and earlier chapters, length favors diphthongization. The greater the duration of a vowel, the greater the opportunity for heterogeneous articulation, and the greater the possibility that two targets--articulatory and perceptual--will replace one. A vowel which is extended in duration is especially susceptible to changes which affect it only over part of its duration, and to the further dissimilations which follow upon such initial changes. And as I have also noted, it is not only distinctive length which favors diphthongization; context-determined length is just as likely to produce diphthongs; and even intrinsic length may occasionally be a factor in diphthongization.

4.4.1. Accent, timing, and diphthongization.

The relationships among length, lengthening, and diphthongization become especially apparent when one surveys the long-term vowel histories of certain languages and language families. In some languages or families, the vowel systems are quite stable; over centuries, vowel changes are few and relatively minor. Japanese, Finnish, and the Dravidian languages, for example, contrast sharply in this respect with the Germanic and even the Romance languages. The extensive vowel quality changes which have occurred in most Germanic languages and in some varieties of Romance (especially in French) appear to be associated with a loss of contrastive vowel length and the replacement of an iso-moric timing system allowing (near-) double time for long vowels (as in Japanese and, presumably, in Classical Latin) by an iso-accentual timing system--one which aims at equal time between accents or stresses.

An iso-accentual system, of course, makes it very difficult to maintain a vowel-quantity distinction because--speaking quite generally --in such systems unaccented vowels tend to be shortened and accented vowels lengthened; further, accented vowels in short words (i.e. in short accent groups) show a tendency to be lengthened and those in longer words, to be shortened. Iso-syllabism also plays a role in stress-timed languages like the Germanic ones, in that accented syllables show some tendency to all be equally long, and unaccented ones, to be equally short. Thus, accented vowels in open syllables may lengthen, and those in closed syllables, especially heavily closed syllables (with two or three offset consonants), may shorten (cf. Stampe 1973b, c).

The reasons for shifts from one type of prosodic system to another are well outside the scope of this thesis, but, once begun, a shift to stress-timing--with its lengthenings in open syllables and in monosyllabic words, its shortening in closed syllables and polysyllabic words, its reduction and deletion of unstressed vowels, etc.--may have extensive effects on the segmental as well as temporal character of vowels.

Such extensive temporal adjustments threaten a vowel quantity distinction because if the quality of /ɨ/ is identical to that of /ɨ:/, lengthened /ɨ/ and shortened /ɨ:/ may become indistinguishable. To help prevent confusions of long vowels with their short counterparts, a quality difference is often superimposed on the durational difference: long vowels are tensed and short vowels are laxed. If the quantity difference is eroded to the point of extinction, the distinction is reinterpreted as tense vs. lax. (It is of interest that in certain languages, like Japanese, where mora-timing is entirely undisturbed, there is no regular tensing of long vowels and laxing of short vowels.)

Further qualitative changes often ensue. The old-long/now-tense vowels may be diphthongized--often as up-/out-gliding diphthongs (as in Faroese, etc.), particularly when they are lengthened by context (as,

for example, in French)--or they may be raised, as in English. The old short vowels--now lax--may also undergo qualitative changes. Especially when they are lengthened, they may diphthongize (as in various Low German dialects)--often as in-gliding or down-gliding diphthongs, or they may lower (as in English 'open syllable lengthening' or as in the Aurland (Sogn) dialect of Norwegian (cf. Grundt 1976:20)).

It is worth noting that, in both the Romance and the Germanic cases, the 'low vowel', /ɑ(:)/, is treated differently from the other vowels. In Romance, short and long a merge, unlike the other short/long pairs. In the Germanic languages, either the long or the short a colors, or both do so. Since the tense/lax distinction is inapplicable to achromatic vowels, the Latin a's merge because they do not color, and the Germanic a's color so that they do not merge.

The segmental changes which follow upon the prosodic changes and the loss or reinterpretation of distinctive length are actually the results of the same phonological processes (fortitions and lenitions) in language after language, but, since these processes apply in different combinations (e.g. Bleaching and Lowering, or Bleaching and Coloring, or Lowering without Bleaching), in different chronological orders (e.g. Palatalization, then Raising; or Raising, then Palatalization), and with differing degrees of generality (e.g. non-high vowels delabialize; or low vowels delabialize; or non-high vowels delabialize before labial glides), the cumulative effects of the many individual changes produce a wide variety of ultimate outputs. A few basic patterns of diphthongization may be recognized, however:

a. Tense vowels are often diphthongized as tensing, up-gliding, or out-gliding, with subsequent dissimilation of color. Historical examples include Faroese:

$\underline{\text{í}}$, $\underline{\text{ý}}$ → ɪi̯ → ɨi̯ → ʊi̯
$\underline{\text{á}}$ → ʊu̯ → ɨu̯ → ɪu̯ (→ ʏu̯)
$\underline{\text{ó}}$ → ɔu̯ → ʌu̯ → ɛu̯ (→ øu̯) (cf. Rischel 1968),

and early French:

$\underline{\text{u}}$(:) → ʊu̯ → ɨu̯ → ɪu̯ → iu̯ (→ y)
$\underline{\text{o}}$: → ɔu̯ → ʌu̯ → ɛu̯ → eu̯ (→ ø)
$\underline{\text{e}}$: → ɛi̯ → ʌi̯ → ɔi̯ → oi̯ (→ wɛ) (cf. Pope 1934),

and current examples include dialects of English (Australia, Norwich, Coastal North Carolina) and Malmö Swedish, which may have [ɨu̯], [ɪu̯] or [eu̯] for [u:], [ʌo̯] or [ɛo̯] for [o:], etc.

b. Tense vowels may diphthongize as tensing, up-gliding, or out-gliding, with following height dissimilation and, often, with color dissimilation as well. This occurs historically in English, Standard German, Yiddish:

$\underline{\text{i}}$: → ɪi̯ → ɛi̯ → ʌi̯ → ɑi̯ (→ ɔi̯)
$\underline{\text{u}}$: → ʊu̯ → ɔu̯ → ʌu̯ → ɑu̯ (→ ɑʊ̯ → æu̯) (cf. Stampe 1972,

Priebsch and Collinson 1934, Sapir 1915).
This also occurs in some American dialects (Tennessee and North Carolina [aɪ̯] for [ɛɪ̯], Boston children's [eɪ̯] and [oʊ̯] for [i:] and [u:], etc.), and in Malmö Swedish (with [eɪ̯] for [i:], [øʏ̯] for [y:], etc.).

c. Lax vowels, especially when lengthened, may diphthongize as in-gliding or down-gliding. They do so in the histories of French and Spanish:

e ɛ: → eɛ̯ → iɛ̯ → iə̯ (→ i in French, i̯e in Spanish)
o ɔ: → oɔ̯ → uɔ̯ → uə̯ → uɛ̯ (→ ø in French, u̯e in Spanish)

and in Faroese:

e ɛ: → ɐɑ̯
o ɔ: → oɑ̯ (cf. Rischel 1968),

and currently, in Malmö Swedish, in Icelandic, and in many American dialects of English.

These are not the only patterns of possible diphthongization, of course. There may be others, and it may be possible to specify even the three I have mentioned more precisely. It should be recognized, however, that the patterns noted here have no special status or causality of their own. They result from the interplay of individual processes; and the changes they include are constrained by the hierarchical limitations on the individual processes.

4.4.2. Vowel Shifts.

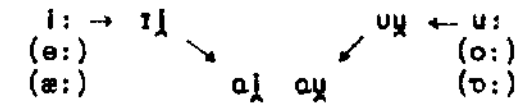
Vowel shifts can occur with little diphthongization, and many of the 'classic' examples of vowel shift--French, for example, and São Miguel Portuguese--are often discussed (though, I think, misleadingly) with no reference to diphthongization at all. But an important question, often overlooked in discussions of vowel shifts, is that of why diphthongization is so frequently an important factor in these shifts.

In the Germanic languages, at least, as the long-short distinction is eroded by the shift to stress-timing, the tense-lax distinction assumes increasing importance in maintaining the lexical distinctions previously marked by length (duration). Particularly in stressed syllables, speakers have phonological occasion for increasing the phonetic properties of the vowels in such ways as to emphasize the distinction. And the increased length of the vowels in these syllables, especially in open stressed syllables, is an ideal phonetic condition for increasing their phonetic properties. Consequently, the phonetic properties of both tense and lax vowels are increased--sometimes by increasing color in tense vowels (by Raising, as in English, or as in the French back vowels of closed syllables), and sometimes by increasing sonority in lax vowels (by Lowering, as in English or Aurland Norwegian). In such circumstances, diphthongization is another alternative, a way of

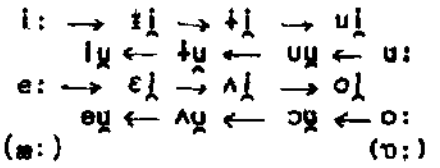
applying fortition processes to increase color without decreasing sonority, or to increase sonority without loss of color. Since the vowels of stressed syllables are often long, or lengthened, diphthongization is frequently the chosen alternative.

In general, it appears that tense or higher vowels are most susceptible to diphthongization as up- or out-gliding diphthongs, and that lower or lax vowels are most susceptible to in-gliding or down-gliding diphthongizations. There may be exceptions to these tendencies, however, as in the case of ie and uo, from e: nd o: in the Baltic languages; McKenzie (1922) argues from dialect evidence, from loans, etc., that these diphthongs arose from the tense monophthongs [e:] and [o:] ('e fermé', and 'o fermé'). Also, in Finnish, ee is raised to ie (3.14a), but ää is not raised to eä in all dialects where the mid vowel is raised. Even a high tense vowel may acquire an in-glide; Major (1977) reports [i:] → [iɐ] in the Portuguese speech of his bilingual daughter, and in some Brazilian speech, in Rio de Janeiro.

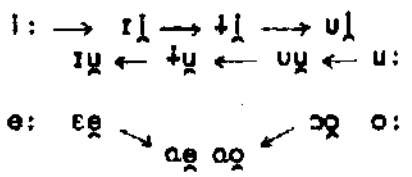
It further appears, in general, that if only the high vowels diphthongize, they often become diphthongs that polarize sonority and color with height dissimilation, as in English, Standard German, Yiddish, etc.:



But if several vowel heights diphthongize, as in Faroese, French, Australian or North Carolina English, etc., dissimilation of color often occurs:



Of course, both height and color dissimilation may occur, affecting different vocalisms, as in the Soest dialect of Low German, where Germanic *ī and *ū have become [ʊi̯], [ɪu̯], and *ē², *ō have become [ɑe̯], [ɑo̯]:



--or dissimilating both height and color in the same diphthongs, as they do in Australian and North Carolina English, where /ɑi/, /ɑu/ (< ME ī, ū) become [ʊe̯], [æo̯], or in Yiddish, where *[y:] (< MHG ū) has become [ʊi̯].

It is often the case that up- or out-gliding diphthongization and in- or down-gliding diphthongizations occur in the same language or dialect, but the two phenomena are not directly related, either phonetically or phonologically; they occur independently of each other. For example, American English speakers who say [rɪi̯d] for reed do not necessarily say [rɪê̯d] or even [rɪɨ̯̂d] for rid--and vice versa. Certainly there are many English speakers who say [pɛi̯d] for paid but [bɛ:d]--not [bɛê̯d] or [beê̯d]--for bed. And while early French diphthongized lengthened e̯ and o̯ to out-gliding diphthongs and lengthened e̯ and o̯ to in-gliding diphthongs, early Spanish underwent only the latter diphthongization (ɛ: → eɛ̯̂ → iɛ̯̂ → iê̯ → i̯e vĕnit > viene, dĕce > diez; ɔ → oɔ̯̂ → uɔ̯̂ → uê̯ → uɛ̯̂ → uê̯ → u̯e rŏta > rueda, bŏnu > bueno, etc.) (Menendez Pidal 1944:54-60).

As I noted earlier (Section 3.4), the changes which together make up a vowel shift are individual changes, separately carried out. The individual changes (like tensing or raising of glides and laxing or bleaching of glides) may share some common phonetic conditioning factor (such as length). They may also be related phonologically in that one change (A) is not allowed to occur until another (B) has altered a segment that might have been merged with, had A occurred first (i.e. A may be kept from applying until B has 'moved a segment out of A's path'). But as we shall see in Chapter V, phonological conditioning factors are always matters of limitation rather than motivation of changes.

4.4.3. Length and diphthongization.

In the Germanic languages, tense vowels and lengthened lax vowels in stressed syllables are, as we have seen, extraordinarily susceptible to diphthongization. This appears to be a consequence of their length--first, the length of the original long, tensed vowels, and then the length of stressed syllables. This seems to be why the Germanic diphthongizations typically produce falling (VV̯) diphthongs, which are usually the prosodic equivalent of long vowels.

But diphthongization does not occur only--or even principally--as a means of maintaining a vanishing length distinction. The existence of a length distinction alone is not a sufficient condition to require diphthongization (witness Japanese, Finnish, and many other languages), and it is not a necessary condition either. The diphthongizations which occurred in the Romance languages occurred after the length distinction of Classical Latin had been entirely lost; the length which conditioned them was entirely contextually determined, and the segmental conditions for diphthongization were quite independent of the old length distinction. In fact, in the Germanic languages themselves, where maintenance of an old length distinction clearly has played an important role in diphthongization, diphthongization has continued long after the old distinction was re-established on other phonetic grounds.

In Romance, the relationship between the loss of distinctive length and diphthongization was not one of cause and effect, but one of shared causality. Length was lost because of an apparent change in the timing system from the mora-timing of Classical Latin to what appears to have been stress-timing in Vulgar Latin and early Romance. (The syncope of unstressed vowels, and the mergers and reductions of vowels in unaccented syllables--processes often found in stress-timed languages--are suggestive of this timing change.) The stress-timing system which shortened or deleted the vowels of unaccented syllables lengthened those of accented syllables--and this lengthening allowed diphthongization.

The aspect of the Germanic languages which underlies the continuation of diphthongization is the continued length of the stressed vowels, in contrast to languages like French or Spanish, which have undergone a further shift to syllable-timing (coinciding with periods of monophthongization, syllabicity shift, etc.), and which consequently have less of a length difference between accented and unaccented vowels. In a language like English, even a 'short' vowel like the [ɪ] of sit may diphthongize in a stressed syllable, particularly in a monosyllabic word. For example, in Tennessee, sit may be misheard as see it--as in Do you want to [sɪ̯ɪt] here? Although this [ɪ] may be short for a stressed vowel in a monosyllable, it is nevertheless relatively long--long enough to be interpreted as disyllabic, and certainly long enough to diphthongize.

Clearly, it is not just the presence or preservation of a length distinction which motivates diphthongization, but the phonetic durations of the diphthongizing vowels themselves. This recalls a basic claim of the theoretical framework in use here (cf. Stampe 1969, 1973a, Donegan and Stampe 1978a): that phonological substitutions, and the historical changes that result from them, are phonetically (not phonologically) motivated.

V - PHONOLOGICAL SYSTEMS

5.1. The organization of processes.

In Chapter III, I attempted to show how the form of each natural process is directly related to its function. The organization of the set of natural processes and the manner of their application is likewise related to their functions. Natural processes apply to overcome specific difficulties presented to the speech capacity; one should expect them to be organized so as to apply to overcome these difficulties in ways consistent with their teleologies. This assumption--that process application, as well as process form, should be consistent with process functions--underlies the application principles proposed in Donegan and Stampe 1978a. The theory of simultaneous, phonologically constrained process application proposed therein is not a central issue of this thesis, but I will briefly discuss some of its principles here because they may contribute to an understanding of vowel substitutions, especially vowel shifts.

5.1.1. Natural applications.

Since the function of processes is the elimination of difficulties, the optimal-- 'most natural'--manner of process application is unordered or free iteration, in which a process applies whenever its input conditions are met, so that a difficulty may be eliminated whenever it arises, even if it is created in the course of a derivation by the application of another process. But processes do not always apply in this 'most natural' manner. For a number of reasons, constraints must be, and are, imposed.

The application of natural processes, in eliminating difficulties, also eliminates distinctions (cf. Stampe 1973), as the application of delabialization eliminated the distinction between ʏ and ɪ in Faroese, or between /ɔ/ as in bought and /ɑ/ as in cot in some Midwestern American dialects. Likewise, the natural iteration of these processes may eliminate distinctions that might instead be preserved if a process were constrained not to re-apply--as the re-application of palatal raising in early Modern English eliminated the distinction between Middle English ē as in sleep and ē as in reap. In the original raising of the English vowel shift, Middle English ē became ē and ē became ī; in this later re-application of Raising, the new ē (< ME ē) also became ī and was thus merged with ME ē. My use of a historical example here is not accidental. Synchronic re-applications of a

single process like this are rare.

They are, in fact, sufficiently rare that most theories of process application assume that each process may apply only once. In standard generative phonology (as in Chomsky and Halle 1968), a linear order of application is also assumed, in which process A applies, then process B applies to the output of A, then process C applies to the output of B, and so on, with each process applying only once. Anderson (1969) has argued that this scheme is too restrictive to account for many rule applications and has offered the alternative of local ordering--in which each process would apply only once, but the order of a pair of processes A and B may differ from form to form (with A preceding B in some derivations and B preceding A in others) based on 'natural ordering principles'. However the nature of these principles is not altogether clear, and Kenstowicz and Kisseberth (1977) cite cases where Anderson's proposals do not apply. Koutsoudas, Sanders and Noll (1974) have offered a different sort of alternative, which avoids the assumption of ordering altogether; in their theory, rules apply simultaneously. This has the advantage of placing the applications of separate processes in the same relation to each other as the applications of the subparts of a single process. (In a synchronic analysis of the São Miguel Portuguese vowel shift, for example, the raisings of labial vowels--[ʊ] → [o], [o] → [u]--would be simultaneous in any process framework, but labialization of [a] to [ʊ], which involves a different change, would be a separate process and would follow raising if processes are assumed to apply in sequence.)

Stampe (1973a:59ff.) showed not only that processes must be allowed to apply in feeding orders, but that they must be allowed to reapply within derivations to the outputs of other processes. In Donegan and Stampe 1978a, the simultaneous application proposal of Koutsoudas et al. is modified to allow for constraints against the re-application of processes. When processes are viewed as applying simultaneously, re-application or iteration produces outputs previously attributed to 'counter-feeding' (ibid.). For example, with two processes like

A: VV → V̲V̲ and B: C → ∅ / V_V

in a linearly ordered system, B feeds A if B precedes A; and B counter-feeds A if B follows A. In a system in which A and B apply simultaneously, the 'feeding' effect is achieved if A is allowed to re-apply, and the 'counter-feeding' effect is achieved if A is not allowed to do so. If re-application occurs, the underlying representations VV and VCV are merged in surface representation, as V̲V̲; if A does not re-apply, VV and VCV are distinguished in surface representation, as V̲V̲ vs. VV. Variable feeding (feeding in some styles, counter-feeding in others) is due to the relaxation, in some styles, of the constraint against re-application.

Feeding and counter-feeding are accounted for in theories which assume sequential application, whether linearly or locally or randomly (Stampe 1973a) ordered, by ordering-statements like 'B precedes A' or 'A follows B' (feeding), or 'A precedes B' or 'A may not follow B' (counter-feeding). Theories of simultaneous application describe feeding, but must allow constraints against re-application in order to account for counter-feeding (see Stampe 1973a, Donegan and Stampe 1978a).

In a theory where process application is natural (phonetically-motivated) and non-application must be learned, it is consistent for iteration or re-application to be natural and non-iteration to be learned. Kiparsky (1968) noted that counter-feeding orders often become feeding orders in historical change. With simultaneous application this means a learned constraint against re-application is lost and the process so constrained begins to re-apply, thus more completely fulfilling its phonetic function. The opposite kind of 're-ordering'--feeding to counter-feeding--is occasionally apparent in child speech, when children who merge two sounds at an earlier stage of acquisition acquire a distinction--though not the adult distinction--at a later stage. Stampe (1973a:67) analyses a number of these 'sound shifts' of the type [ı] → [ɹ] but [ɹ] → Ø as resulting from 'antisequential constraints' imposed by the child on processes which she cannot as yet fully suppress. For example, Stampe notes (ibid.) that Hildegard Leopold 'glottalized initial vowels, [ʔaiʃ] ice, eins, and deleted [h]: [aiṭa] high-chair. But at first she had applied these in sequence: [ʔaiʃ] heiss (Leopold 1947:84-5, and 1939, glossary).' Thus, counter-feeding (with less phonetic naturalness, more learned constraints) to feeding (with greater phonetic naturalness, fewer learned constraints) is the preferred direction of language change; and the opposite order is the direction taken by the child acquiring phonetic control in the course of acquisition. It must be noted, however, that while process applications (and re-applications) are phonetically motivated by the teleologies of the individual processes, the learned constraints against application (or re-application) are phonologically motivated by the necessity of maintaining distinctions.

Other process relations--like 'bleeding' and 'counter-bleeding' (Kiparsky 1968)--are accounted for in sequential theories by ordering statements, just as feeding and counter-feeding are. If simultaneous application is posited, counterbleeding results, and bleeding must be accounted for by principles which allow--or require--non-simultaneous application. Possible candidates will be described below, in Section 5.1.4.

5.1.2. Lenitions and fortitions.

As noted in Chapter I, segmental processes include both fortitions, which increase or optimize the phonetic properties of segments and which are typically context-free, and lenitions, which ease the articulation of segment sequences and which are typically

context-sensitive. Since the two kinds of processes have different functions, they also have somewhat different patterns of application. Lenition processes increase their domains of application in hypoarticulate (e.g. fast, casual, or 'mumbled') speech and in weak positions (e.g. unstressed syllables, intonational 'valleys'), where a premium is placed on ease of articulation rather than clarity or emphasis.

(5.1a) Thus, diphthongs in English may assimilate or even monophthongize in unstressed or lightly stressed syllables, as [aɹ̯] becomes [aɹ̯], [aɚ̯], or [a] in I'd lóve some, or [æɔ̯] becomes [æɔ̯], [æɚ̯], or [æ] in How much ís it?, but these assimilations occur far more freely in casual speech than they do in careful speech.

Conversely, in very careful or slow speech, and (especially) at the intonational peaks of emphatic or emotive speech, lenitions may be suspended or limited, and fortition processes apply most freely and extensively.

(5.1b) So [aɚ̯] in stressed syllables in careful speech is [aɚ̯] or [aɪ̯], as in I'd go; and [æɔ̯] is [æɔ̯] or [æʊ̯] or (in some dialects) [ɐɔ̯], as in I don't know hów. Such polarizations affect the more-stressed occurrences of diphthongs more readily than their less-stressed occurrences, and they apply most freely where the stress is *strong or exaggerated and entails considerable lengthening.*

Lenition processes may neutralize oppositions, but since they are typically context-sensitive, they rarely merge sounds in all their occurrences. The neutralization of /nd/ and /n/ in pairs like bands, bans, for example, occurs only before /z/. Elsewhere, /nd/ and /n/ have distinct realizations: band, ban; banded, banned; banding, banning. Therefore the underlying representations of bands and bans remain distinct. Context-sensitive neutralizations like this are usually only superficial neutralizations; sounds which become the same in certain contexts through a lenition process remain distinct in other contexts. The phoneme inventory of the language is thus unaffected.

Fortition processes, on the other hand, are typically context-free (at least with regard to segmental context). When they apply obligatorily, they merge sounds in all their occurrences. Thus, the surface neutralizations they produce--

(5.2) as when [ɔ] as in caught, dawn becomes [ɑ] as in cot, Don in some Midwestern American dialects--

easily become mergers of underlying form, because they leave no surface alternations.

5.1.3. Feeding, counter-feeding, and 'natural selection'.

The application relationships among lenition processes--and those among fortition processes--reflect this difference in neutralization capacity. Because the neutralizations they produce are typically superficial ones, and because neutralizations are more easily tolerated in the loosely-monitored styles and positions which lenitions most often affect, lenition processes are often allowed to re-apply freely.

(5.3a) For example, while go in Don't go! is pronounced [gʌʊ̯] or [gɛʊ̯], the same word, in I've got to go home often has a monophthongal vocalism: (ʌʊ̯ →) ɔʊ̯ → ɔo̯ → oo̯ . The successive assimilations (lenitions), attested by intermediate pronunciations, apply to each others' outputs.

Of course, lenitions, do not always iterate; they may be restricted to one-time application, and when they are, the restriction often serves to maintain a distinction.

Fortition processes may also apply to each others' outputs--especially context-sensitive (dissimilative) fortitions. (This certainly happens synchronically in the American dialects where [ʊʊ̯] → [ɨʊ̯] → [ɪʊ̯] in words like spoon, two, etc.) But it is not unusual for fortitions to fail to iterate in adult speech, particularly when such reapplication would cause mergers.

(5.3b) For example, the American dialects (in various northern cities) which diphthongize /æ/ to [eə̯] in bad, man, Kansas, etc. and which also palatalize /ɑ/ to [a] in Chicago, cotton, Donahue, etc. (cf. Labov et al. 1972) show no tendency whatsoever to diphthongize these newly-fronted [a]'s.

Or, to cite a historical example,

(5.3c) the diphthongization of Middle English i̯ and u̯ at the beginning of the English vowel shift was followed by a change which produced new i̯'s and u̯'s: the raising of ę̯ and ǫ̯. But these new i̯'s and u̯'s did not undergo the diphthongization--which would, of course, have merged them with the older i̯'s and u̯'s.

Such sets of changes, which may be far more extensive than those noted here, are often described as chain shifts. Because chain shifts are fairly ordinary occurrences in language histories, Martinet (1955), Labov et al. (1972) and others have viewed the chain movement itself as somehow causal. These researchers follow Jakobson in the sense that they see chain shifts as attempts by speakers of a language to maximize phonological oppositions. But, like the non-chainlike vowel shifts of Coastal North Carolina or Faroese, chain shifts may also be viewed as

sets of phonetically-motivated, essentially independent processes that are constrained in their chronological order of occurrence--or constrained synchronically to non-iterative application--by a 'natural selection' principle based on avoidance of merger: a phonetically motivated substitution is more likely to be allowed to apply if its application produces no mergers than if its application would produce merger. If its application would result in merger or neutralization, the process is more likely to be allowed to apply if the neutralizations produced would be superficial than if they would involve underlying representations and thus decrease the inventory of possible phonological distinctions. So, for example, if a process such as diphthongization or bleaching has affected u, raising of other labials is more likely to be admitted (though it is not absolutely predictable) than it would be if u had not been affected, since, in the latter case, o would merge with u.

This natural selection principle is a matter of relative likelihood rather than absolute prohibition; processes do produce neutralizations, and even absolute mergers, like the Yiddish mergers of ȳ with ī and ø̄ with ē (Sapir 1915), or the Greek convergence of six different vocalisms (ι, η, ει, οι, υ, υι) as [i] (Sturtevant 1940:30). The independence of processes and their phonetic causalities allows for the explanation of such mergers, which have always been a problem for theories which view the maximization of phonological distinctiveness as the motivation for change. Mergers result when processes maximize phonetic properties at the expense of phonological distinctiveness. Because of the natural selection principle, however, such occurences are the exception rather than the rule.

This is not an altogether novel view. As Jespersen wrote of language change,

> If we turn now to the actuating principles that determine the general changeability of human speech habits, we shall find that the moving power everywhere is an impetus starting from the individual, and that there is a curbing power in the mere fact that language exists not for the individual alone but for the whole community. The whole history of language is, as it were, a tug-of-war between these two principles, each of which gains victories in turn (1964, Ch. XIV, 6).

With this in mind, we might perhaps more appropriately regard the selection principle as a 'rejection principle': process applications (i.e. substitutions) which result in mergers are typically--though not necessarily--rejected by the speech community.

The typical non-merging application of fortitions--both synchronic and diachronic--can be seen as resulting from constraints: a synchronic constraint against re-application, and a diachronic constraint on process selection. The phonological principles of Jakobson and Martinet play an important role in the order of changes and in the manner of

application of processes--but as constraints, rather than as causes.

5.1.4. Fortitions first, lentitions last.

As noted above, fortitions and lenitions often have different domains of application, but this does not mean that they apply under entirely complementary conditions. In fact, they often affect the same utterances, and when they do, it appears that a particular, consistent order relationship is maintained.

In claiming that fortition processes constrain morpheme structure, Stampe (1973a:25ff.) argued that context-free fortition (paradigmatic) processes, like vowel de-nasalization, are ordered prior to context-sensitive lenition (syntagmatic) processes with contrary effects, like nasalization of vowels before nasals. Stampe showed this ordering to be a response to the different functions of the two classes of processes: lenition processes follow fortitions so that lenitions may have maximal effect on surface phonetic representation. If they preceded fortitions, in many cases they would have no effect at all, as in Stampe's example of vowel nasalization: if the context-sensitive assimilation applied first, the context-free fortition would entirely undo its effects. When the context-free fortition applies first, its effects are undone in some contexts (before nasals) but not in all contexts.

This 'fortitions first, lenitions last' (FFLL) principle is extended to all fortitions and lenitions--not just those with directly contrary effects--in Donegan and Stampe 1978a. This principle means that fortitions 'feed' lenitions:

(5.4a) For example, the processes which assimilate the palatal and labial elements of [ɪu̯] or [iu̯] when this diphthong varies with [ɪy̯] or [y:] in two, spoon, etc. (cf. 3.28g) are lenitions, and they apply to the outputs of the dissimilative fortitions that bleach and palatalize the syllabic of this vocalism. If the lenitions preceded the fortitions, we might expect to find monophthongization of the underlying /iu/ in few, cue, etc. but not in words like two, spoon, etc. according to the following scheme:

	/iu/	/u:/
lenitions	yy̯	--
fortitions	--	ɪu̯

Instead, where /iu/ assimilates, [ɪu̯] (←/u:/) does so as well; the fortitions apply first.

The principle also requires that lenitions 'counterfeed' fortitions:

(5.4b) The dissimilative palatalization of /ɑo/ to [æo] and the delateralization of syllable-final [ɬ] to [u̯] (1.15) are,

respectively, a fortition and a lenition. The failure of this palatalization process to affect the output of delateralization in words like doll [dɑɣ], *[dæɣ], etc. falls out from the FFLL principle.

The fortition/lenition distinction and the FFLL principle also account for many 'bleeding orders'--interactions in which one process (the 'bleeding' process) eliminates sequences or segments that would otherwise be inputs for another process (the 'bled' process) (Kiparsky 1968; cf. Kenstowicz and Kisseberth 1971, 1977). (Counter-bleeding, the expected result of simultaneous application, requires no special explanation.)

(5.4c) Kenstowicz and Kisseberth note that in many languages, vowel epenthesis between consonants and voicing assimilation in consonant clusters apply in 'bleeding' order: epenthesis eliminates consonant clusters which would otherwise undergo voicing assimilation in Lithuanian, Latvian, Hebrew, and most of the Slavic languages (1977: 163). Kenstowicz and Kisseberth do not mention English, but the bleeding interaction of ɨ-epenthesis (between sibilants [kɪsɨz] kisses, and between dentals [weɪ̯tɨd] waited) and voicing assimilation of the plural and past-tense suffixes ([kæts] cats vs. [dɑgz] dogs; [pækt] packed vs. [wægd] wagged) in English further exemplifies the ordered relationship between epenthesis (a fortition) and voicing assimilation (a lenition): *[kɪsɨs], *[weɪ̯tɨt], etc.

Kenstowicz and Kisseberth cite a number of other examples of bleeding orders, as they look for a single principle which will account for interactions of this sort. In the cases they cite where the two interacting substitutions are a fortition and a lenition, the FFLL principle appears to account for their order of application. However, since Kenstowicz and Kisseberth do not distinguish between processes and rules (cf. Sec. 1.1.1), some of their examples of interacting substitutions may be more relevant to the 'rules first, processes last' principle, which orders rules without synchronic phonetic motivation (like 'trisyllabic laxing' in English) before processes, which have such motivation (see Donegan and Stampe 1978a). This 'rules first' principle may motivate some of the bleeding interactions among lenitions which Kenstowicz and Kisseberth cite. Interactions where both substitutions are due to rules--not processes--may be governed by quite different principles from those discussed here. There is no reason to presume, for example, that FFLL would apply other than accidentally to rules.

For further examples of fortition/lenition interactions in processes, see Donegan and Stampe 1978a.

As Stampe suggests (1973a:24), the order of fortitions and lenitions may be a manifestation of their different teleologies.

Lenitions apply to make speech more articulable, to decrease the difficulties involved in producing sequences of segments; they have exclusively articulatory motivation. Fortitions have perceptual motivation as well as articulatory motivation. They are often responsible for 'prophylactic' changes like epenthesis which block lenitions like voicing assimilation. Correspondingly, fortitions apply first, closer to the level of conscious intention; and lenitions apply last, closer to the level of actual articulation, so that they can mitigate any transitional difficulties the fortition processes may introduce.

5.2. Processes and phoneme inventories.

The possible inventories of phonemes in languages have long been an important question in the study of language universals. Liljencrants and Lindblom (1972) tested the Jakobsonian assumption that maximal contrast plays an important role in determining the possibilities for vowel phoneme inventories by matching the vowel systems which provide maximal distances among points in an acoustic space (whose two dimensions were F_1 and a weighted average of F_2 and F_3) against systems with the same number of contrasts which actually occur in the world's languages. Their interesting experiment met with some success, but many phoneme inventories which actually occur were not predicted, and there were some inventories maximally differentiated in their vowel space (e.g. their seven-vowel system) for which the authors found no actual examples. Crothers (1977) altered their vowel space and revised their predictions; and he came up with a better match between predicted and actual systems, particularly among the larger systems of seven or more vowels.

But even if acoustic distance among members of an inventory could be interpreted directly as degree of perceptual contrast, it would not be the only factor which determines vowel inventories. Articulatory factors--especially the role of acoustically stable regions in which minor misarticulations have little acoustic effect--must, as Liljencrants and Lindblom note, also be taken into consideration. And so must the tendency of languages to class vowels in series so that, for example, two (non-low) labiopalatals or two (non-low) achromatics are more to be expected than one of each (cf. Crothers 1977, §3). The characteristic phonetic attributes of individual segments in the inventories--and not just their distinctive aspects--must be considered as well, difficult though this may be in the presence of the usual contextual variation.

Natural phonologists share with Liljencrants and Lindblom the view that the limitations on phoneme inventories have a phonetic basis, but in the Stampean view (1969, 1973a), the synchronic and developmental constraints on phoneme inventories are manifestations of phonetically-motivated natural processes, rather than metalinguistic frameworks like the implicational laws of Jakobson (1968) or the marking conventions of Chomsky and Halle (1968). The 'preferences' of languages

for vocalic optima express themselves by means of these processes both diachronically, as Greenberg (1966) claims, and synchronically, as Stampe (1973a) proposes. Since processes apply in languages with different degrees of completeness and (historically, at least) in different orders, considerable variety--rather than a single 'optimal' arrangement of a given number of vowels--is to be expected.

In [Donegan] Miller 1972, I attempted to show how a small set of processes (similar to, though not identical with, the set described in Chapter III) could be viewed as limiting the phoneme inventories of a wide variety of languages. The processes presented here are similarly suited to this task. Processes applying context-free, with varying degrees of generality, limited (when limited at all) always in the directions predicted by their hierarchies of applicability, can produce most occurring vowel inventories in straightforward ways. Not only can the limitations on 'normal' inventories be expressed by processes; unusual variants can usually be accounted for as well. A few examples of the ways in which processed limit inventories follow.

5.2.1. Limitation of phoneme inventories.

The common three-vowel system, /ɨ, ɑ, u/, is found in dialects of Arabic, in Arunta, Cree, Eskimo dialects, Ojibwa, and a number of other languages (Hockett 1955:84). Remembering that the natural state of processes is application, we may note that such a system requires no process suppressions and relatively weak limitations on process application. When there are no non-high chromatic vowels in the phoneme system (* /e, æ, ʊ, ʊ, o, ø/, etc.), we may assume that Raising of chromatic vowels is free to apply, and also that Bleaching is free to apply to all but high vowels (! lower). (Note that unlimited application of Bleaching would be consistent with an inventory like the /ɨ, ʌ, ɑ/ of Adyghe and Kabardian (cf. Catford 1977:294; cf. also Sec. 3.3.1).) Since there are no mixed (bichromatic) vowels, Bleaching is also free to apply to any mixed vowel, regardless of height (! mixed). Since no non-low achromatics exist in the inventory, (*/ɨ, ʌ/), Lowering is free to apply to any achromatic vowels (! achromatic), and the Coloring processes, Palatalization and Labialization, are free to apply to all but low vowels (! higher). To summarize:

(5.5a)

Raising: $\begin{bmatrix} V \\ +\text{chromatic} \end{bmatrix} \rightarrow [\text{higher}]$ */e, æ, o, ɔ, ø, e / etc.

Bleaching: $\left[\begin{matrix} V \\ \{ -\text{high} \\ +\text{palatal, +labial} \} \end{matrix}\right] \rightarrow [\text{-palatal}]$ */e, æ, o, ɔ, ø, y/ etc.

$\left[\begin{matrix} V \\ \{ -\text{high} \\ +\text{palatal, +labial} \} \end{matrix}\right] \rightarrow [\text{-labial}]$

Lowering: $\begin{bmatrix} V \\ -\text{chromatic} \end{bmatrix} \rightarrow$ [lower] */ɨ, ʌ/

Coloring: */ɨ, ʌ/

$\begin{bmatrix} V \\ -\text{low} \end{bmatrix} \rightarrow$ [+palatal]

$\begin{bmatrix} V \\ -\text{low} \end{bmatrix} \rightarrow$ [+labial]

The small number of vowels which speakers of three-vowel languages must command corresponds to the relatively free applicability of these context-free processes.

Now compare this to an eight-vowel system like that of Turkish: in a system containing /i, y, ɨ, u, e, ø, ɑ, o/, Raising is free to apply to low chromatic vowels only (! lower); Bleaching, too, may apply to low vowels only (! lower); Coloring must be suppressed entirely, since both high and low achromatics exist in the system; and Lowering is free to apply only to the non-high achromatic, ʌ. To summarize:

(5.5b)

Raising: $\begin{bmatrix} V \\ +\text{chromatic} \\ +\text{low} \end{bmatrix} \rightarrow$ [higher] */æ, ɒ, e/ etc.

Bleaching:

$\begin{bmatrix} V \\ +\text{low} \end{bmatrix} \rightarrow$ [-palatal] */æ/

$\begin{bmatrix} V \\ +\text{low} \end{bmatrix} \rightarrow$ [-labial] */ɒ/

Lowering: $\begin{bmatrix} V \\ -\text{chromatic} \\ -\text{high} \end{bmatrix} \rightarrow$ [lower] */ʌ/

Coloring: suppressed entirely.

The context-free applicability of these processes is far more strictly limited, corresponding to the larger inventory of vowels.

Different limitations, of course, produce different inventories. The linear (or 'color-blind') three-vowel systems of Adyghe and Abkhas and Gude (cf.3.3.1) involve full application of Bleaching and full suppression of Coloring. Lenition processes which color vowels assimilatively may, however, affect these achromatic phonemes, producing chromatic vowels in phonetic representations (cf. 2.3.2.3.2). Process hierarchies allow for these 'linear' systems as well as 'triangular' systems like /i, ɑ, u/ (or even /i, ɑ, o/--see below), and for 'quadrangular' systems like /i, e, æ, u, o, ɒ/. But they rule out

'inverted triangles' like /ɨ, æ, ɒ/ in the following ways: Bleaching eliminates the higher achromatics only if it eliminates the lower ones too; Lowering eliminates the higher chromatics only if it also eliminates the higher achromatics; and Coloring affects lower achromatics only if it also affects higher ones, etc.

Such asymmetries are apparent in larger vowel inventories, too. Even in the symmetrical pattern of Turkish, the non-high achromatic is low (/ɑ/), while the corresponding chromatic vowels are mid (/e, ø, o/). In larger inventories like this eight-vowel system, there is, as noted above, considerably more limitation of processes; correspondingly, as there are many more possible forms of process limitation (or application), there are many more possible--and occurring--inventories.

(5.5c) For example, if Coloring (! higher) is allowed to apply to non-low vowels instead of being suppressed--cf. (5.5b), and if Bleaching is limited to low labials, we may derive, instead of the Turkish inventory (5.5b) /i, y, ɨ, u, e, ø, ɑ, o/, the pattern of Finnish (Trubetzkoy 1969:102) and some Hungarian dialects (Hockett 1955:87):

i	y	u
e	ø	o
æ	ɑ	

Or, to exemplify an eight-vowel inventory less like that of Turkish (and one in which Tensing and Laxing are limited in an observable way), one might take the following:

(5.5d) The inventory

i		u
e	ɛ ʌ	ɔ o
	ɑ	

, given by Hockett (1955:81) for some Portuguese dialects, and by Crothers (1977, Appendix III) for Ewondo and Javanese, is constrained by:

Raising: $\begin{bmatrix} V \\ +\text{chromatic} \\ +\text{low} \end{bmatrix} \rightarrow$ [higher] */æ, ɑ, ɒ, ɔ/

Lowering: $\begin{bmatrix} V \\ -\text{chromatic} \\ +\text{high} \end{bmatrix} \rightarrow$ [lower] */ɨ/

Coloring: $\begin{bmatrix} V \\ +\text{high} \end{bmatrix} \rightarrow$ [+palatal] */ɨ/

$\begin{bmatrix} V \\ +\text{high} \end{bmatrix} \rightarrow$ [+labial] */ɨ/

Bleaching: $\begin{bmatrix} V \\ \{+\text{palatal}\} \\ \{+\text{low}\} \end{bmatrix} \rightarrow$ [-labial] */y, ø, e, ɒ, ɔ/

$$\begin{bmatrix} V \\ \{+\text{labial} \\ +\text{low}\} \end{bmatrix} \rightarrow [-\text{palatal}] \quad */y, \phi, e, æ, a/$$

Tensing: $\begin{bmatrix} V \\ +\text{high} \end{bmatrix} \rightarrow [+\text{tense}] \quad */ɪ, ʊ/$

Laxing: $\begin{bmatrix} V \\ +\text{low} \end{bmatrix} \rightarrow [-\text{tense}] \quad */æ, ɒ/$

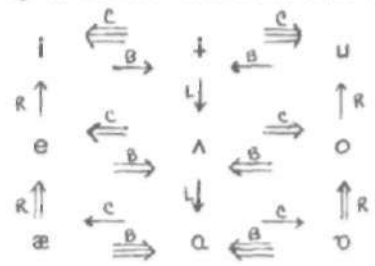
From just the few examples given here, it should be apparent that expectations about 'normal' vs. 'extraordinary' vowel systems fall out from process hierarchies.

The tendency to a greater number of timbre contrasts among higher vowels is largely due to the ! lower condition on application of Bleaching (which of course reflects the phonetic factors that work against chromaticity in vowels with high sonority). The tendency for low vowels to be achromatic (or for languages to have one low achromatic vowel) is also due in part to this ! lower condition--as well as to the +chromatic condition on Raising and the ! achromatic condition on Lowering. The tendency for high (and mid) vowels to be chromatic is due to the ! higher conditions on Coloring. The overall tendency to 'triangularity'-- i u, i u, i ɨ u, etc.--

e o e ʌ o

a a a

corresponds to the combined implicational hierarchies. Disregarding tenseness and bichromaticity (which require extra dimensions), these might be represented thus (where the lettered arrows represent processes: C = Coloring, etc., and a more-shafted arrow represents a substitution entailed by a fewer-shafted one of the same letter):



However, there are languages which run counter to these tendencies, violating Jakobson's 'implicational universals' --and the expectations of many linguists. Languages like Pashto, Gadsup, Wichita (Crothers 1977, App. III) etc., with long /e:, o:/ in the absence of long /i:, u:/, violate the implicational law that mid (chromatic) vowels imply the corresponding high vowels (cf. Jakobson 1968:49-59). In such languages, Raising is suppressed or limited to low chromatic vowels (! lower), while Lowering is free to affect long vowels (as is most apparent when /i, u/ alternate with /e:, o:/, as in Yokuts (Newman 1944:20ff.)), or free to affect all vowels (as in Amuesha, where the

short vowels, too, are all non-high (Crothers, op. cit.).

There are also many languages which are asymmetrical with respect to the height of their chromatic vowels; such languages may have a high palatal, but only a mid labial. A typical pattern is the i e o ɑ of Fox, Shawnee, Apachean, Campa, dialects of Nahuatl, and Wichita (Hockett 1955:84); similar systems occur in the i e ʌ o ɑ of Potawatomi (ibid.:85), and the i o ɑ of Mikasuki (Crothers, op. cit.). Two possibilities suggest themselves for such systems: they may involve lowering of */u/, which is possible because labial vowels are often treated as if they were less chromatic than their palatal counterparts (by other processes as well as by Lowering--cf. Sec. 3.3.4), and Lowering favors less chromatic vowels; or they may involve a change in the type of labiality (to compression rather than protrusion) in high vowels, with subsequent Bleaching (as suggested for Japanese--cf. 3.3.1.1.) and Lowering or Palatalization of the resulting ɨ.

Further study of such systems will be needed, but it seems quite possible that the existence of such 'skewed' systems will be found to be consistent with the predictions that processes make, although these systems may represent unusual or complex process limitations. (Occasionally, the existence in a language of phonemes in a pattern that does not seem to be derivable by these processes applying context-freely may be a historical accident--a relic, perhaps, of diphthongization and subsequent monophthongization. Such cases are exceptional, however; and understanding them will require a more complete understanding of the relationships between successive historical stages of underlying representations.)

Although a complete account of the way processes limit phoneme inventories is not possible here, the systems of (5.5a-d) provide examples that illustrate how such an account can be given. (For a somewhat more extensive attempt at such an account, which is generally consistent with the examples given here, see [Donegan] Miller 1972.)

5.2.2. Evidence from nativization of foreign words.

We can view these processes as eliminating non-occurring vowels because speakers do apply them if they encounter such vowels. Ordinarily these processes have nothing to apply to; they exist latently, as constraints on the possible-vs.-impossible segments of a language. For example, a speaker whose language has the inventory /i, e, ɑ, o, u/, as in Japanese or Hawaiian or Spanish, may be unable to pronounce an

[ʌ] without considerable special effort (or even with such effort); he has not learned to violate the processes which substitute other sounds for [ʌ]. But he has not learned to do so because he confronts no [ʌ]'s in his native tongue; he does not ordinarily make any substitutions for [ʌ]. Only if he finds it necessary to try to say [ʌ]--as when he learns a foreign language or pronounces a foreign word--does a substitution occur.

Because there may be alternative processes which would eliminate a given segment, the substitutions speakers make are not necessarily perfectly consistent, although speakers (and even languages) will ordinarily settle on one substitution (like [ɑ] for [ʌ], or [e] for [ʌ]), unless pressured--but unable--to 'get it right'. Thus, in language classes, one hears English speaking students of German alternate between [u] and [i] in attempting [y]--with [i̯u] as a third possible alternative, or between [ʃ] and [ᶜ] in attempting [ç]. But in the normal case of nativization, speakers with foreign accents and languages accepting loans will use a single substitution--like Japanese [ɑ] for English [ʌ], or [o] for English [ɔ] (cf. Lovins 1972). In such foreign-language cases--as in the case of child language (cf. Stampe 1969, 1973a)--the role of processes as responses to phonetic difficulties the language learner has not yet learned to overcome is clear.

But the above suggests only half an explanation of the way segment inventories are constrained: i.e. non-occurring segments are disallowed from phonological representation by context-free processes which the speaker has not learned to violate. 'Non-occurring', however, is not really specific enough, since sounds which do not occur as phonemes often occur phonetically in languages. Thus, speakers often do violate the context-free processes in certain situations or contexts, as when some American English speakers monophthongize /iu/ to [y], or spirantize final /k/'s, or pronounce nasalized vowels before nasals.

Stampe (lectures) has remarked that this is a primary puzzle of phonology--that speakers are unable to produce a particular segment when they aim directly at that segment (*/y/ → [i̯u], */ɛ̃/ → [ɛ]), but produce that very segment when they aim at something else (/iu/ → [y], /ɛ/ → [ɛ̃]--in certain contexts). The nasalized vowel of [bɛ̃nd] bend and the labiopalatal glide of [vɪɣ] view (in some southern U.S. speech), which result from the application of context-sensitive lenition processes which adjust them to be compatible with--i.e. similar to--their environments, and they are not admitted to the phoneme inventory merely by virtue of their occurrence in speech.

When there is a lenition process to which the speaker can attribute the appearance of a surface segment that is barred from underlying representation by a context-free fortition process--then the phonetic segment is regarded as the result of that lenition process and its phonemic value is taken to be that of the phoneme which the lenition process adjusts.

(5. a) For example, the [ɛ̃] of bend results from vowel nasalization, a context-sensitive lenition process which has no exceptions in English. Since this [ɛ̃] results from a regular lenition process, it is taken by speakers to be the same as the vowel of bed. (Stampe (1969) shows that it is indeed the same vowel if anything interferes with the nasalization process, in similar examples.) Thus [ɛ̃] may still be barred from the phonemic inventory; the context-free process of vowel nasalization is still applicable, even though its effects are sometimes undone by the lenition.

Speakers even seem to be capable of undoing, in this manner, more than one 'layer' of processing.

(5. b) In bent, the /n/ which conditions nasalization may be deleted quite regularly, yielding [bɛ̃t], yet by reversing both of these regular lenition processes (vowel nasalization and nasal deletion), the hearer arrives at the phonemic representation /bɛnt/.

Contrast this situation with one in which a lenition process cannot be held accountable for the 'impossible' segment:

(5. c) The English pronunciation of French maman [mamɑ̃] is [mamá]. In French, the nasalized vowel is followed by no nasal to which English speakers can attribute its nasality; neither can they attribute its nasality to a deleted nasal, since there is no lenition process in English which deletes word-final nasal consonants in accented syllables: If we assumed a phonemic representation /maman/, we would have to say the /n/: [mamán]. So we attempt to say */mamɑ̃/ and say [mamá].

Since it is not unusual for context-sensitive lenitions to produce phonetic forms that are barred from the phoneme inventory, this leads to the question of why two processes--a fortition and a lenition --do not more often come together to produce the 'right' result in foreign words. If an English speaker can say [bæx] for /bæk/ back, why doesn't he just do the same for Bach--assume the final [x] to be a /k/ and then apply the /k/ → [x] syllable-final lenition to produce [bɑx]? In some cases, things may work out this way: French [y] is often pronounced [y] in some southern U.S. French classes, where students apparently take [y] to be /ɪu/ and monophthongize their /ɪu/ to [y]. (These same students may have considerable difficulty pronouncing French [u] or [o], however.) But usually we are less fortunate; either we do not have just the appropriate fortitions and lenitions to make the right interpretation (as happens with maman), or, if we do have such processes applying in our phonological system (as some Americans do with Bach and back) they apply only in the wrong styles for making such interpretations. Speakers who spirantize

syllable-final /k/ ordinarily do so only in very relaxed styles, while speech in language-learning situations is typically very careful. So the English speaker who hears [bɑx] may assume that the German speaker is leniting a /k/ and arrive at the underlying representation /k/, but he cannot himself allow spirantization in the careful mode which typifies attempts at foreign pronunciations.

'Foreign accents' and nativization of foreign words in loans are process-governed phenomena of considerable complexity. I have hinted at this complexity here (for enlightening discussion, see Ohso 1971; Lovins 1973, 1974) in order to illustrate the inventory-constraining functions of context-free fortitions and context-sensitive lenitions. These two kinds of processes constrain the phoneme inventory in rather different ways--the former by making substitutions for segments that do not occur as basic native segments, and the latter by 'recognizing' certain phonetic segments in particular contexts as substitutions for other, more basic segments. These 'basic' native segments, or phonemes, then, are the sounds of a language which, at least in some contexts, cannot be derived by the natural lenition processes of the language from other sounds in the language (as English [ɛ̃] is derived by vowel nasalization from /ɛ/, but [ɛ] cannot be derived from another sound and so must be basic--/ɛ/), and which, at the same time, survive the obligatory fortition processes of the language (as vowel denasalization eliminates /ɛ̃/ but no such obligatory fortition eliminates /ɛ/ (cf. Donegan and Stampe 1978a, Sec. 4).

VI - CONCLUSION

The principal aim of this work has been to describe and to make first steps toward explaining the principal fortition processes affecting vowels. Examples of the application of these processes from historical change, synchronic alternation and variation, and child language have been offered. The phonological data reveal implicational hierarchies or conditions on application of the processes which are the same whether the processes apply in children's or adult's speech, and whether synchronically or diachronically. This is clearly because these hierarchies reflect the phonetic motivations of the processes, which are of course the same regardless of the circumstances of their application.

The proposal and justification of these implicational hierarchies is perhaps the most novel aspect of this thesis. These implicational constraints on process application determine the possible effects of a process on entire phonological systems. Each vocalism in a system must be considered, in terms of its phonetic features, as a possible candidate for the process; and it turns out that, although the limitations on the classes of vowels which actually undergo the process may vary from one application to another, these limitations vary in predictable and phonetically definable ways. In this sense, the theory presented here furnishes an account of the notions 'vowel system', 'vowel shift', and so forth that is universal, holistic, and explicit in ways that previous accounts are not. (The accounts given by Martinet and his followers, for example, include ad hoc hypotheses of push and pull chains--with effects preceding as well as following their causes--and cases vides or 'holes in the pattern'--some of which, like /ɨ/, are widely tolerated while others, like /i/ or /ɑ/, are not; and they make ex post facto attributions of 'distinctiveness' versus 'redundancy' to features which persist versus those which are lost.)

Unlike lenition processes, whose reductive and assimilative phonetic functions may be relatively obvious, fortition processes, which are typically context-free or dissimilative, have motivations that have not previously been apparent. I have argued that in fortition processes these motivations always involve the increase or optimization of a phonetic property in the segment(s) subjected to the process. The optimization appears to be at least in part perceptually motivated. I have attempted to show here what some of these process motivations may be. In short, processes which increase sonority, in increasing intrinsic intensity, make vowels more suitable for their functions as

syllabicity-bearers, accent-bearers, consonant-bearers, etc., and processes which increase color appear to make vowels more suitable for their distinctive functions.

The implicational conditions on the application of fortitions suggest that they may apply according to a principle whereby 'the rich get richer and the poor get poorer': segments which already possess to a relatively high degree the property a process increases are more susceptible to the process than segments which possess the property to a lesser degree (e.g., achromatic vowels, which are more sonorant than the corresponding chromatics, are more susceptible to Lowering, which increases sonority). In other words, in fortitions, a property is most susceptible to increase where it is already strongly present. Further, segments are more susceptible to increase of a given property where they lack incompatible properties (e.g., achromatic vowels are more susceptible to Lowering because they lack color, which is relatively incompatible with the sonority Lowering increases).

Since the properties co-occurring in an individual segment are often in some degree of conflict with each other (as are sonority and color, or palatality and labiality), the increase or optimization of one property often entails the loss or attenuation of an 'opposing' property. This is why different fortition processes (Raising vs. Lowering, Bleaching vs. Coloring) may affect a given segment in opposite ways; a segment like [ɛ], for example, may be raised or tensed to increase its color, or lowered or bleached to increase its sonority. This 'excess' of possibilities has occasioned some pessimism about ever explaining such changes--but if segments regularly combine conflicting properties, each of which may be increased by alternative fortitions, such diverse possibilities are not only allowed but predicted. (Note that this does <u>not</u> mean that 'anything can happen', because the implicational hierarchies on the processes provide strong constraints on the form a fortition may take in any given application.)

This is also why fortitions so often apply dissimilatively: in dissimilation, the lost or attenuated property can be preserved in an adjacent segment. Dissimilations of adjacent elements uniformly appear to be context-sensitive fortitions. Thus, the process that palatalizes [ʌ] before [u̯] ([ʌu̯] → [ɛu̯]) is a special case of the one that palatalizes [ʌ] context-freely ([ʌ] → [ɛ]).

When fortitions apply dissimilatively in vowels, the result is diphthongization. Often a fortition process will affect only 'half' of a vowel, in effect making two vocalic elements where there had been one. In such cases, the two elements of the vocalism typically polarize, with one preserving or increasing the original color, and the other increasing sonority, and often losing its color. In this way, the vocalism comes to possess both a high degree of color and a high degree of sonority (as when [o:] → [ɔo̯] → [ɔu̯] → [ʌu̯] → [ɑu̯], for example). Alternatively, a diphthongized vocalism may polarize with respect to color, with one element retaining (or increasing) the

original color, and the other losing that color and acquiring another (as when [o:] → [ɔo̯] → [ɔu̯] → [ʌu̯] → [ɛu̯] → [eu̯]).

Although, other things being equal, diphthongization of short vowels entails diphthongization of their long counterparts, length is neither a necessary nor a sufficient condition for diphthongization. But length, of course, favors diphthongization, since the dual targets of a diphthong are more easily articulated if a longer time interval is available for the whole vocalism. Diphthongization may result from contextual lengthening, or it may be employed to preserve an eroding length distinction, but the polarizing effects of dissimilative fortitions may continue long after the new contrast would seem to be securely established, as in the continuing vowel shifts of English dialects. Diphthongization ordinarily produces falling diphthongs (V̯), even when the diphthongized vowel is short, but timing or syllable structure constraints may produce shifts of syllabicity, yielding rising diphthongs (V̯).

The individual processes have, as noted, their own phonetic motivations, and it is these phonetic motivations which underlie process applications in vowel shifts, as well as in individual changes. The existence of mergers testifies to the phonetic motivations of processes. Changes whose motivation was maximization of phonological contrast would violate their own teleologies in merger-causing applications. But mergers appear to be the exception rather than the rule, even in the far-reaching re-shufflings of vowel qualities found in vowel shifts: only those process applications which the linguistic community accepts survive, and communities appear to favor applications which do not cause mergers. In other words, the individual changes which make up vowel shifts are phonologically constrained, though phonetically motivated. Thus the diachronic selection of processes can share certain aspects of its explanation with the synchronic application of processes. If synchronic application is simultaneous and naturally iterative (with learned constraints against rule re-application, which prevent neutralizations, required in many cases), then diachronic constraints against process survival share with synchronic constraints against re-application the function of preventing mergers.

I have claimed in this thesis that a very small number of processes which vary considerably in scope, but which vary within strictly defined limits, can account for most changes of vowel quality, synchronic and diachronic, in the world's languages. There are, undoubtedly, other fortition processes, as there are a number of vocalic features which I have neglected here; but in working with the features which appear to be fundamental in the languages I have been able to survey, I hope to have described the most basic of the processes. It may seem surprising that so few basic processes can account for such a wide variety of context-free and context-sensitive changes in such varying circumstances as child language, stylistic variation, and so on. But if

vowel quality can be defined with a limited set of phonetic features and if the presence or degree of each feature is systematically related to the presence or degree of others, then a relatively small set of possible substitutions which reflect these feature relationships is what we should expect to find in the study of universal phonology.

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