

On the Natural Phonology of Consonants*

Roderick D. Goman

0. Synopsis of natural phonology

A natural phonological process is an innate, freely applying constraint on what is normally pronounced. Given a potential phonological opposition, a process will eliminate that member of the opposition which presents the greatest difficulty in terms of pronunciation or perception, or both. In American English (and in some forms of British English), the flapping of /t/ and /d/ to [ɾ], as in Betty [b'ɛɾi], allows the speaker to expend less effort in producing the stop sound, i.e., the application of the process makes the stop easier to pronounce. The English aspiration of voiceless stops before stressed vowels affords the speaker a clearer distinction between these stops and the context in which they occur, i.e., the application of the process makes the stops easier to perceive.

Speakers (especially children), confronted with a new language, at first allow processes to apply that aren't, properly speaking, an inherent part of the language. This observation accounts in children for "baby talk" (child language) and in adults for foreign accents. Speakers confronted with the difficulty of learning a language must suppress or limit the application of the otherwise freely applying processes in order to match the native adult model. Suppressing a process completely negates its effect on the forms of a language, e.g., English speakers must suppress the process which devoices final obstruents in order to distinguish between such words as bet and bed. Limiting a process partially negates its effect, e.g., in English initial obstruent clusters are always voiceless: spat, stop, skit (cf. Russian zdanie 'building'). But medially and finally the devoicing process has been suppressed: Mazda, used [juzd], etc. So, in English the devoicing of obstruent clusters is limited to word-initial position.

Through a procedure of suppressing some processes, limiting others, and allowing still others to apply freely, the individual speaker arrives at the mature pronunciation of the language he is learning. In the case of children, they are normally eventually entirely successful at this. Adults have a harder time.

The suppression or limitation of a process, in terms of either historical change or language acquisition, proceeds in a hierarchical fashion. For instance, the sequence of [hj] in English, as in huge [hjudz], is sometimes simplified to [j], e.g., yuge [judz]. The sequence [hw] is, for most American English speakers, simplified to [w], e.g., what [wat], instead of [hwat]. The [h] in such sequences as [hn hl hr] has been lost historically in Middle English times. From these facts, we can set up this hierarchy of h-loss:

(0.1) n l r w j

Sounds at the left end of the hierarchy simplify h-clusters earliest and

most widely. Those at the right end simplify last and least widely. The loss of [h] in English has worked its way from left to right in this hierarchy, [n l r] having simplified first, [w] next, and last of all, [j] is now in the process of simplifying (cf. Stampe 1973).

0.1. Process vs. rule.

Processes regularly perform minimal substitutions in accordance with the principles outlined above, in addition to principles yet to be discussed. Processes represent an innate (intuitive or instinctive) restriction on what regularly passes for a linguistic message. Because they are freely applying, there is no linguistic "cost" involved in allowing them to apply. The "cost" comes when the speaker must exert an effort to keep them from applying, in terms of the suppression and limitation just discussed.

Opposed to processes are rules, which are learned and not innate. Rules are generally morphophonemic in character and do not represent limitations on pronunciation but are merely traditional or customary ways of handling phonological particulars inherited from former stages of the language. Processes, on the other hand, are by and large allophonic and represent real limitations on what can be pronounced.

The "velar-softening rule" in English, in which s is substituted for k in certain instances (see Chomsky and Halle 1968), is indeed a rule and not a process. It produces alternations like electric with final [k] vs. electricity with [s] before -ity. But notice that this rule is not a limitation on what one can say but merely a customary substitution of one sound for another (apparently borrowed from French). It is easy to fly in the face of custom and say electrickity, pronouncing [k] where we would normally expect [s].

The alternation in English of [k] and [k̠] is due to a process. Unlike the rule above, the average speaker does not consciously control the use of these two alternates, instead using [k̠] only in the neighborhood of palatal vowels, and [k] elsewhere. Thus the spoonerism of sitcom [sɪtkam] is not *[kɪtsam] but [k̠ɪtsam], revealing the palatal alternate at the phonetic level. So while rules do not limit pronunciation, processes are real limitations constraining what is normally pronounced and defining, language by language, what sorts and sequences of sounds are to be considered pronounceable.

0.2. Fortition vs. lenition.

There are two types of processes: fortitions and lenitions. Fortitions (or paradigmatic processes) are based on the requirement that linguistic messages must sound different to be understandable. Fortitions govern such things as whole sound systems and lexical representation. They optimize the perception of individual segments, i.e., they are based on the notion that individual segments must be distinct from their environment in order to be more easily perceived. They are dissimilative and most noticeable in slow, precise (hyperarticulate) speech. While they may apply in a context-free way, they are often catalyzed, i.e., their application may be triggered by the context in which they occur. The aspiration of voiceless stops in English, which was mentioned at the opening of this article, is an example of a fortition.

Lenitions (or syntagmatic processes) are based on the assumption that, in a given setting, only a few different linguistic messages are normally possible and that these need only differ in a relative way to be understandable. Lenitions are sequence-optimizing, i.e., they provide strategies for pronouncing sequences of segments. They are based on the principle of "least effort" (ease of pronunciation) and thus are assimilative and most apparent in casual, fast, sloppy, or lazy (hypoarticulate) speech. They are always context-sensitive. The flapping of /t/ and /d/ in American English, mentioned at the opening of this article, is an example of a lenition.

0.3. Explanation of terms.

The remainder of this article makes use of a number of terms which may be unfamiliar to the reader. It is best to introduce these terms in anticipation of their use in the text.

There are five basic positions (tonalities) referred to in the text:

(1) chilic (= labial), (2) coronal, (3) dorsal (= velar), (4) radical (= pharyngeal), and (5) glottal. There are likewise five colors (chromaticities): (1) labial, (2) palatal, (3) velar, (4) pharyngeal, and (5) rhotacized (= r-colored). So, while labial refers to color, chilic refers to position--both being articulated with the lips.

There is a rather complicated set of terms referring to types of sonority and stricture; fortunately, most of these are not unfamiliar terms. There are five types of sonority. From least sonorant to most sonorant they are: (1) stop, (2) fricative, (3) nasal, (4) approximant, and (5) vowel. Stops and fricatives are obstruents; nasals, approximants, and vowels are sonorants. Nasals and approximants are sonorant consonants, or resonants.

There are four types, or degrees, of stricture: (1) closure (stops and nasals), (2) fricative, (3) approximant (approximants and high vowels), and (4) sonants (nonhigh vowels). The following table summarizes the various sonority and stricture types:

(0.2)	Obstruent	{ STOP }	Closure	}	} Consonant
		{ FRIC }	Fricative		
	Resonant	{ NASAL }	Closure	}	
		{ APP }	Approximant		
	Vowel	{ HIGH V }	Sonant	}	
		{ NONHIGH V }			

1. Sonority distinctions.

1.1. Introductory remarks.

Sonority can be defined as the ability of a speech sound to carry a syllable. So, typically, we would not expect that a stop, like t, would be a syllabic nucleus. On the other hand, we would expect a vowel, like a, to be one. We would thus expect vowels to occur centrally in the syllable and stops (and other consonants) to be peripheral to the syllable, as in the nonsense syllable [tat]. Vowels are thus demonstrably more sonorant than stops (and other consonants).

This is not to say that vowels, when they occur, always carry the syllable. Sometimes they are simply closely associated with the nucleus of the syllable, being part of the vocalic nucleus, but not the main part of it, as with the nonsyllabic vowel i in the nonsense syllable [təit].

Further, this is not to say that consonants cannot carry a syllable. Resonants in English, like m n l, are capable of carrying an unstressed syllable, e.g. bottom, button, and bottle, which end in syllabic m n l. Also compare stressed syllabic trilled r in Serbo-Croatian, e.g. srće [s'rtʃɛ] 'heart' (personal comm., Ilse Lehiste; Kondrašov 1962).

Obstruents can also carry syllables, e.g., English interjections like psst! and shh! In Itel'men, a Paleo-Siberian language of central U.S.S.R., there is at least one word with no vowels: ckpc 'spoon' (Skorik 1968:238).

But nevertheless, gradations of sonority exist among consonants. In English, obstruents and resonants, as we noticed above, are used in two different ways. Obstruents are used to carry syllables only in interjections, and as Jakobson (1968) points out, imitative or suggestive sounds are outside the purview of normal phonology. Resonants in English, on the hand, carry syllables in nonimitative lexical items, like those mentioned above for m n l. We would expect, given these considerations, that resonants are the more sonorant ones, and this is exactly right.

The four types of sonority for consonants are: stop, fricative, nasal, and approximant. These four are classified consonants and specified in features as C. They oppose sounds classified as vowels, specified V, or -C.

Stops and fricatives are obstruents; nasals and approximants are resonants. Obstruents are specified Obs and oppose sonorants, specified -Obs. Sonorants include both resonants and vowels.

So, we have the following categories of speech sounds:

(1.1)	Consonant	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;">Stop</div><div style="display: inline-block; vertical-align: middle;">Fricative</div><div style="display: inline-block; vertical-align: middle;">Nasal</div><div style="display: inline-block; vertical-align: middle;">Approximant</div> </div> <div style="display: inline-block; vertical-align: middle; font-size: 3em; margin: 0 10px;">}</div> <div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;">Obstruent</div><div style="display: inline-block; vertical-align: middle;">Sonorant</div> </div> </div>	
	Vowel	{ Vowel	

In implicational terms, we can see that: (1) all vowels are sonorant, (2) all obstruents are consonants, and (3) resonants--the middle case--are sonorant consonants.

The four sonority types for consonants suggest that there is a linear gradation of sonority with stops as least sonorant and approximants (and vowels) as most sonorant. Grammont (1933:99) reports the following degrees of sonority:

- (1.2)
0. occlusives (stops)
 1. spirants (fricatives)
 2. nasals
 3. liquids (l, r)
 4. semivowels (j, w, ɥ)
 5. high vowels (i, u, y; ī, î, etc.)
 6. mid vowels (e, o, ø)
 7. low vowels (a).

Here the numbers 0 through 7 represent "degrés d'aperture." Saussure (1959:44ff.) reports a similar hierarchy which distinguishes only seven degrees of aperture (0-6) combining liquids (Grammont's degree 3) and semivowels (degree 4) into a single group "liquids" (47).

Such hierarchies are confirmed by Zwicky's more recent (1972) study of sonority. The study is based on comparisons of slow-speech and allegro forms of speech by speakers of American English. It depends on such rules (or processes) as Slur, which deletes [ə] following any consonant and preceding r, l, or n plus an unstressed vowel, e.g., happening becomes happ'ning. Zwicky delineates the exceptions to Slur which would not otherwise result in an unpronounceable sequence. These include those examples in which schwa occurs before stressed syllables, clusters, obstruents, the nasal m, and across word boundaries. Referring to the hierarchy given below in (1.3), Zwicky states:

I shall argue that the hierarchy...[in 1.3/RDG]...corresponds to a differential in the acceptability of the outputs of Slur, ranging from normally entirely acceptable before [r], to less acceptable before [n], to normally unacceptable before [m] and [ŋ], to entirely unacceptable before obstruents... (285)

Based on such rules as Slur which apply hierarchically, Zwicky presents the following sonority hierarchy:

(1.3) Stop Fric η m n l r Glide Vowel

In this hierarchy sonority decreases toward the left and increases toward the right. Fric represents fricatives. The "r" referred to is, of course, American English [ɹ], not the trill.

Restating Zwicky's hierarchy in terms of the classes discussed above, we get:

(1.4) Stop Fric Nasal App Vowel.

Here Fric is fricative and App is approximant. We are therefore left with the conclusion that nasals are less sonorant than approximants. Further, within the class of nasals, the velar (dorsal) nasal is least sonorant, the labial (chilic) in the middle, and the coronal most sonorant. Also "liquids" like l ɹ are less sonorant than "glides" like w j. And further, l is less sonorant than ɹ. We reach similar conclusions below, in sec. 1.2.3.

We turn now to a discussion of perceptual, articulatory, and acoustic considerations of consonants and vowels vis-à-vis the question of sonority.

1.1.1. Perceptual, acoustic, and articulatory properties of consonants.

In terms of perception, the presence of sonority is linguistically less salient than its lack. Consider, for instance, the fact that consonants (of low sonority) can be used as the only markers of words ("letters") in an orthographic system, as for example that of Hebrew. Vowels (of high sonority), on the other hand, would not offer unique orthographic representations, e.g., the consonant sequence ct could stand for cat or act, but the significance of the vowel letter a is less obvious.

In acoustic terms, sonority peaks are marked by a spectrum in which the various formants transit rapidly from their consonant values to their steady-state values for vowels and then back to their consonant values. The steady-state periods for vowels are longer in duration than those for consonants. Further, sonority valleys like stops are largely inaudible (spectrographically invisible), being defined instead in terms of the various transitions which they exhibit and not in terms of an identifiable steady-state.

It is clear from these considerations of the perceptual and acoustic properties of speech sounds that two separate phonological teleologies are involved. On one hand, it is clear that consonants are perceptually more important. This goes hand in hand with the idea that consonants are semantically more salient. On the other hand, it is clear that vowels are acoustically more important. They are the more audible "carrier waves" of speech, broken up by the intrusion of less audible consonants. In a word, consonants are semantically indicative; vowels are semantically ambiguous. Further, vowels are more clearly audible; consonants are less so.

In articulatory terms (after Catford 1977), with reference to stricture, closures like stops and nasals are clearly consonants and so are fricatives. Stops, which are largely inaudible and identified by their transitions, have already been discussed. Fricatives have a more audible spectrum involving diffuse areas of noise. They are identified partly by the frequency around which this noise gathers, partly by their transitions, like stops. Nasals, like vowels, may exhibit a steady-state but they are identified, in part, by their transitions; they can be distinguished from other consonants by resonant frequencies in their spectra corresponding to the resonancies of the nasal pharynx (cf. Lehiste 1970:156).

Sonants are clearly vowels, having steady-states in which the formants move toward the average frequency of the oral resonator. These consist of the nonhigh vowels.

But approximants, which represent the last type of stricture, may be either consonants or vowels and stand on either side of the line between these two classes. Acoustically, approximant consonants (or more simply "approximants") exhibit dynamic formant transitions with virtually no steady-state. Approximant vowels ("high vowels") exhibit steady-states but ones which are more extreme in comparison with those of sonant ("non-high") vowels. The formant values of high vowels are further from the norm, further from the average resonant frequency of the oral resonator. Approximants which correspond to high vowels, such as the correspondence between *j* and *i*, or *w* and *u*, show a similar displacement. But unlike the vowels with their steady-state, the dynamic spectra of approximant consonants reflect a rapid movement of the articulators to and from their place of articulation. For *j* and *w*, this dynamic mode serves to differentiate them from *i* and *u*, their corresponding vowels. For approximants lacking a corresponding vowel, such as *l* *r* *ɹ*, the movements, while more deliberate, apparently operate on the same dynamic basis. In the case of the flap *ɾ*, the tip of the tongue taps against the roof of the mouth; for the trill *ʀ*, it taps repeatedly and intermittently.

In such a way, arguments for the various types of sonority may be based on: (1) perception, to give the distinction between sonority valleys and sonority peaks (consonant versus vowel), (2) acoustic information, to

verify this same distinction and further to indicate the four stricture types (closure, fricative, approximant, and sonant), and (3) articulatory considerations, to verify the stricture types and further to account for the difference between approximants and high vowels. As we shall see, more discerning arguments may also be based on processes affecting sonority (as in sec. 1.2) and sequences of segments which reflect sonority.

1.2. Sonority and process.

1.2.1. Fortition and lenition.

In arguing for the various classes of sonority and the features which express these same classes, it is sufficient to show how natural processes affect speech sounds in general. Of course, we are not totally in the dark about what these sonority classes should be and the features which should be used to express them, so natural processes appear to serve simply to confirm or disconfirm our initial impressions. But more than this, natural processes show us how individual sounds are perceived, in terms of mental representations, and how sequences of sounds are integrated into pronounceable units, in terms of ease of articulation.

There are two types of processes: fortitions, and lenitions. Fortitions, also called paradigmatic processes, affect mental representations of speech sounds, in terms of their being perceived as individual sounds. Fortitions not only affect phonological representation, they also exhibit the endeavor of the conscious mind to make understandable conversation with the external world. Such understandability is based on the succinct notion that words with different semantic content should have different phonological forms. Fortitions thus account for the concept of phonological differentiation.

Generally, the language succeeds in making different messages bear a different form. Nevertheless, entire sentences may be phonologically ambiguous, as in these two sentences given by Hockett (1958:15):

- (1.5) a. The sons raise meat.
b. The sun's rays meet.


Although these are pronounced exactly alike--i.e., phonologically, they cannot be differentiated--such an arrangement is rare. If this were not so, we would be forced to comprehend the world and the speakers in that world on the basis of animalistic (and somewhat psychic) inferences. (And perhaps this is the way that the child originally perceives the problem involved in learning his native language.)

While the concept of the fortition and its application to paradigmatically defined speech acts is largely the creation of the subconscious mind, which views everything as relative to the present moment, it is the endeavor of the conscious mind to make these internal relationships tantamount to absolutes. So, when it comes to any phonological parameter--whether it is sonority, position, or color--the upper mind tries to look beyond the present moment in order to conclude that the difference between p and b is not one of voicing but is in fact a global difference. Further, an occurrence of p in the word pin in the present moment is perceived to be a repetition of the p in pen, pan, pun, etc., and further, it is concluded that the p in such words is an instance of the same sound. These are not unreasonable conclusions.

Language has essentially two facets: the external and the internal. In terms of the speech act, there is at once the observation of the external parameters of speech in terms of pronunciation and comprehension ("phonetics") and the inner motivation and perception of that self-same speech act ("phonology").

Fortitions account for phonological differentiation and also reinforce it. They not only refer to our perception of the speech act, they also serve as a model of it. Fortitions regulate what sort of thing can count as a mental representation, or mental intention, concerning speech. Lenitions, on the other hand, lead to phonetics. They regulate our notions about what is a suitable or favorable utterance.

Lenitions, also called syntagmatic processes, are based on syntagmatic concepts of speech and thus account for the need for ease of articulation. They are strategies for pronouncing sequences of segments and are based on the pragmatic notion that in a given context there are generally only a few messages that are likely to be given and these need differ only in a relative way from all the other likely messages. So, for instance, if a question has been asked, the response might be:

(1.6) .

This message represents the sentence "I don't know." Only the "melody" or intonation of the utterance remains, as indicated by the curved line, the segmental part being reduced to three moras of a syllabic bilabial (labial) nasal.

1.2.2. Evidence for sonority types.

Processes themselves provide evidence for the categories of sounds which may properly be attributed to the phonological parameter of sonority. For instance, consider the common change of *w* to *v* which occurs in such Indo-European languages as Sanskrit and the Romance family, as well as the Slavic family, northern Germanic (Scandinavian), and western Germanic except for English. I have observed it in child language and it is also common in such non-Indo-European language groups as eastern and nuclear Polynesian, e.g., Tahitian (eastern) and Samoan (nuclear), and the related Tongic family, e.g., Tongan (Biggs 1971). In Hawaiian, an eastern Polynesian language, the *w*:*v* distinction appears allophonically, *w* occurring after labial vowels, *v* after palatal vowels, and either (apparently depending on the dialect or disposition of the speaker) after achromatic /a/ and initially, e.g. Hawai'i [həvʌʔi] or [həwʌʔi].

The change from *w* to *v* can be analyzed this way:

(1.7) $w (=w\omega) \rightarrow \omega \rightarrow v \rightarrow \beta \rightarrow v.$

The sound *w* may be analyzed as a velar-labial approximant (as a dark velar "l" made with the lips rounded). The first step (*w* to ω) simply eliminates the weaker of the two colors, the velar one (ω). The second change (ω to *v*) also eliminates the labial coloring (lip-rounding), leaving behind a bilabial (nonlabial) approximant pronounced with spread lips. The third step (*v* to β) narrows the stricture one notch, from approximant to fricative.

And the fourth and last step (β to v) changes the bilabial to a labiodental one (dentalizes it).

The third step (v to β) is the one we are interested in here. It establishes the existence of two types of sonority neither of which involves total closure of the oral cavity (as with stops and nasals). This change, involving the narrowing of the stricture, is similar to the change of j to z in Puerto-Rican Spanish (and elsewhere in the Spanish dialects) and also the change of r to z in the central and southeastern dialects of fifteenth-century French, as in the change of chaire 'chair' to chaise (Pope 1934: 157f.). The process producing such narrowing of stricture is a fortition called, appropriately enough, narrowing (see sec. 3.1.1. below).

It is also possible to find examples of widening, produced by a contradictory process of that name (see sec. 3.1.2.). An example is rhotacism (as in western and northern Germanic and Old Latin), first voicing s to z between vowels. The widening then occurs as z becomes r . Proto-Germanic final z also widened to r in northern Germanic; cf. Gothic (Eastern Germanic) dags, Old Icelandic dagr, and Runic Norse dagaR, all meaning 'day (nom. sg.)' (Moulton 1972).

Other facets of these same processes reveal other sonority types. For instance, the change of the sound θ to t in languages lacking θ establishes the sonority type called stops. The English substitution of k for x , e.g. [bak] Bach, is a similar example.

Changes to and from nasals also occur, but less commonly, and establish this fourth sonority type. A student of mine from Hong Kong, whose native language was Cantonese, regularly substituted n for l in her English, e.g. nook for look. A child speech example relating nasals to stops is Joan Velten's denasalization of nasals to voiced stops, e.g., [bub] for broom and [bud] for spoon (Velten 1943).

Such an exposition of sonority types can easily be expanded, but at least it establishes the four main types. Other lines of argument are needed to determine the tensing or laxing of sounds, but this will be left to sec. 3.2 below.

1.2.3. Sonority within the syllable.

Another kind of evidence that can be used to establish sonority types and relative sonority, incident to the process, is the evidence of sonority patterning within the syllable. David Stampe (pers. comm.) has suggested that the patterning of types of segments within the syllable is in a fairly direct relation to their sonority. Basically, he suggests that the nearer to the nucleus of the syllable a segment is, the more sonorant it is. Conversely, the more removed or separated it is from the nucleus, the more obstruent it is. All this is subject to language-specific variations and exceptions, but the basic tenet stands.

For instance, in an English word like pit, the i is the nucleus and the p and the t are peripheral to it. This syllable may be analyzed as CVC, or more revealingly, OVO (where O = obstruent). In a word like print another part of the sonority hierarchy is revealed since r and n represent resonants. This syllable can be analyzed as ORVRO (where R = resonant). This example may bother some more discerning readers since print is phonetically [pɹɪt] (no nasal remaining). Consider then quilt.

Consider the word ironed [aɪrənd], which is pronounced as one syllable. This syllable can be analyzed as VVANO (where V = a non-syllabic vowel,

or "glide", A = approximant, and N = nasal). This effectively demonstrates that nonsyllabic vowels are less sonorant than syllabic ones, yet more sonorant than resonants. And the [ʌn] sequence divides those resonants into approximants (more sonorant) and nasals (more remote from the nucleus and thus less sonorant). (Cf. Saussure's 1959 distinction between explosive and implosive parts of a syllable. The sounds of ironed would all be implosive, except for [a], which is neither (51ff.).)

Also consider the word girl, phonetically something like [gɹɹl] and phonemically probably /gɹɹl/. Using the phonemic form as a model (or extrapolating from the phonetic form), we can see that the ɹ is more sonorant than the l. (Recall Zwicky's hierarchy at the opening of this section.) As further evidence, note that if the two approximants were reversed, a two-syllable utterance would result: [gɹlɹl].

Sonority gradation patterns within the syllable also suffer what might be termed language-specific exceptions. For instance, consider the English word scamps. The two instances of s are more sonorant than the two stops (represented by c and p) but nevertheless are more remote from the nucleus. They represent then sonority peaks subordinate to the main sonority peak represented by a [æ], i.e., the s's are satellite sonority peaks. (Cf. Donegan and Stampe 1978 for their discussion of the German word Stumpf.)

It is understandable that such satellite half-syllables then would cause learning problems for children. Children usually handle this problem by combining the position of the stop with the sonority of the s, e.g., spoon comes out foon. Only later do they acquire the adult pronunciation.

At any rate, sonority patterning within the syllable accounts for the various gradations, or types, of sonority of the kind we have discussed. They are based on strategies associated with connected speech such as are reflected in lenitions (see sec. 5 below).

2. Position and color distinctions.

2.1. Introductory remarks.

Position and color may best be defined in terms of their perceptual properties. The perceptual property of position is tonality. In a word, position is the tonality associated with a given articulation. The perceptual property of color is chromaticity. Color is chromaticity, as I will be using the word here, so that any particular color is the chromatic type associated with its particular articulation.

It remains then to specify the meaning of tonality and chromaticity. This will be done in the following two sections, beginning with tonality and ending with chromaticity.

2.1.1. Tonality.

Tonality may be briefly defined in terms of the tonal quality with which various sounds are associated. Tonal qualities associated with the various positions depend on three independent factors: (1) The tonal quality may be lower or higher (darker or lighter). Lower (darker) tonal qualities are expressed in features as grave (Grv); higher (lighter) ones, as acute (-Grv). (2) The tonal quality may be lingual or nonlingual. Lingual tonal qualities are, naturally enough, specified as lingual (Ling.); nonlingual ones, as nonlingual (-Ling). (3) The tonal quality may be implosive or explosive (somewhat in the Saussurean sense). Implosive tonal qualities are specified as retracted (Ret); explosive ones, as advanced (-Ret).

We can thus set up the following feature matrix. Here the four stops represent four positions: k represents dorsal, p bilabial, t coronal, and ? glottal.

(2.1)

	k	p	t	?
Grv	+	+	-	-
Ling	+	-	+	-
Ret	+	-	-	+

The typical order of voiceless consonants occurring in coarticulations (combinations of consonants having the same sonority but different positions) is as above in matrix (2.1). That is, k regularly precedes p t ? in coarticulations, e.g., kp kt k?. Then p regularly precedes both t and ?, e.g., pt p?. But t regularly precedes only ?, e.g., t? (combinations like ?t being analyzed as ?d). Much the same is true for nasals, i.e., their corresponding order would be η m n (there being no glottal nasal). So, we would expect the coarticulations ηm ηn mn, which typically do occur.

Generalizing on these two sets of examples, the stop order k p t ? and the nasal order η m n, we can make the following statement:

- (2.2) Within a given sonority type, the degrees of tonality function as a way of determining the order of sequence in combinations (specifically, coarticulations) of consonants. The order is as follows: (1) Grave precedes nongrave. (2) For the grave sounds, lingual precedes nonlingual. (3) For the nongrave sounds, the same thing applies: lingual precedes nonlingual.

Thus the function of tonality is to structure the syllable within the constraints of sonority. It is assumed that the above rule (2.2) applies within the limits of a single syllable; otherwise, no coarticulation would be involved.

2.1.2. Chromaticity.

Chromaticity is best examined in relationship to the articulations and interrelationships of the members which compose it. These members consist of the five colors, namely: labial (Lab), palatal (Pal), velar (Vel), pharyngeal (Phar), and rhotacized (Rho). Of these five, Donegan (1978) has identified the first two, labial and palatal, as the "primary colors". This is altogether fitting since these two colors are rarely lacking in a given language. They are certainly the most basic, with palatality taking an edge over labiality, e.g., Donegan (1978:47) reports that for vowel systems, there are languages with palatal vowels and no labial ones, but no cases of labial vowels without palatal ones.

Labiality, of course, is lip-rounding; and palatality is j- or i-coloring produced by approximating the blade of the tongue to the (hard) palate. This means that both labiality and palatality are advanced (nonretracted) sounds, wholly isolable to articulations made toward the front of the mouth. It is probably no accident that the two most basic colors are articulated toward the front. Front sounds are the first to be learned by children, and their existence is categorically implied by the existence of backer consonants (cf. Jakobson 1968:53).

The other three colors are all retracted, being articulated further back in the mouth. Velarity is ω -coloring produced by approximating the back of the tongue to the velum, or soft palate. Pharyngeality is α -coloring produced by approximating the root of the tongue toward the pharyngeal wall. And rhotacism is r -coloring produced by approximating the extreme lower end of the root of the tongue toward the lower pharyngeal wall.

If we were to classify the five colors according to classes of tonality, as addressed in the section above, the following would be the result:

(2.3)

	ω	j	υ	α	r
Grv	+	-	+	+	-
Ling	-	+	+	+	+
Ret	-	-	+	+	+

In the matrix above, labiality is represented by its approximant symbol ω , palatality by j , velarity by υ , pharyngeality by α , and rhotacism by r .

One thing is perfectly obvious from the above matrix and that is that the three features used to differentiate the four tonalities leave ω (velar) and α (pharyngeal) undifferentiated. They are both marked plus (+) for grave (Grv), lingual (Ling), and retracted (Ret). This can be remedied by adding either the feature high (High) or the feature low (Low). The colors j and υ are High; the colors α and r are Low. Three features are all we really need, as follows:

(2.4)

	ω	j	υ	α	r
Grv	+	-	+	+	-
Ret	-	-	+	+	+
High	-	+	+	-	-

In such a way, the colors can be distinguished in terms of tonality. The advanced colors are the basic ones; the retracted colors are of a more subtle nature.

2.1.3. Chromaticity and tonality in synesthesia.

Chromaticity (the property of colors) may produce visual images or evoke colors, e.g., a color like red or white may be associated with the vowel [a]. This is an example of a synesthesia, in which the stimulation of one sense evokes the sensation in another; in the case at hand, hearing evokes sight. Synesthetes, i.e., people with synesthesia, reported on by Jakobson (1968), reveal a constant and clear sound-color agreement which they have in most cases perceived since childhood. A typical case is SP, a speaker of Czech, who has the following sound-color agreements for vowels occurring in Czech:

(2.5)

i canary yellow	u dark blue
e light green	o blue-red
a red	

Langenbeck, Deichmann, and Argelander (as reported by Jakobson 1968:82f.) all report similar photisms for vowels, e.g., Argelander reports that white is most often associated with i , black with u , yellow with e , brown

with o, and red, white, or a dark color with a. These color sensations are synesthetic responses to the chromaticity of the vowels, as I am using the term here.

SP reports that consonants evoke colors that are mainly various shades of gray with brighter overtones, some of the brightest overtones being connected with consonants with palatal coloring. Langenbeck, a synesthete himself, reports that for him consonants are all equally colorless. These color sensations, or relative lack of them, are synesthetic responses to the tonality of the consonants, as I am using the term here.

But the meaning is evident, and the analogy is particularly pertinent since it is based on perceptual data due to the psychology of synesthesia. Namely, chromaticity is associated with bright colors and gross distinctions of color. Vowels (and chromatic consonants) have bright colors. However, tonality is associated with various shades of gray or with various degrees of lightness and darkness, more subtle color distinctions. Consonants are various shades of light and dark.

Colors--i.e., palatal, labial, and so forth--represent gross distinctions of phonological coloration, e.g., they have great chromaticity. The vowels, which all exhibited bright colors, are highly chromatic. The approximants of color (w j ɥ ɹ) are also highly chromatic. Consonants without color exhibited low degrees of chromaticity and thus need to be distinguished on the basis of tonality.

2.1.4. Consonant-vowel agreement.

Various phonologists from Panini on have assumed that certain consonants correspond to certain vowels. For instance, consonants like c j correspond to the vowel i, agreeing with it in certain aspects of chromaticity and tonality. For the set č ɟ i, all are of the same chromaticity, palatal, and of the same tonality, coronal--granted that i can be referred to as a coronal vowel.

Trubetzkoy (1969) proposed a linear arrangement of consonants and a triangular, more or less linear, arrangement of vowels. In such a system it was impossible to correlate consonant and vowel subsystems, and Trubetzkoy made no attempt to do so.

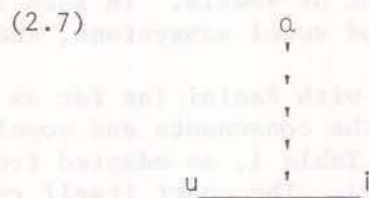
But the Indian phoneticians, starting with Panini (as far as we know), used a system of interrelationships among the consonants and vowels of Sanskrit. These sounds are given below in Table 1, as adapted from W. S. Allen's Phonetics in Ancient India (1953:20). The chart itself reads in a reverse order to what we would normally expect, because the Indian grammarians started with those sounds "nearest to the origin of the airstream" (Allen 1953:48) and from there they "work upwards and forwards towards the lips" (ibid).

Of the five orders of vowels, a is considered to be glottal or pulmonic, i is palatal, ɹ is retroflex, l dental, and u labial. Referring to the stop consonant in each file of the chart, we can establish the following basic consonant-vowel correlations:

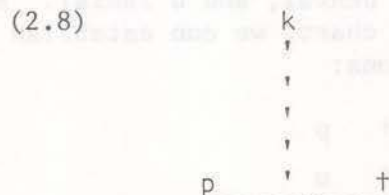
(2.6)	h	k	č	†	†	p
	a		i	ɹ	l	u
				ɹ	l	

		glottal or pulmonic	velar	palatal	retroflex	dental	labial
Closures			k	č	ʈ	t̪	p
			kh	čh	ʈh	t̪h	ph
			ɡ	ɟ	ɖ	d̪	b
			ɡh	ɟh	ɖh	d̪h	bh
			ṅ	ɲ	ɳ	n̪	m
Non-closures				ɻ	ɽ	l̪	v
	h ṁ	(x)	ɕ	ɖ	s̪	s̪	(ɸ)
Vowels	a ā			i	ɨ	ɪ	u
				ī	ī		ū
				e			o
			ai				au

Jakobson (1968:73-81) proposes an ontogenic view of consonant and vowel correlation with the following chart (74).



He notes that the u/i process (the base line) expresses lightness and darkness distinctions, where i is considered light and u dark. The a process, on the other hand, expresses the degree of chromatism. A similar chart is given for consonants (ibid.):



So, k corresponds to a, p to u, and t to i. Cf. the Indian phoneticians' h (not k) to a, c (not t) to i, and both agree on p to u.

Even Jakobson's feature system responds to this relationship (as given in Jakobson and Halle (1956:29ff.)). It is summarized in the following feature matrix:

(2.9)

	k	a	p	u	t	i
consonantal	+	-	+	-	+	-
compact	+	+	-	-	-	-
grave	(+)	(+)	+	+	-	-

Chomsky and Halle (1968) added the features high, low, and back not only for vowels but also for consonants. This produced the agreements given in Table 2. Vowels in the table are given above, and consonants and glides below. Thus č, c (K), y (J) correspond to i, k and w to u, p and t to e, q to o, h and ? to æ, and finally to a. All of these agreements are drawn from the chart on p. 307 of Chomsky and Halle (1968). The consonant features anterior and coronal, for which vowels are all specified negatively, have been omitted.

Table 2

Chomsky and Halle's system of agreements

Vowels	i	u	e	o	æ	a
high	+	+	-	-	-	-
low	-	-	-	-	+	+
back	-	+	-	+	-	+
Labials	p ^y	p ^w	p	p ^ɣ	p ^a	p ^a
Dentals	t ^y	t ^w	t	t ^ɣ	t ^a	t ^a
Palato-alveolars	č	č ^w				
Palatals	c					
Velars		k				
Uvulars				q		
Pharyngeals						ħ
Glides	y	w			h, ?	

While the columns of the chart under i, u, o, and a express plausible enough sound relationships, it is hard to see how p and t are related to e, and how h and ? are related to æ.

Based on what I have learned about consonants and their interrelationships, and their relationships to vowels, I would suggest the following agreements:

(2.10)	p	+	+	+	k	q	k	?
	ω	-	J	r	ɥ	ɥ	α	-
	-	-	i	i	u	ɤ	o	-

In the first row are stops, representing the individual positions: chilic (p), coronal (+ + +), dorsal (k q), radical (k), and glottal (?). In the second row is the corresponding color, if any. And in the third is the corresponding vowel.

We should first note that the vowels e æ are lacking. These are internal vowels, being remote from the external areas where consonants are articulated.

Chilic p has no corresponding vowel; however, it does have the color ω, which applies to rounded consonants and vowels. The dorsal labial consonant k^ω would correspond to w (= ɥ^ω).

It is probably significant that neither plain coronals (+) or glottals (?) have any corresponding colors or vowels. These two have the highest tonality of all the stops.

In the column headed by + (retroflex), the corresponding color is r (rhotacized) and the vowel i (high central unrounded). These three would all be specified as -Grv Ret Ling (see sec. 2.2. just below).

The q (uvular) column corresponds to uvular coloring (if there be such), represented by the symbol ɥ. The corresponding vowel is the mid (-High -Low) back vowel ɤ.

The argument for these consonant-vowel agreements carries over into the relationships among position, color, and the application of processes, to which we now turn.

2.2. Position, color, and process.

Evidence for the various types of position and the various types of color is revealed in the operations of processes. We start with a consideration of position (primary and secondary) and continue with a discussion of color, which creates various secondary positions. A consideration of the ontogeny (individual development) of position and color concludes our discussion.

2.2.1. Position and process.

The primary positions are easily established according to the workings of processes. The primary positions are the five given for the primary consonants in sec. 0 above: chilic through glottal.

The fortitions affecting position, appropriately called fronting and backing, normally front or back a consonant one "notch" on the position continuum. For instance, chilic p can be backed to coronal +, one position further back, as in the speech of Elizabeth Stampe at age 1:6 (pers. comm., David Stampe). Coronal + in turn was backed historically in Hawaiian, and + and k alternate in various styles of Samoan (Biggs 1971). I know of no language in which k backs to k; however, the velar approximant ɥ backs (or alternates with) pharyngeal α in the individual speech patterns of many speakers of American English: it is the dark -l sound for some speakers in little [ɥiɾɥ] or, for some, even [αiɾα]. And the radical (pharyngeal)

fricatives ħ ʕ in proto-Semitic reportedly became ʔ in Akkadian, along with several other sounds, e.g., uvular q and the glides j w (Gray 1934:10-20).

In such a way, the primary positions may be established. I have used here the process backing; its opposite, fronting, would have given less complete results, e.g., I know of no change which fronts ʔ to k or k to k . However, Walter, a first-grade pupil, when asked what the sound of the letter h was, replied "Huck". Apparently, huh [$\text{h}\text{ʌ}$], the expected answer, took on a final glottal stop (became [$\text{h}\text{ʌ}\text{ʔ}$]), which in turn fronted to k (to give [$\text{h}\text{ʌ}\text{k}$]).

Chilic has two subpositions, bilabial and labiodental, that we need to consider. Similarly, coronal and dorsal have likewise two subpositions, neither of which involve color. The two coronal subpositions are (inter)-dental and (post)alveolar; those for dorsal are velar and uvular.

There is a process that dentalizes chilic fricatives and coronal smooth fricatives; namely, ɸ β become f v , and ɸ β become θ ð . Speakers of languages with f v , e.g., English, hear instances of ɸ β as their own f v . For instance, the Spanish word saber [$\text{s}\text{a}\text{β}'\text{e}\text{r}$] 'to know' is heard as [$\text{s}\text{a}\text{v}'\text{e}\text{r}$] by beginning students of Spanish, sometimes also as [$\text{s}\text{a}\text{b}'\text{e}\text{r}$]. Notice that both these changes, β to b or v , involve a nontangent sound (β) becoming a tangent one (b or v), i.e., for the articulation of b and v , both the articulators actually touch. In the case of b , the two lips come together; in the case of v , the upper teeth articulate directly against the lower lip. The dentalizing of ɸ β ɸ β all involve an accompanying introduction of tangency.

For dorsals, the distinctions velar and uvular commonly show up for stops, k/q , and for fricatives, x/x . The backing process has changed x to x in Castillian Spanish (cf. Harris 1969:196f.).

For coronals, the distinctions dental and alveolar commonly show up for stops t/t (as in Bengali), and fricatives θ/s (as in English).

On the basis of tonality properties (without reference to color), we can distinguish the following set of positions and subpositions. I have used fricatives here to symbolize the variations just discussed.

(2.11)	ɸ	f	θ	ɸ	x	x	ħ	h
Grv	+	+	-	-	+	+	+	-
Ret	-	-	-	-	+	+	+	+
Low	-	-	-	-	-	-	+	+
High	-	-	-	-	+	-	-	-
Dent	-	+	+	-	-	-	-	-

The first three features delineate the five primary positions. Only two more features are needed to distinguish the three subposition variations which we considered above.

2.2.2. Color and process.

The interrelationships of colors themselves are best considered with reference to their ontogeny; this is done in the next subsection (sec. 2.2.3.). But the effect of color on consonant position and the relation of chromaticity to tonality are other matters. Let us start with a consideration of tonality, chromaticity, and sonority.

In languages with simple consonant systems, we can observe the variations of the development of positions, expressed in terms of tonality.

Every language must have at least two distinctions for tonality (otherwise there is no distinction). Yet even languages with simple consonant systems exhibit at least three tonality distinctions. For stop systems, we have /p t k/ in Iwam (a language of northern New Guinea), /p t ʔ/ in (Classical) Samoan, /p k ʔ/ in Hawaiian, and /t k ʔ/ in Oneida (cf. Biggs 1971; Ruhlen 1976). Yet no language has a stop system based purely on chromaticity, e.g. */p p^w p^j/. It is evident that processes apply that eliminate this possibility. Tonality is thus a more salient parameter for consonants than chromaticity.

Moreover, sonority for consonants seems to measure up to tonality. There are always at least three sonorities, typically stop, nasal, and approximant. So, sonority is also more salient for consonants than chromaticity.

But as Donegan (1978) has pointed out, sonority is more salient for vowel systems than either chromaticity or tonality. Vowel systems like /i e a/ are possible, which exhibit height (sonority) distinctions but not timbre (tonality) distinctions. Yet when timbre distinctions are involved, they typically also exhibit chromatic oppositions, generally palatal versus labial. These colors act to maximally differentiate front (palatal) and back (labial) vowels from one another.

The addition of color to an otherwise achromatic (noncolored) consonant generally results either (1) from occurrence adjacent to a vowel bearing a color, or (2) from occurrence adjacent to a color approximant. In the first case, that of the vowel, a consonant becomes palatalized next to a palatal vowel, labialized next to a labial vowel, velarized next to a velar vowel, or pharyngealized next to a pharyngeal vowel. So, tɛ becomes t^uɛ, tɔ becomes t^uɔ, t^uw becomes t^uw and t^ua becomes t^ua. The process which performs this color addition is a lenition called color matching (see sec. 5. below).

In the second case, that of occurrence with a color approximant, the approximant loses its identity as a separate segment and becomes attached to the consonant. In so doing, the consonant takes on a color, e.g., t + j becomes t^j, t + w becomes t^w, t + r becomes t^r (retroflex), etc. For t^j becoming t^j, compare the change of t^j to t^s in gotcha (from got you), etc.

In Table 3, an attempt is made at distinguishing eleven subpositions. The features grave (Grv), lingual (Ling), and retracted (Ret) delineate the basic positional distinctions. Then high (High) and low (Low) are used to differentiate some of the backer sounds. Finally, dental (Dent) is used to distinguish labiodentals and (inter)dentals from everything else.

The letters across the top represent the subposition categories: A = bilabial, B = labiodental, C = dental, D = (post)alveolar, E = (alveo)-palatal, F = retroflex, G = (velo)palatal, H = velar, I = uvular, J = pharyngeal, and K = glottal.

Below that, four rows of fricative symbols appear. Fricatives have been chosen as representatives here since they are the commonest occurrences of these various subpositions. These rows are numbered at left. In row (1) are the laterals. They are the least sonorant of the fricatives and are accordingly placed at the top. They are differentiated from other fricative sonority types by being specified tangent (Tan). In rows (2) and (3) are given the grooved (Gru) fricatives. Those in (2) are laminal (-Api); those in (3) are apical (Api). In row (4) the smooth (Smu)

fricatives are given. Any other distinctions of subposition would require the use of the individual color features, e.g., palatal (Pal), labial (Lab), etc.

Table 3

Positions and color distinctions

	A	B	C	D	E	F	G	H	I	J	K
(1)				ɤ		ɤ̃					
(2)				ɤ̃	ɤ̃	ɤ̃					
(3)				ɤ̃	ɤ̃	ɤ̃					
(4)	ɸ	f	θ	ɸ	ɸ	ɸ	χ̃	x	χ̃	h	h
Grv	+	+	-	-	-	-	+	+	+	+	-
Ling	-	-	+	+	+	+	+	+	+	+	-
Ret	-	-	-	-	-	+	-	+	+	+	+
High	-	-	-	-	+	+	+	+	-	-	-
Low	-	-	-	-	-	-	-	-	-	+	+
Dent	-	+	+	-	-	-	-	-	-	-	-

The main additions to Table 3, over the eight distinctions given in (2.8) above, are the inclusion of the alveopalatals (E), retroflexes (F), and the velopalatals (G). They agree for all features except grave (Grv) and retracted (Ret). So, with the addition of velars (H), the following matrix is needed to distinguish them:

(2.12)		ɤ̃	ɤ̃	χ̃	x
	Grv	-	-	+	+
	Ret	-	+	-	+

Above, in sec. 2.1.4., it was pointed out that ɤ̃ (represented in (2.7) above by ɤ̃ in the list of consonant-vowel agreements) corresponds to the front (apalatal) vowel i, which is, like s, -Grv -Ret. The sound ɤ̃, here representing the reflex ɤ̃ of (2.7), corresponds to the central vowel i, which is -Grv Ret. No vowel is like χ̃, which is Grv -Ret, and so it corresponds to no vowel. The sound x corresponds to u; both are Grv Ret.

It is clear that front vowels are neither grave nor retracted and that back vowels are both. It is fairly clear that central vowels are retracted but nevertheless nongrave. The color rhotacized (Rho), symbol r̥, is the approximant related to retroflexes like s and accordingly this color appears almost exclusively with retroflex coronal consonants and central vowels. It also appears with nonretroflex coronal approximants like r̥. I know of no examples of rhotacized occurring with noncentral vowels. When it does occur with central vowels, it occurs with lower ones, e.g. ə a to give ɤ̃r̥, (= ɤ̃) and ɤ̃r̥. This is due probably to the fact that rhotacized is specified Low, being produced in the lower pharynx.

The sound ɤ̃ is typically to be identified with the retracted consonant x, which often becomes substituted for it (e.g., Slavic ɤ̃ produced by the ruki rule, becomes backed to x). Accordingly, both ɤ̃ and x are specified Ret, but because of its lighter tonality, ɤ̃ is specified -Grv.

The sound \acute{x} is typically related to the sound \check{s} ; accordingly they are both specified -Ret. The fortition fronting changes \acute{x} to \check{s} (more typically to \check{c}) and the backing of type \check{s} to \acute{x} is not without example (e.g., Macedonian \check{c} became \acute{k} ; Kondrasov 1962). Nevertheless, \acute{x} still retains its darker tonality and is accordingly also specified as Grv.

2.2.3. The ontogeny of position and color.

Here I would like to make a few general remarks about the ontogeny (development within the individual) of position and color vis-à-vis whole systems of consonants. The material which inspired this section is drawn (either explicitly or implicitly) from observations by Jakobson (1968), Velten (1943), Leopold (1947), Edwards (1973), Stampe (1973), and Major (1977).

Of all the implicational relationships concerned with whole consonant systems, the only one that holds for sure is that back (retracted) consonants imply front (advanced) ones (Jakobson 1968:51-58). Thus in the ontogeny of position there is a marked preference for advanced consonants. (Jakobson also lists two sonority implications: fricatives imply stops and affricates imply fricatives.)

For stops, then p and t are naturally acquired first, first as variations of one sound, later as separate phonemes. Often during the variation period p comes to be associated with a , and t with i .

In languages which do not have p , p comes to be replaced by a retracted sound, either k (preserving gravity) or $?$ (preserving non-linguality). In languages with $p + k$, there is generally a period when t is identified with k , or if not identical, t becomes k when there is another velar in the word. In languages with $?$, this may be identified with any buccal stop, but especially k , with which it shares retractedness. Michou Landon at age 2 identified $?$ with p , e.g., button [bʌpʰ] (pers. comm., Bill Landon).

Voicing for stops starts out on a contextual basis, only later becoming nonautomatic. At first, initial stops may be voiced and final ones devoiced.

The first fricative is usually s ; if not, then f --advanced fricatives being preferred. At first processes relate f and s ; later, they become differentiated. Palatal coloring first enters the system through the sound \check{s} , which at first alternates with s (and sometimes with f). At this stage retracted fricatives are usually lost, especially in association with stops (cf. Major 1977).

Voicing for fricatives is contextual at first. Compare the situation for stops.

Nasals are similar in their ontogeny to stops, appearing very early. At first, m and n are related by processes. At this stage, retracted nasals become advanced, e.g., η typically becomes n .

Approximants are at first typically narrowed to fricatives or lost. So, j may become \check{z} or z or be lost. Typically, w is the first approximant to widen, generally having started out as f (v) or having been lost. At this stage, l becomes j or w according to context. Either j or w may replace l initially. The sound \downarrow , as in English, is typically replaced by w or lost. The development of w and j is largely independent. The general loss of approximants is probably due to their being identified with the retracted consonants.

Voicing for nasals and approximants is typically natural (sonorant voicing).

3. Sonority fortitions.

3.1. Narrowing and widening.

There are two contradictory fortitions (paradigmatic processes) which affect stricture: (1) narrowing, and (2) widening. As their names would indicate, the process called narrowing reduces the opening between the articulators, and the process called widening increases it. Typically, narrowing changes approximants to fricatives and fricatives in turn to stops. Widening does the exact opposite; it typically changes stops to fricatives and fricatives in turn to approximants.

Instances of both narrowing and widening follow the guidelines for what constitutes a fortition. These criteria were established above in sec. 1, and include the following principles: (1) Fortitions are segment-optimizing and dissimilative. (2) They are typically context-free, occurring regardless of the specific phonetic environment in which they are found. (3) They are strengthening, i.e., they reinforce some characteristic of the sound in question. (4) They are typically to be associated with hyperarticulate forms of speech. Both narrowing and widening answer to these criteria, as we shall see below.

It is reasonable to conclude, given that both narrowing and widening are fortitions yet have opposite effects, that they must in fact also have opposing teleologies, or reasons for being. In this section and the next I present four pairs of processes, two in this section and two in the next. In sec. 3, the two pairs are narrowing/widening and tensing/laxing. In sec. 4, they are fronting/backing and coloring/bleaching.

The first (left-most members) of these pairs are chromatizations. The second (right-most members) of these pairs are sonorizations. Chromatizations are fortitions which either increase chromaticity (color) or increase its favorability. Chromatizations do so at the expense of sonority. Sonorizations, on the other hand, increase sonority, at the expense of chromaticity.

Narrowing is a chromatization. Typically, the narrower a consonant is, the more likely it is to show the greatest variety of chromaticity, or color. It is not surprising then that, conversely, the wider (more sonorant) consonants should be the first to lose chromaticity. An example is the loss of palatality for every instance of *r* in Belo-Russian. Cf. Russian pered [pʲerɐtʲ] 'before' (with palatalized *r*) with Belo-Russian perad [pʲerɐt] 'before' (with non-palatalized *r*) (examples from Kondrašov 1962:113-4).

Adjunct to the notion of chromaticity is the concept of tonality, or position. Typically, the narrower a consonant is, the more likely it is to show the greatest variety of tonality, or position. English is a good example here. For the voiceless obstruents, English has a *p* and a corresponding *f*, a *t* and a corresponding *s* (also *θ*), but *k* has no corresponding fricative (**x*).

While narrowing is a chromatization, widening is a sonorization. It increases the opening between the articulators and makes them more vowel-like, i.e., more sonorant. In the following discussion of the two processes, we will find that narrowing is particularly applicable to lighter (more acute) colors (chromaticities); widening, on the other hand, especially affects

darker (more grave) positions (tonalities). So, colors like palatal and labial and consonants with these colors become narrowed. And consonants with darker tonalities, like dorsal and radical, become widened. A specification in terms of the two major sonority features, closure/nonclosure and obstruent/sonorant makes clear the relationships of the four sonority types. These relationships may be schematized as follows:

(3.1)		Obstruent	/	Sonorant
	Closure	STOPS		NASALS
	Nonclosure	FRICATIVES		APPROXIMANTS

Changes usually move horizontally or vertically, but only rarely diagonally. So, while approximants frequently narrow to nasals (upwards) or fricatives (to the left), they seldom make a one-step change to stops (across, diagonally). As we have seen, approximants do make two-step changes to become stops, typically with fricatives as the middle step. Other relationships, not just those of narrowing, can be gleaned from this little chart. For instance, stops rarely widen directly to approximants but rather become nasals or fricatives first.

The process of narrowing for consonants corresponds to Donegan's (1978) vowel process called raising; further, the consonant process widening corresponds to the vowel process lowering. The function of each pair is therefore similar. Narrowing and raising increase chromaticity at the expense of sonority; opposing these two are widening and lowering, which increase sonority at the expense of chromaticity. Thus both narrowing and raising are chromatizations; both widening and lowering are sonorizations.

We now turn to the discussion of these two consonant fortitions, first the chromatization narrowing (in sec. 3.2.1.) and then the sonorization widening (in sec. 3.2.2).

3.1.1. Narrowing.

The fortition narrowing may be stated as follows:

$$\left[\begin{array}{c} C \\ n \text{ narrow} \\ ! \text{ lighter} \\ ! \text{ Tns} \\ ! \text{ Gloz} \\ ! / \$ \end{array} \right] \rightarrow [n + 1 \text{ narrow}].$$

This statement is to be read as follows: "A consonant of n narrowness, especially when it is of a lighter chromaticity or tonality, especially when it is tense, especially when it is glottalized, and especially when it occurs syllable-initially, becomes the corresponding consonant of n + 1 narrowness, i.e., becomes one notch narrower."

In the statement of the process, the exclamation point (!) signifies "especially when." It tells the specific conditions which catalyze (or help bring about) the operation of the process.

In the statement, the notation "narrow \rightarrow n + 1 narrow" means that an approximant and a fricative become a fricative and a closure, respectively.

It is also possible for a (nonsyllabic) high vowel to become an approximant.

Here are some general examples in which the fortition narrowing operates:

- (3.2) a. Old Armenian t, phonetically probably [ɰ], has become [ɣ] in the modern dialects (Vogt 1974).
- b. In the central and southeastern French of the fifteenth century, intervocalic [r] lost its trill and assibilated to z. In the fifteenth and sixteenth centuries, this pronunciation became popular in Paris and produced changes like: chaire 'chair' > chaise, bericles 'spectacles' > besicles, and Oroir 'place-name' > Ozoir. (Pope 1934:157f.).

In each of the above two cases, an approximant was changed to its corresponding fricative. In (3.2a) the dorsal (velar) approximant ɰ became the dorsal fricative ɣ, and in (3.2b) the (grooved) coronal approximant r became the (grooved) coronal fricative z. In the following example, a fricative is changed to the corresponding stop:

- (3.2) c. Speakers of English typically substitute [k] for [x] when [x] occurs in a word of foreign origin, e.g., Bach [bɒk] and Khrushchev [kɹʊʃtʃɛf].

We now turn to an explanation of the specific "especially-when" cases which serve to catalyze this process.

3.1.1.1. ! Lighter.

In reference to chromaticity, the palatal color j can be said to have a lighter color than the colors ɰ (velar) or α (pharyngeal). The labial color ω is in between these two groups (and rhotacism, or r-coloring, as symbolized by r, could conceivably be in this middle group as well). So, we have the following hierarchy of colors:

- (3.3) a. j ω ɰ α

Leftwards in this hierarchy is lighter; rightwards is darker. Such terms as bright, clear, and slender have been used to indicate the tonal aspects of the term light. For dark, the terms obscure and broad have also been used.

In reference to tonality, a similar hierarchy exists, as follows:

- (3.3) b. t p k ḳ

Here stops have been used to signify positions: ʔ for glottal, t for coronal, p for chilic, k for dorsal, ḳ for radical. There is an exact correspondence between the colors given above in (3.3a) and the positions given here in (3.3b): j corresponds to t, ω to p, ɰ to k, and α to ḳ.

Glottal position has no corresponding color. Again, leftwards in the hierarchy is lighter; rightwards is darker. In features expressing tonality (position), glottal and coronal are acute, and the other (rightmost) three are grave.

Given this information, we see that lighter colors and positions exhibit narrowing most often:

- (3.4) a. Common Slavic palatalized \acute{r} has become narrowed to \check{r} [žr] in Czech (Kondrašov 1972:136). The symbol [žr] refers to a ž-sound having r-coloring.
- b. In early Gallo-Roman, j and w were narrowed to dž and g^ω when initial, e.g., Latin jam 'already' became [džə], and Germanic waddju 'gāge, pledge' was borrowed as [g^ωadže] (Pope 1934:96f.). Ibero- and Italo-Roman also exhibit the same change.

In the above two examples, approximants with light color (palatality and labiality) have undergone narrowing. The following change shows us how the Gallo-Roman change in (3.4b) must have come about:

- (3.4) c. In Puerto Rican Spanish and other dialects of Spanish, j has become z and w has become y^ω before a vowel. When initial, z in turn becomes dž and y^ω becomes g^ω, e.g., yo [džɔ] 'I' and huevo [g^ωεβɔ] 'egg' (pers. comm., Barry Nobel; Harris 1969:20ff., esp. 25).

The narrowing of j and w thus proceeds this way:

- (3.4) d. j → z (→ dž) → dž
w → y^ω → g^ω

Here is an example of the operation of narrowing on consonants of lighter tonality:

- (3.4) e. In American English, θ (after s and f, or before s) dissimilates to t, e.g., sixth > sixt, fifth > fift, and months > munts. Also in slightly sub-standard speech, f dissimilates to p (after s, or before θ), e.g., sphere > spere (pronounced like spear) and diphthong > diphthong.

This change differs from the change of x to k in that it is dissimilative in nature and not generally applicable.

3.1.1.2. ! Tense.

A full discussion of tenseness and laxness will be given below in sec. 3.2. For our purposes here, it is sufficient to note that voiceless obstruents are usually tense. Tense (and voiceless) fricatives become stops in the following examples.

- (3.5) a. In the English of speakers of various Indian languages (e.g., I have observed it for speakers of Hindi, Bengali, and Gujarati), f and θ become ph and th (strongly aspirated) in careful or emphatic speech.
- b. Prakrit retroflex \dot{s} became x ; this x in turn became kh (pers. comm., David Stampe).
- c. Indo-European $*sw$ became hw in Armenian (by the general substitution of h for s). This hw then became k^h (aspirated), as in Armenian k^hoyr 'sister' (< IE. $*swesor-$) (Meillet 1936:50). Possibly hw became x before being narrowed to k^h .

3.1.1.3. ! Glottalized.

When a consonant is coarticulated with glottal stop $ʔ$, i.e., when it is glottalized, that consonant becomes narrowed. I know of no examples in which a $fʔ$, for example, has become $pʔ$, but the point is that the languages of the world rarely exhibit glottalized fricatives where there is no corresponding glottalized stop or affricate (as evidenced in Ruhlen 1976). Glottalization then is clearly a catalyst for narrowing. Conversely, aspiration (coarticulation with the glottal fricative h) is a catalyst for widening, as we see in 3.1.2 below. Other glottal phenomena, like voicing, will be mentioned in the discussion on tensing and laxing (see sec. 3.2).

3.1.1.4. ! Initially.

This section refers primarily to consonants occurring initially in the syllable, although most of the examples actually refer to consonants occurring initially in the word. The following examples demonstrate the operation of narrowing on consonants which appear in initial position:

- (3.6) a. The Puerto Rican Spanish example in (3.4.c) above shows narrowing of j and w in both syllable-initial and word-initial position. Initially in syllables, j and w become z and y^w respectively, e.g., calle [kaze] 'street', mayo [mozo] 'May', and Chihuahua [čiy^way^wo] 'state of Mexico'. Initially in words, $j > z (> dz) > dʒ$ and $w > y^w > g^w$, e.g., yerba [džerβa] 'grass' and huerta [g^werto] 'garden' (Harris 1969:20ff.).
- b. The change of w to v is common, probably $w > \omega > v > \beta > v$, where the change of v to β is a narrowing. It occurs in Sanskrit, Slavic, Romance, Germanic except for English, and various Polynesian languages, and child language (see sec. 1.2.2).
- c. In Kekchi, a Mayan language, j and w have become tj and kw , respectively, in initial position (Anttila 1972:69).

This completes the discussion of narrowing.

3.1.2. Widening.

Widening is a fortition and sonorization that can be stated as follows:

$$\left[\begin{array}{c} C \\ n \text{ narrow} \\ ! \text{ darker} \\ ! -\text{Tns} \\ ! \text{ Asp} \\ ! / __\$ \end{array} \right] \rightarrow [n-1 \text{ narrow}].$$

This may be read as "A consonant is widened one notch (becomes the corresponding consonant of the next wider stricture), especially when it is of a darker chromaticity or tonality, especially when it is lax (nontense), especially when it is aspirated, and especially when it occurs syllable-finally." Again, the exclamation point (!) signifies "especially when."

In the statement, the notation "n narrow \rightarrow n - 1 narrow" means that closures would become fricatives, and fricatives would become approximants.

Here are some general examples of the operation of this process:

- (3.7) a. In Ukrainian and Slovak, two languages of the Slavic family, g widened to ɣ, which in turn gave ɦ (voiced). Compare Russian golova 'head', with initial [g], and its cognates in Ukrainian and Slovak, golova and hlava, respectively, both with initial [ɦ]. (Examples from Kondrašov 1962.)
- b. In morphophonemic alterations, Finnish p + k voiced and widened to β ð γ. β then dentalized to v. γ then fronted to j before a labial vowel, to j before a palatal vowel (after r or l), or was lost. ð appears as d in the standard language. (pers. comm., Ilse Lehiste; cf. Anttila 1972:219-222.) Examples:

nom. sg.	gen. sg.	gloss
papu	pavu-n	'bean'
kato	kado-n	'loss'
suku	suvu-n	'family'
järki	järje-n	'intelligence'
joki	joe-n	'river'

- c. The Russian adjective endings -ego and -ogo were also affected by widening. Here g became ɣ (and later fronted to v under the influence of the labial vowel following). E.g., Russian xorošogo [xɐ'ɔʃəvə] 'good (gen. sg.)'.

3.1.2.1. ! Darker.

In accordance with the hierarchy given in sec. 3.1.1.1. above, narrowing affects lighter chromaticities and tonalities and now widening affects darker ones. I repeat the hierarchy here, using colors to symbolize themselves and stops to symbolize positions:

(3.8)	j	ω	ɥ	α
	?	t	p	k

For colors, leftwards indicates lighter chromaticity and rightwards, darker chromaticity. For positions (the stops), leftwards indicates lighter tonality and rightwards, darker tonality. Widening works most often on positions of darker tonality, and on darker colors.

The following examples illustrate the "darker" condition:

- (3.9) a. The absence of radical (pharyngeal) closures (like $k̤$ $g̤$ $ŋ̤$) in the languages of the world is a good indication that the darkest closures must widen. (It is however, possible for some speakers to produce a voiced, imploded radical stop.)
- b. After i; Old English xt became Modern English jt (spelled ght, as in night), while ft and st remained unaffected. (Cf. Wright 1928:21.)
- c. Latin kt between vowels became early Portuguese ft or xt , while pt and tt fell together as the geminate tt (p and t both being lighter than k). Latin aktum 'done' became afto (whence Portuguese auto, as in auto da fe); Latin noktem 'night' became noxe (whence Portuguese noite); Latin kattum 'cat' became katto (whence Portuguese gato). Latin ps ks similarly became fs xs . (Grammont 1933:203ff.; Williams 1962:84f.)

We can thus see the widening hierarchy affects dorsals first, then chilis, and then coronals. Cf. the tensing hierarchy for the Old High German example given below in sec. 3.2.1.1, which works in the reverse order.

3.1.2.2. ! Lax.

Lax (voiced) stops become fricatives in the examples which follow. A full discussion of the tense/lax distinction is given in sec. 3.2 below.

- (3.10) a. Spanish b d g became β δ γ (allophonically), typically in allegretto speech. Harris (1969:38) states that the process applies when these environments occur:

- (1) V ____
- (2) Fric ____
- (3) App ____ except for ld
- (4) ____ App
- (5) ____ N

All this happens while p t k remain unaffected.
Examples for b:

- (1) V ____ (#): haba [aβa]; club [kluβ]
- (2) Fric ____: adverso [aδβersɔ]
- (3) App ____: calvo [kaɫβɔ]
- (4) ____ App: habla [aβla]
- (5) ____ N: submarino [suβmarino].

- (3.10) b. Ancient Greek b d g have become Modern Greek v ð γ, while p t k remain unaffected. (At the time that this change occurred, Ancient Greek ph th kh (aspirated) had already become f θ x.)

The Ancient Greek aspirates, although tense, were also aspirated and thus fall under a slightly different teleology. (See example 3.12d) in the next section.) It is necessary, and sufficient, to realize for our purposes here that because the Spanish and Greek voiced stops were lax, they underwent widening, the voiceless (tense) stops being unaffected.

3.1.2.3. ! Aspirated.

Aspirated stops become fricatives under the provisions of the process of widening, as in the following examples:

- (3.11) a. For speakers of Indian languages who have served as my informants, the strong aspirates ph th kh become f θ x in casual speech, e.g., the Gujarati word phodz 'army' (as cited by Ladefoged 1971:13) is pronounced [fodž] by JL, a Gujarati speaker.

I might point out that BNP, a Bengali student of mine, could pronounce fricatives in English (voiceless ones, at least) only in fast or careless speech, i.e., when he wasn't paying attention. The full aspirates for him were connected with emphatic speech.

- (3.11) b. Early Germanic p^h t^h k^h k^{wh} from Indo-European p t k k^w, widened to f θ x x^w. (x x^w later became h h^w.) (cf. Prokosch 1939:53; Pribsch and Collinson 1934:67.)

- c. Old High German p^h t^h k^h, from earlier p t k (Indo-European b d g), underwent two different but related changes, both widenings. Initially p^h t^h k^h became pf ts kx (kx later reverted to k^h). Medially they became ff ss xx. These geminates later simplified to Modern German f s x, spelled ff, ss, and ch. As for chronology and dialectal variation, t^h changed first and most widely, p^h next, and k^h last and least widely (Prokosch 1939:54; Pribsch and Collinson 1934:111ff.).

- d. Ancient Greek ph th kh (aspirates), from Indo-European bh dh gh (and variously from g^{wh}), have become widened to f θ x in the modern language (pers. comm., Malikouti Drachman).

3.1.2.4. ! Finally.

This section of particulars refers primarily to widening changes occurring in syllable-final position, but also refers secondarily to those in word-final position. All three examples, in fact, refer to word-final phenomena.

- (3.12) a. Gallo-Roman $\dagger d k$ widened to $\theta \check{\delta} x$ in final position after a vowel, i.e., /V__# (Pope 1934:142).
- b. In Danish, $\dagger d$ become widened (and in the case of \dagger also voiced) to $\check{\delta}$ in final position after a vowel; g becomes widened to γ in final position after a vowel (Spore 1965:41-43). Examples: skibet [sgɪʔbɐ̃ $\check{\delta}$] 'the ship', tog [tɔʔ γ] (also [tɔʔw] 'was taking'. (\dagger after $d = [\check{\delta}]$ simply voices to d , e.g. badet [baʔ $\check{\delta}$ ɐd] 'the bath'.) (I am assuming here that what Spore writes as voiced lax $b g$ are really voiceless lax $b̥ g̥$.
- c. Spanish $b d$ widen to $\beta \check{\delta}$ finally after a vowel, e.g., club [klu β] 'nightclub', usted [uste $\check{\delta}$] 'you (polite)' (my observation based on Harris 1969). Spanish $b d g$ also widen to $\beta \check{\delta} \gamma$ syllable-finally before resonants (nasals and approximants), e.g., for b : submarino [su β marino] 'submarine' and habla [a β la] 'speaks'. (Cf. example (3.10a) above.)

As for other examples of syllable-final position, American English flapping occurs in that position as a rapid-speech pronunciation of the word hothouse [h'o \check{r} h,aqs]. But this is probably due to a lenition. Compare the Tagalog alternation of d and r . r becomes d initially: duaryo 'rosary' from Spanish rosario. d becomes r between two vowels: tukod or tukuran, both meaning 'prop' (Tablan and Mallari 1961:xi). Also compare this Hindi example:

- (3.12) d. Hindi retroflexed $\check{d} \check{d}h \check{n}$ widen to $\check{r} \check{r}h \check{r}$ in syllable-final position, as in reduplications of VC syllables (Davison 1971).

This completes the discussion of widening.

3.2. Tensing and laxing.

Tensing is a chromaticization, i.e., it favors chromaticity at the expense of sonority. Laxing, on the other hand, is a sonorization: it increases sonority while simultaneously decreasing the favorability of chromaticity. So, like the processes of narrowing and widening just discussed, tensing and laxing respond to opposing teleologies. But it should be pointed out that, unlike narrowing and widening, the processes of tensing and laxing do not change stricture. Instead, they merely serve to change the "orientation," as it were, of a sound to its stricture, tensing (within a given stricture) favoring chromaticity and laxing (within a given stricture) favoring sonority.

To accomplish this orientation, or perhaps to act as its signature, tensing and laxing are closely related to other phenomena which act to serve notice that these processes have in fact applied. These "signatures" fall into three categories: (1) glottal phenomena, like voicing and aspiration, (2) timing phenomena, i.e., longness or shortness, and (3) associations with accentual phenomena, e.g., tensing is connected with position before the syllable peak and laxing is connected with position before the measure peak.

Tensing, then, is related to (and often expresses itself as): (1) voicelessness, glottalization, and aspiration (even though these last two give separate results for narrowing and widening), and (2) length (longness). It is also associated with (3) initial position in a stressed syllable (position before the syllabic peak).

Laxing, however, is related to (often expresses itself as): (1) voicedness, and (2) lack of length (shortness). It is associated in turn with (3) unstressed syllables occurring before stressed ones (before the measure peak), generally in syllable-final position.

It is necessary at this point to question the meaning of the phrase "often expresses itself as." Voiceless consonants are typically tense; aspirated, glottalized, and long (geminate) consonants are, as it were, "overtense." Compare Jakobson and Halle's (1956) provision for their feature tense/lax to cover the phenomenon of aspiration. Voiced consonants are typically lax; short consonants are also typically lax.

But "overtenseness" is not real and the basic binary distinction of tense/lax holds. Let us assume that there are but three combinations of tense/lax and voiceless/voiced. These three are then possible: tense voiceless, lax voiceless, and lax voiced. The fourth, tense voiced, is impossible (for obstruents, at least). Then given this one limitation, all other features are independent. Tense voiceless t^h can be aspirated, glottalized, long, or short. The same goes for lax voiceless d^h and lax voiced d . (Incidentally, we must distinguish $?d$ and d^h , the first simply glottalized and the second glottalized and also imploded, i.e., having the feature suction.) Further, glottalized t^h (tense) counts as an "ejective"; glottalized $?d^h$ (lax), as an "injective." As a result, we must distinguish between "typical" cases, e.g., t^h being tense, and "independent" cases, e.g., d^h being lax.

In this same general vein, all these phenomena--voicing, devoicing, aspiration, glottalization, lengthening, and shortening--may at one time or another be the result of lenitions. For instance, if we find a proto-form $[təta]$ and a reflex form $[təda]$, we would be forced by the weight of the argument advanced here to posit an intermediate form with d^h : $[təda^h]$. The significance of this is that the change of t to d^h is a fortition, merely catalyzed by the more sonorant, voiced environment in which it occurs. But the change of d^h to d is a lenition, an assimilation to voicing. If it were not otherwise, we would be forced to conclude that laxing, one of the fortitions to be discussed in this section (along with tensing), was in reality a lenition.

But both tensing and laxing are fortitions, and we now turn to a discussion of them, starting with tensing.

3.2.1. Tensing.

The fortition tensing may be stated as follows:

$$\left[\begin{array}{l} C \\ ! \text{ narrower} \\ ! \text{ Long} \\ ! \text{ -Voi} \\ ! \text{ / ___ Syl Peak} \end{array} \right] \rightarrow [\text{Tns}].$$

This statement should be read as "A consonant becomes tense, especially when it is narrower, especially when it is long, especially when it is voiceless, and especially when it occurs before a syllable peak (i.e., before a stressed vowel in the same syllable)." Again, the exclamation point (!) signifies "especially when."

Here are some general examples of tensing:

- (3.13) a. Early Germanic $b \ d \ g \ g^w$ (from Indo-European) became $p \ t \ k \ k^w$, even in voiced environments (Pribsch and Collinson 1934:64ff.) Compare Latin pedem 'foot', Gothic fōtus, and English foot (d to t); Latin jugum 'yoke' and English yoke (g to k). Examples of g^w to k^w are rare; b to p is relatively unattested.
- b. The same Indo-European series, $b \ d \ g \ g^w$, became Armenian $p \ t \ ts \ k$ (Meillet 1936:28-29, chart on p. 37). The k results from delabialization of g^w (and subsequent tensing); the ts involves the palatalization of g : $g > \check{g} > d\check{z} > dz > ts$ (the last step representing tensing).

We turn now to the specific contexts in which tensing is catalyzed.

3.2.1.1. ! Narrower.

- (3.14) a. Old High German $b \ d \ g$ became $p \ t \ k$ while $\beta \ \check{x} \ \gamma$ remained unchanged. d underwent tensing first and most widely, then b , and then g last and least widely (Pribsch and Collinson 1934:115ff.; cf. Prokosch 1939:54).

Many of the b to p and especially the g to k changes never made it into the dialect upon which modern standard German is based. But the d to t change was common; compare English dead, deer, door, and do with German tot, Tier 'animal', Tür, and tun.

- (3.14) b. Languages of the following families typically have no voiced obstruents: Sino-Tibetan, Salishan, and to a lesser extent Penutian. Salishan languages like Bella Coola, Clallam, Columbian, Comox, Cowlitz, and Squamish have extensive systems of obstruents, yet all are voiceless (my observation based on Ruhlen 1976).

We can conclude from the above that narrower consonants, e.g., obstruents, devoice readily (and become tense).

3.2.1.2. ! Long.

Here I will just make the general observation that long (geminate) consonants which are already voiceless do not voice (remain tense) even in cases where their nongeminate counterparts do, e.g., Old English *f* s voiced to *v* *z* between vowels while geminate *ff* *ss* remained tense, and early Latin *s* voiced to *z* between vowels and became rhotacized to *r* but *ss* remained unchanged, later simplifying to *ʃ* after long vowels and diphthongs, e.g., *causa* 'cause' from earlier *caussa* (pers. comm., David Griffin).

3.2.1.3. ! Voiceless.

This can be demonstrated by lenitive final devoicing of stops and their subsequent fortitive tensing, e.g., American English dialectal variations of final *b d g*, first leniting in final position to *b̥ d̥ g̥*. The fortition tensing then changes these to *p t k*, e.g., *cold* [kʰo:|t], *world* [wɜ:|t], *dog* [dɔ:k], and *big* [bɪk]--all preserving the long or diphthongized form of the vowel typically found before voiced consonants. It is important to remember that all of the tensing changes involving voicing that are described here start with devoicing, either due to a fortition or a lenition, and then undergo tensing.

David Stampe (pers. comm.) reports that the type of devoicing referred to in the preceding paragraph is also typical of the English of speakers from Australia and New Zealand.

3.2.1.4. ! Before a syllable peak.

In the following two examples, aspiration and glottalization act as a way of "tensing" consonants which are already tense.

- (3.15) a. In German, English, and other Germanic languages, *p t k* (and *č*) become aspirated before a stressed vowel.
- b. In French and Spanish *p t k* (*č*) optionally become glottalized (slightly) before a stressed vowel. This is typical of emphatic or formal speech. (This statement is based on my own observations of native speakers of these languages.)

This completes the discussion of tensing.

3.2.2. Laxing.

The fortition laxing may be stated as follows:

$$\left[\begin{array}{l} C \\ ! \text{ wider} \\ ! \text{ Short} \\ ! \text{ /wider} \\ ! \text{ /___ Meas Peak} \end{array} \right] \rightarrow [-\text{Tns}].$$

This statement may be read as: "A consonant becomes lax, especially when it is wider, especially when it is short, especially when it occurs in the neighborhood of a wider sound (e.g., a vowel), and especially when it occurs before a measure peak (i.e., in the syllable before a stressed syllable)."

Here are some general examples of laxing, which also show lenitive voicing:

- (3.16) a. In Joan Velten's speech, p + s become b d z before a vowel, e.g., peach [butʃ], toe [du], and sauce [zɑs] (Velten 1943).
- b. A number of northern Australian languages, such as Dyirbal, Gudandji, Ngarndji, and Yanyula, have a series of voiced stops (constituting the only obstruents) with no voiceless series (Ruhlen 1976).

In both these cases, we can assume that the stops were laxed to lax voiceless stops, and then these lax stops assimilated to the voicing of the surrounding sounds. This last case establishes that laxing is in fact a fortition, since otherwise it could not affect a whole system in a context-free way.

- (3.16) c. In Cherokee, + k and d g contrast only before the vowel a; before the other vowels, i e ə o u, only d and g occur. (Walker, 1975).

This last is again an example of laxing followed by voicing. We turn now to specific catalyzing elements.

3.2.2.1. ! Wider.

- (3.17) a. Resonants (nasals and approximants), which are typically voiced, may generally be assumed to be lax and to have tense counterparts (in the strict sense of the word) only allophonically, e.g., the n of French words like bonne [bɔn⁺] 'good' (fem.) is pronounced rather tensely in the standard dialect (my own observation).
- b. In the Kentish dialect of late Old English, f s θ become laxed and voiced to v z ð initially, the corresponding stops p t (k) remaining unchanged in this same position (Wright 1928:107f.). Examples (from Wright): vrend 'friend', zinne 'sin', and ðing 'thing'.

This last case can be connected to the occurrence of two series of fricatives (voiceless and voiced) in languages which have only one (voiceless) series of stops, e.g., Modern Greek. This establishes the pattern but is not meant to preclude languages like Spanish that have both series of stops but one (phonemic) series of fricatives (voiceless).

3.2.2.2. ! Short.

This is the converse of the examples given for ! Long in sec. 3.2.1.2. for the process tensing. There it was pointed out that single (nongeminate) consonants lax and become voiced in the same environments where long (geminate) consonants remain tense, e.g., the Old English voicing of

f s to v z between vowels, geminate ff ss remaining tense in the same position. Further, short (i.e., flapped) resonants such as ñ or ř devolve only lenitively, e.g., from my own observations of the Spanish of Mexico City, speakers optionally devolve the last half of final ř to produce an apical fricative effect: señor [senɰ̞ř̞]. In all other (nonlenitive) cases, laxing allows the voicing of flapped sounds, e.g., the voiceless flapped ř̞, resulting from the American English flapping of t, is generally voiced to ř̞.

3.2.2.3. ! Around wider sounds.

- (3.18) a. In late Latin (Vulgar Latin) p + k laxed and voiced to b d g between vowels (Pope 1934:137).
- b. Danish p + k become lax b̞ d̞ g̞ in combination with a fricative even when in final position, e.g., spille [sɸelə] 'to play,' lapset [lɔpsə̞] 'elegant,' and gisp [gisɸ] 'groan' (Spore 1965: 35-39). Similar to sp, etc., st and sk are realized as [sɸ] and [sg], etc. (I am assuming that what Spore writes as b d g are b̞ d̞ g̞ in these positions.)
- c. In Pre-Welsh (Brythonic Celtic) p + k laxed to b d g between vowels (or after a vowel and before n l r plus a vowel). This was incidentally accompanied by a previous widening of b d g m to v ɸ γ ɱ (this last sound remaining in some dialects of Breton). (Morris Jones 1913:161-67).

3.2.2.4. ! Before a measure peak.

This environment refers specifically to consonants appearing in a (usually initial) syllable preceding a stressed syllable:

- (3.19) a. My childhood pronunciation of potato was [ɸəth̞'ɛɹ̞ə], or even [bə...], this pronunciation recurring in my stepson Arthur's speech at age 6 (cf. my own lazy speech pronunciations, e.g., tomorrow [dm'ɑɹ̞]).
- b. ks is laxed and voiced to gz before stress, e.g., e[gz]ist, e[gz]ert, e[gz]haust, etc.; otherwise ks remains: e[kɹ̞]it, a[kɹ̞]is, Me[kɹ̞]ico, etc.

Verner's Law changed voiceless f θ s x to voiced v ɸ z γ after an unstressed vowel (cf. Prokosch 1939:60). Generally, the vowel following was stressed. As a result, Verner's Law is probably related to the two cases above, particularly the second.

This completes the discussion of laxing.

4. Position and color fortitions.

4.1. Fronting and backing.

The two fortitions which affect position are fronting and backing. The first of these, fronting, is a chromatization; the second, backing, is a sonorization.

As a chromatization, the fronting process favors chromaticity or increases it, often at the expense of sonority. Like the chromatization process of narrowing, fronting applies to tense sounds. It typically affects narrower sounds and sounds bearing a color, or colors themselves, especially when the color involved is one of the fronter colors, either labiality or palatality. Fronting also affects dental sounds; specifically, it fronts coronal sounds like $\theta \delta$ to chilic $f v$.

As a sonorization, backing increases sonority, often at the expense of chromaticity. It most typically applies to achromatic (non-colored) consonants, lax consonants (cf. the sonorization process of widening), and wider consonants, those consonants with some degree of sonority already. It is also very common in word-final position.

The statement of and evidence for each of these processes will now be presented, starting with the discussion of fronting, and ending with backing.

4.1.1. Fronting.

The fortition fronting may be stated as follows:

$$\left[\begin{array}{l} C \\ n \text{ front} \\ ! \text{ Color} \\ ! \text{ Tns} \\ ! \text{ narrower} \\ ! \text{ Dent} \\ ! \text{ /Max. Diff.} \end{array} \right] \rightarrow [n + 1 \text{ front}]$$

This statement may be read as: "A consonant of a given position (n front) becomes the next position forward (n + 1 front), especially when it bears a color, especially when it is tense, especially when it is narrower, especially when it is dental, and in cases involving the principle of maximal differentiation." Again, the exclamation point (!) is to be read "especially when" (see sec. 3.1.1.).

A typical change which fronts dorsals to coronals occurs in the speech of children. Specifically, $t d$ are substituted for $k g$, e.g., my cousin Lori at about age 4 pronounced her last name Kisling as "Tisling." Such fronting occurs not only in child language but also as part of the natural history of languages of the world, to which the examples which follow testify.

We now turn to a discussion of the specific environments which catalyze (help bring about) instances of fronting.

4.1.1.1. ! Color.

Frontings involving color always front to the position associated with that color. So, labial(ized) consonants become chilic, and palatal(ized) consonants become coronal. Here are some examples of the fronting of labial consonants:

- (4.1) a. Latin $k^{(w)} g^{(w)}$ (qu, gu) has become p b in Rumanian, e.g., Latin aqua > Rum. apă 'water', Latin quattuor > Rum. patru 'four', and Latin lingua > Rum. limbă 'language' (Nandris 1963:263).
- b. Indo-European $*k^{(w)} *g^{(w)}$ have become p b in the Brythonic branch of Celtic (consisting of Welsh, Cornish, and Breton) and $g^{(w)}$ has become b in Irish. Cf. Latin quinque, Old Irish cóic, Old Welsh pimp 'five'; Latin vīvus (Indo-European $*g^{(w)}iwo-$), Irish beo, Welsh byw 'living' (Lewis and Pedersen 1937: 43f., 34f.).

There is also the Latin change of $*g^{(w)}h$ (Indo-European) apparently to $*x^{(w)}$, fronting then to f, e.g., Latin formus 'warm' (from $*g^{(w)}hermos$, cf. Greek thermos 'warm'; cf. Pokorny 1959). There is also the fronting of $t^{(w)}$ to p in the Yiddish word epas 'something' (cf. standard German etwas). This is apparently an isolated example.

Palatal consonants similarly front to the position corresponding to palatal coloring, i.e., coronal. Here are some examples:

- (4.1) c. Latin $k̄ ḡ$ (from k g before a palatal vowel) fronted to $t̄š d̄ž$ (= $č ĵ$) in virtually all the dialects (probably through an intermediate stage of $t̄ d̄$). Italian and Rumanian still preserve this pronunciation, e.g., Latin pacem 'peace', Italian and Rumanian pace with $č$; Latin legit 'reads', Ital. and Rum. lege with $ĵ$ (cf. Nandris 1963).
- d. Common Slavic $k̄ ḡ x̄$ (from k g x before original palatal vowels or j) became $t̄š d̄ž š̄$ in the dialects ($d̄ž$ most usually simplifying to $ž̄$). In Russian, this sound change produced the following alternations: oko 'eye', oči 'eyes'; sluga 'tear', služat' 'to cry'; uxo 'ear', uši 'ears' (Kondrašov 1962:39-41).

Similar instances of color fronting occur in Chinese, Old English, and Tumbuka, a Bantu language.

The backing of a sound to match the position of a color is, however, usually assimilative in nature, i.e., a lenition. For instance, a change in eastern and southern Slavic, similar to the one described above, shifted chilics plus j (i.e., pj bj vj mj) to chilics plus l plus j (plj blj vlj mlj). The wide j has assimilated to the narrowness of the chilics involved by becoming lj [l']. One example is Russian zemlja 'land', cf. Polish ziemia (examples from Kondrašov 1962).

Also, Nandris (1973:111-12, 240ff.) notes cases of dialects of Rumanian where palatalized f' and b' have become palatals of various types, some showing intermediate stages of assimilation, some showing complete stages, e.g., f' becomes intermediate $f\acute{k}$, $f\acute{h}$ and complete \acute{s} , $\acute{\acute{s}}$, $\acute{\acute{c}}$, \acute{h} ; and b' becomes intermediate $b\acute{d}$, $b\acute{d}\acute{z}$, $b\acute{g}$ and complete d' , $d\acute{z}$.

ġ. The Old French change of \acute{p} b' to $pt\check{s}$ $bd\check{z}$ and then to $(+)\check{s}$ $(d)\check{z}$ (and of $\acute{m}\acute{v}$ to $n(d)\check{z}$) appears everywhere complete in the modern language, e.g., sache 'may know (subjunctive)' from Latin sapiam, and rouge 'red' from Latin rubeum (Pope 1934:129).

4.1.1.2. ! Tense.

I have but one example here, but it is, I believe, a rather convincing one:

- (4.2) A two-year old Russian child fronted k (tense) to t but g (lax) was merely devoiced to k , e.g., ruki 'hands' became $[j'ut'i]$ but knigi 'books' and ogon' 'fire' became $[h'i'ki]$ and $[ak'a\check{n}]$, respectively (Jakobson 1968:15, based on observations by Alexandrov).

Jakobson goes on to point out (ibid.) that the boy probably first fronted both k and g , only later limiting the fronting process to the tense counterpart.

4.1.1.3. ! Narrower.

The child language frontings of k g in the speech of Hildegard Leopold and Joan Velten, mentioned above in the opening of this section (4.1.1), are examples here. Other examples include:

- (4.3) a. Proto-Polynesian $*\eta$ was fronted in all positions to n in Hawaiian and dialects of Marquesan and Maori (Biggs 1971). Accordingly, North Auckland Maori η corresponds to Bay of Plenty Maori n .

An interesting case of fronting which preserves the gravity (Grv) of the consonants fronted occurs in Rumanian:

- (4.3) b. Latin kt ks gn have become Rumanian pt ps mn (Nandris 1963:108, 117). An example for kt is Rum. opt from Latin octo 'eight'; for ks , Rum. coapsă from Latin coxa $[k\check{o}ksa]$ 'thigh'. Vulgar Latin must have nasalized gn to ηn ; the η then fronted to m , e.g., Rum. lemn from Latin lignu(m) 'wood'.

4.1.1.4. ! Dental.

In these examples the dental coronal fricatives θ δ become labio-dental (chilic) f v . I know of no examples in which dental t d become fronted.

- (4.4) a. In the English of London, standard θ δ are replaced by f v , e.g., three $[frej]$, father $[fa>:v\check{e}]$ (Jones 1914:29).
b. Greek θ was often replaced in Russian by f in names borrowed from Greek, e.g., Russian Fëdor, cf.

Theodore in English; Russian Marfa, cf. Martha (cf. Passy 1890:151).

- c. In the development of Indo-European into Latin, IE. *dh must have been pre-Latin θ. This θ fronted to f in initial position (falling together with f developed from IE. *bh). (Similarly, IE. *gh became x in initial position in Latin, eventually backing to h.) For θ to f, compare English deer and Latin fera 'wild beast' both reflecting IE. *dh (cf. Passy 1890:151).

4.1.1.5. Fronting changes due to maximal differentiation.

There is one type of fronting that affects dorsals like k especially when there is a backer dorsal like q in the same sound system. For instance, in Greenlandic Eskimo, a k/q distinction exists in which k has become slightly fronted to k[<]; somewhere in between k and k̄. The result sounds "slightly palatal" (pers. comm., Jerrold Sadock). This change is a result of the principle of maximal differentiation.

One might also speculate that maximal differentiation was the key factor in the fronting of Indo-European *k *g *gh to k̄ ĝ ĝh in the satem dialects. This was apparently done to widen the contrast for the distinctions between plain dorsal and labial dorsal, i.e., k/k^ω, g/g^ω, gh/g^ωh.

This completes the discussion of fronting.

4.1.2. Backing.

The process backing may be stated this way:

$$\left[\begin{array}{l} C \\ n \text{ front} \\ ! -\text{Color} \\ ! -\text{Tns} \\ ! \text{wider} \\ ! / __\# \\ ! / \text{Max. Diff.} \end{array} \right] \rightarrow [n - 1 \text{ front}].$$

This statement may be read as: "A consonant of a given frontness gets backed one position, i.e., one notch farther back, especially when the consonant bears no color, especially when it is lax, especially when it is wider (i.e., more sonorant), especially when it occurs (word-) finally, and in cases involving the principle of maximal differentiation." Again the exclamation point (!) is to be read as "especially when."

Here are some general examples of backing:

- (4.5) a. The Polynesian languages exhibit a number of context-free instances of backing: (1) k becomes ʔ in Hawaiian, Samoan, Tahitian, Rurutu, South Marquesan, etc. (2) ŋ becomes ʔ in Tahitian and Rurutu. (3) t becomes k in Hawaiian and Colloquial Samoan (Biggs 1971). In each case, the

reflex corresponds to the prototype in some dialect, which is assumed to be more original, e.g., for (3) $t > k$, compare Tahitian tabu and Hawaiian kapu, both meaning 'taboo'.

Here is an example from child language:

- (4.5) b. Elizabeth Stampe at age 1:6 backed all bilabials to coronals, i.e., $p b f m$ became $t d s n$, as in powder [tadə], Baba (from baby, a name for herself) [dada], fox and fish [sə] and [sɪs], and mama [nana] (pers. comm., David Stampe).

We now turn to specific instances of catalyzing environments.

4.1.2.1. ! Achromatic (noncolored).

All the examples of backing illustrate this principle, except for the cases involving maximal differentiation, which all affect color in what appears to be a special catalyzing environment. Particularly illustrative of this achromatic environment are examples like the Polynesian and child language data given above. For the first two Polynesian changes, dorsal $k ŋ$ are backed to $ʔ$, and for Elizabeth bilabials become coronals. Glottals and coronals are connected with higher tonalities and so are more sonorant; backing, as a sonorization, thus moves toward sonority. (Cf. sec. 4.1.1.1.)

4.1.2.2. ! Lax and ! Wider.

These two cases will be considered together since they constitute, for backing, similar cases; i.e., wider (more sonorant) consonants, as long as they bear no color, are typically lax.

- (4.6) a. Ukrainian and Slovak g first widens to $ɣ$, which in turn backs to $ɦ$ (the voiced glottal fricative) while x remains unaffected (Kondrašov 1962).

The above example and those to follow have occurred for lax consonants; those which follow especially concern wider consonants.

- (4.6) b. American English $ɪ$ becomes $ʊ$ and even $α$ in the idiolectal speech of individuals (cf. sec. 2.2.1 above).
- c. Old French trilled apical r became (trilled) uvular R and remains so in the modern language (Pope 1934: 156ff.).
- d. In some forms of Puerto Rican Spanish trilled apical \tilde{r} (long) becomes (trilled) uvular R , then devoicing and narrowing to the uvular fricative x e.g., ron rico [x'ɔŋ x'ikɔ] 'rich rum (a brand name)' (pers. comm., Barry Nobel).

Here is one more example, whose teleology is not clear to me:

- (4.6) e. Dutch *f* becomes *x*, apparently a dissimilative backing after a labial vowel in what may be an isolated example, namely: Dutch *lucht* [lœxt] 'air'; cf. German *Luft*, same meaning (pers. comm., David Stampe).

4.1.2.3. ! Finally.

All of the following examples are instances of backing which occur in word-final position:

- (4.7) a. Puerto Rican Spanish *n* backs to *ŋ* word-finally, e.g., *ron* [xɔŋ] 'rum' (pers. comm., Barry Nobel). I have also noticed this change in the Spanish and English of my students from Venezuela, Colombia, and Ecuador.
- b. Similarly, Old French *n* backed to *ŋ* in final position before being lost (cf. Pope 1934:169-70).

The above examples concerned the backing of *n*; the next two, the backing of *m*:

- c. Pre-Greek *m* became Ancient Greek *n* in word-final position; cf. Latin *kentum* and Greek *-katon* 'hundred'.
- d. Ancient Chinese *m* became northern (Mandarin) Chinese *n* in word-final position, e.g., An Chin. *[-s əm] and Mandarin [-sən], cf. Cantonese [səm], all meaning 'deep' (lines represent tones) (data from Forrest 1948:179 and Appendix II).

In the following example, both stops and nasals are affected:

- e. South Vietnamese (Hanoi) *t* *n* back to *k* *ŋ* word-finally except after tense palatal vowels, i.e., [i] and [e]. Conversely, *k* fronts to *t* word-finally after [i] or [e] (using data from Nguyen 1970: 236-240; Thompson 1965:94-103).

One last example of backing follows, which due to its nature is probably an example of stops becoming lax in word-final position:

- f. Ancient Chinese *p* *t* *k* in final position (still extant in some dialects) all become backed to ? (which remains in some dialects). In northern (Mandarin) Chinese, this ? is then lost (cf. Forrest 1948).

Some examples from Forrest (1948: Appendix II, 307ff.) include:

Anc. Chin.	Canton	Suchow	Peking	Gloss
-jɛp	ji:p	-jɛ?	\jɛ	'leaf'
-bjɛt	pi:t	-bi?	/pjɛ	'different'
-tɛk	-tɔk	-tɛ?	/tɛ	'get'

See also 5.1.3.1 below on aspiration and glottalization phenomena.

4.1.2.4. Backing changes due to maximal differentiation.

High is the feature connected with high vowels like i ɨ u and high consonants like ʃ ʂ x, etc. Consonants which are high, sometimes in spite of their color and sometimes because of their retraction, occasionally become backed. This is in some cases due to the principle of maximal differentiation. Here is an example:

- (4.8) a. In dialects of American English, palatal η gets backed to η in such words as onion [' $\wedge\eta$ en], bunion [b' $\wedge\eta$ en], apparently after achromatic [\wedge]. Cf. canyon with [\wedge], which is never *[k $\wedge\eta$ en].

In this example and some of those which follow, this backing proceeds in spite of the color present, which would normally act as a fronting agent, e.g., η often fronts to η .

In the following example, the change occurs because of the retractedness of the sound:

- b. In Common Slavic retroflex ʂ produced by the ruki rule (which changes s to ʂ after r, u, k, i) is subsequently backed to x (my own conclusion based on my studies of the history of Slavic).

In the next two examples, both palatality and retroflexion (probably involving velarity) are involved:

- c. Old Spanish ʃ backed to (became retroflexed to) *ʃ which in turn backs to x, remaining in the modern language (cf. Harris 1969:193-98).
- d. In the standard (Moscow) dialect of Russian, ʃ ʂ get backed to ʃ ʂ, but ʃ remains unaffected, e.g., sibko [ʃ'ɪpkə] 'quickly', židko [ʒ'ɪtkə] 'weakly', but čisto [č'istə] 'clearly' (my own observations; cf. Kondrašov 1962).

In each of these two changes, it is important to note the sound system in which they occur. The reason for this is that these are both examples, I believe, due to the principle of maximal differentiation. In Old Spanish, ʃ (from original ʃ, and ʃ from ʒ) was opposed to apical ʃ (from original ʃ, and ʃ from ʒ). Harris (1969:192) remarks on the palatal-like sound of apical ʃ. The need for a more optimal contrast is apparent; this is accomplished by backing the ʃ to ʃ (in spite of its palatality, normally a fronting agent). Then the retractedness of ʃ backs it still farther to x (x in Castillian).

These changes may be expressed by the following two statements:

- (4.9) a. Fric
 -Grv → Ret
 High
- b. (Fric)
 Ret → Grv
 High

The first of these processes backs nongrave high fricatives to retracted (retroflex) ones ($\check{s} > \check{\check{s}}$). The second one backs retracted (retroflex) high fricatives to grave ones ($\check{s} > x$). (Cf. the distinctions in Table 3 and the discussion in sec. 2.2.2).

In the Russian example, a nonoptimal contrast is also involved. Here the original laminal fricatives \check{s} \check{z} contrast not with plain apical sounds but with palatalized ones, namely $\check{\check{s}}$ $\check{\check{z}}$. Here it is important to note that \check{s} \check{z} and $\check{\check{s}}$ $\check{\check{z}}$ differ only by the property of apicality, the former being nonapical (laminal = tongue-blade) and the latter being apical (tongue-tip). The phonological space is thus too close; it is widened by backing the laminals \check{s} \check{z} to retroflex laminals $\check{\check{s}}$ $\check{\check{z}}$. Note also that \check{c} is not similarly backed: there is no \check{c} [$+\check{s}$], this sound having already become nonpalatal c [ts] in the standard language. However, in Belo-Russian, $+$ has become the palatal affricate \check{c} ; \check{c} is accordingly backed to $\check{\check{c}}$ in that language (cf. Kondrašov 1962:112ff.).

This completes the discussion of backing.

4.2. Coloring and bleaching.

Of the two fortitions which affect the chromaticity of consonants, coloring is the chromaticization and bleaching the sonorization.

Coloring adds color to an otherwise achromatic consonant. Generally, it adds the color associated with the position of the consonant, e.g., chilies become labial and coronals become palatal. Dorsals frequently also become palatal even though the color associated with that position is velar.

Consonants also take on a given color when they occur in the environment of that color, e.g., chilies become palatal around palatal vowels. This is, properly speaking, a lenition, called color matching and will be discussed with the lenitions affecting color in sec. 5 below.

Bleaching subtracts color from a consonant that already has color. Generally, this color is totally lost, leaving behind no trace of its former existence, e.g., the English word new, still pronounced [nju] in some southern American English dialects, has become depalatalized (bleached) to [nu] in midlands and northern dialects. Occasionally, another process may intervene to prevent bleaching, e.g., the [\check{s}] of American English words like sure and sugar reflects an original [$\check{\check{s}}$]. This $\check{\check{s}}$ was laminalized (backed) to \check{s} ; cf. American English tissue [$+\check{h}'i\check{s}u$] and some British dialects [$+\check{h}'i\check{s}ju$].

Coloring and bleaching respond to opposing teleologies. Coloring affects especially lighter consonants and long ones, and bleaching especially darker and wider ones. Coloring and bleaching also occur in what I call "horse" contexts: coloring occurs around achromatic vowels,

and bleaching around vowels of another color or colors ("a horse of a different color").

We now turn to the discussion of these two fortitions, starting with coloring and ending with bleaching.

4.2.1. Coloring.

The coloring process may be stated as follows:

$$\left[\begin{array}{c} C \\ - \text{Color} \\ \alpha \text{ Pos} \\ ! \text{ Long} \\ ! \text{ lighter} \\ ! / \left[\begin{array}{c} V \\ -\text{Color} \end{array} \right] \end{array} \right] \rightarrow [\alpha \text{ Color}]$$

This statement may be read as: "A consonant which bears no color (i.e., is achromatic) and which is of a given position takes on the color associated with that position, especially when it is long, especially when it is lighter, and especially when it occurs around a vowel which itself bears no color (i.e., an achromatic one)." Again, the exclamation point (!) indicates "especially when."

Here are two general examples of coloring:

- (4.10) a. Polish \mid became backed to ω . This ω has now become labial w ($w = \omega w$, i.e., a velar ω with lip-rounding (labiality), ω). This is my own observation based on the fact that Polish \dagger is now pronounced $[w]$.)
- b. In some dialects of midwestern American English s has become palatal \check{s} in such words as racist, licorice, and grocery: ra $[\check{s}]$ list, licori $[\check{s}]$, and gro $[\check{s}]$ ry, respectively. In the first two examples, the palatalization is probably due to the adjacent palatal vowels; in the third, it is due to the r, which has the effect of backing (retroflexing) the s , which in turn palatalizes.

In reference to this last example, compare the discussion of American English dialects in sec. 5 below (on lenitions) and the Caipira dialect of Portuguese in 4.2.1.2. (! Fronter).

We now turn to the specific environments which catalyze the process coloring.

4.2.1.1. ! Long.

The use of the term long here is mainly a cover term for two different phenomena that result in coloring (specifically, palatalization). One of these, the first, is an instance of a consonant cluster (sk), which is long on the basis that it is a cluster. The second example is an instance of geminate consonants (nn , ll) which are, properly speaking, specified long. The third example concerns both geminates and clusters.

First, the example concerning the consonant cluster sk:

- (4.11) a. Germanic sk has everywhere become š in modern English and German; in Dutch the sk assimilated to sx (a separate change and not an intermediate stage). Compare Gothic fiskos, modern Dutch vische [v'isxə], modern German Fisch [fɪʃ], and modern English fish (data from Moulton 1972).

Here is an example for long consonants:

- b. In the history of Spanish, the geminate nn and ll inherited from Latin have become palatal ñ (ñ) and l' (ll). In most dialects, l' has simplified to j. Examples include Spanish año [año] from Latin annum 'year' and Spanish ella [eja] 'she' from Latin illa 'this (one) (fem.)' (Passy 1890: 151-52).

In the following example, geminates and clusters take on the color palatal:

- c. In Old French, geminate kk and the clusters sk nk rk rg became palatal k̄ s̄k̄ n̄k̄ r̄k̄ r̄ḡ; k g also became palatal k̄ ḡ initially (cf. Pope 1934:128).

This Old French change started this way:

- (4.12) a. k → k̄ / k, s, n, r, # ____.
g → ḡ / r, # ____.

The palatal k̄ ḡ then developed this way:

- b. k̄ → t̄ → t̄š (→ š).
ḡ → d̄ → d̄ž (→ ž).

The first two steps both occurred in Old French; the last (in parentheses) is an early modern French change. Here are some examples from Pope (ibid.):

c.

kk	bukka	>	botš̄e	>	buš̄e	>	<u>boche</u>	'mouth'
sk	eskina	>	estš̄ine	>	eš̄ine	>	<u>eschine</u>	'spine'
nk	franka	>	frāntš̄e	>	frānš̄e	>	<u>franche</u>	'free (fem.)'
rk	arka	>	artš̄e	>	arš̄e	>	<u>arche</u>	'arch'
#k	kantare	>	tš̄ānt̄er	>	š̄ānt̄er	>	<u>chanter</u>	'to sing'
rg	larga	>	lardž̄e	>	larž̄e	>	<u>large</u>	'wide'
#g	gaudja	>	dž̄oīe	>	ž̄ūē	>	<u>joie</u>	'joy'.

In all of these Old French examples, dorsal k g become palatal dorsal k̄ ḡ, and not velar dorsal k^u g^u. If the process of coloring is stated correctly, we should have gotten the latter color (velar) instead of the former (palatal). At this point, I am awaiting evidence

that the sort of relationship holds for palatal j and velar w such that w fronts to j , even when w is attached to a consonant, i.e., kw would become kj ($= k^j$). For the time being, I will assume that only the primary colors (labial and palatal) are produced by coloring.

4.2.1.2. ! Fronter.

Coronals particularly are susceptible to palatalization, as in the following examples:

- (4.13) a. In Russian nursery words, $t d n$ become palatal $t^j d^j n^j$, e.g., $[t^j a t^j a]$ 'father', $[d^j o d^j a]$ 'uncle', $[n^j a n^j a]$ 'nurse' (Jakobson 1968:79).
- b. $t d$ become palatal $t^j d^j$ (or at least are given preferential treatment) in the speech of Gregoire's one-year-old son (Jakobson 1968:78).

Chilics respond to the fronter condition by becoming labial in this example:

- c. In Russian, and in the English speech of Russian speaker YM, $p b f v m$ become labial $p^w b^w f^w v^w m^w$ before the nonpalatal vowels ϵ (both occurring in Russian, only the last occurring in English), e.g., Russian bít $[b^w i t^j]$ 'to be', vú $[v^w u i]$ 'you', and English maybe $[m^w e b j i]$ when it occurs in YM's English.

The vowel ϵ , referred to in the example as "nonpalatal," is in fact nonpalatal to a Russian speaker, its palatal version being realized as $[j\epsilon]$. In Russian the vowel ϵ (nonpalatal) occurs mainly in foreign words.

Here are some other examples, which involve coronal grooved fricatives:

- d. In Old High German apical alveolar \hat{s} became laminal palatal \check{s} initially before $p t m n l$; e.g., modern German Spiel 'game', Stein 'stone', Schmerz 'pain', Schnee 'snow', Schleim 'slime', all with \check{s} from earlier \hat{s} (Joos 1952).
- e. In the Caipira dialect of Brazilian Portuguese especially in the town of Piracicaba, state of São Paulo) $s z$ become palatal $\acute{s} \acute{z}$ before a stop, e.g., agosto $[a\acute{g}\acute{o}\acute{s}t u]$ 'August' (pers. comm., Roy Major).
- f. Also in the Caipira dialect (see above), $s z$ become palatal $\check{s} \check{z}$ in the same environment in which $t d$ become retroflex $\dagger d$, i.e., after \downarrow (like English \downarrow , or a "growly flap", possibly $[r\downarrow]$) (pers. comm., Roy Major). Examples include têrço $[t\acute{e}r\check{s} u]$ 'third' and quatorze $[k\acute{w}a t\check{u} \check{z} i]$ 'fourteen' (Rodrigues 1974:159).

4.2.1.3. ! Around an achromatic vowel.

This is the "horse" condition for the process coloring, in this case not a "horse of a different color" (cf. bleaching in sec. 4.2.2 below) but a "horse of no color." This refers to the fact that coloring typically occurs around vowels which bear no color, i.e., achromatic ones. Achromatic vowels are typically central ones, being neither palatal nor labial (nor velar). (Cf. Donegan 1978.)

All of the examples below show dorsal consonants becoming palatal (not velar) when occurring before achromatic vowels. Again, as in sec. 4.2.1.1. above on the tenseness context, a close relationship between palatal and velar coloring is assumed, the velarity of colored dorsal consonants being identified with palatality.

Here are the examples:

- (4.14) a. I have observed that dorsal k g become palatal dorsal \acute{k} \acute{g} initially before stressed [a] in the informal speech of speakers from New York City, especially in those dialects which are "r-less", e.g., Carter [$\acute{k}^h'o:r\acute{e}$], garden [$\acute{g}'o:dn$].
- b. The Old French change given above in sec. 4.2.1.1 involves Latin k g becoming $\acute{t}\acute{s}$ $\acute{d}\acute{z}$ initially before stressed [a], probably through an intermediate stage of \acute{k} \acute{g} , e.g., Latin kantare > Old French chanter [$\acute{t}\acute{s}...$] 'to sing'; Latin gamba > Old French jambe [$\acute{d}\acute{z}...$] 'leg' (cf. Pope 1934:128).

This last change is usually explained by saying that initial sequences like $k\alpha$ became ka (a = lax low palatal vowel), which then became \acute{ka} . This palatal \acute{k} can then be explained as an assimilation to the palatal quality of the following a . The weakness of this argument is that it is then necessary to say that palatal a then changed back to α , leaving the palatality behind: $\acute{k}\alpha$ (cf. Pope *ibid.*).

Another change in Old French converts y (from k g intervocalically) to j before what Pope (1934:128) identifies as a and after i e a . So, Latin baka 'berry' gives Late Latin [$baya$] and Old French [$baj\epsilon$], later [$baie$]. In these forms from Pope (*ibid.*), she has assumed a fronting change of [a] to [a].

A similar change is reported for Slavic (Channon 1972:34, quoting some rules attributed to Halle). The rule in effect is as follows:

$$(4.15) \quad k \ g \ x \rightarrow \acute{k} \ \acute{g} \ \acute{x} / C \ \acute{i} \ (\{ \overset{n}{r} \}) _ + \check{o}$$

In this rule C = any consonant and $+$ = a morpheme boundary. So, a form like otĭk+os 'Atticus' becomes otĭkos, eventually developing into Old Church Slavonic otĭcъ (< otĭcĭ where c = [$\acute{t}s$] 'father'); cf. Russian otec 'father'.

The symbol \check{o} appearing at the end of the rule above actually reflects Indo-European long and short \check{a} as well as long and short \check{o} (Kondrašov 1962:30). So, perhaps the process involved here responds not only to achromatic vowels like [a] but also to labial vowels like [o]. The labiality of o opposes in terms of color the palatal \acute{k} which develops. We might

assume, therefore, that what Slavists presume to be labial \tilde{o} was actually achromatic \tilde{o} .

This completes the discussion of coloring.

4.2.2. Bleaching.

The process bleaching, which is a sonorization, may be stated this way:

$$\left[\begin{array}{c} C \\ \alpha \text{ Color} \\ ! \text{ wider} \\ ! \text{ darker} \\ ! / \end{array} \right] \rightarrow [- \text{Color}]$$

V

$[-\alpha \text{ Color}]$

This statement is to be read as: "A consonant which bears any color loses that color (i.e., becomes bleached), especially when it is wider (i.e., more sonorant), especially when the color combined with it is darker, and especially when it occurs around a vowel of a different color (the "horse" condition)." Again, the exclamation point (!) is to be read as "especially when."

Here are a few general examples of bleaching:

- (4.16) a. Joan Velten at age 1;10 regularly bleached the palatal coronals $\tilde{t}\tilde{s}$ \tilde{s} to $t\tilde{s}$ s (the latter voicing to z before a vowel). At age 2;0 (and presumably also at 1;10) she bleached palatal j to z .
Examples: touch [dɔts], brush [bos], shoes [zus]:
yellow [zowɔ], yard [zo·d] (Velten 1943).

Apparently the bleaching of j to z proceeds this way: (1) j narrows to z , (2) z assibilates to \tilde{z} , (3) \tilde{z} bleaches to z . Only in the last step, (3), does bleaching occur (cf. Stampe 1973).

- b. Arthur as late as age 5 bleached $\tilde{t}\tilde{s}$ to $t\tilde{t}$, apparently with $t\tilde{s}$ as an intermediate step, e.g., church [$t\tilde{t}\alpha\cdot t\tilde{t}$].

This same sort of thing appears not only in child language but also in the natural history of languages of the world:

- c. In western Romance (Gallo- and Ibero-Roman), the $\tilde{t}\tilde{s}$ developed from Latin \tilde{k} (from k before palatal vowels) bleached to $t\tilde{s}$, giving rise to s in Old French (Pope 1934:125f.; Joos 1952) and also Old Spanish, which later gave Castillian θ (Harris 1969:196-98). The $d\tilde{z}$ from Latin \tilde{g} , however, remained palatal.

We now turn to the specific environments in which bleaching is catalyzed.

4.2.2.1. ! Wider.

Both of the examples given here affect coronal approximants, the most sonorant (widest) consonants for the position coronal.

- (4.17) a. Belo-Russian and Slovak \acute{r} bleaches to r in all positions, e.g., Belo-Russian mora [morə] 'sea' as compared with Russian more [mɔɾə] 'sea' (Kondrasov 1962:7, 113f., 151).
- b. In some dialects of British (and Colonial) English, r^1l^1 as early as the end of the seventeenth century became bleached to $r l$, e.g., blue [blju:] became [blu:], brute [brju.ɹ] became [bru.ɹ] (ultimately) [bu.ɹ] (Wright 1924:56, 103).

This last change is related to the northern and midlands American English bleaching of all original palatal coronals before a labial vowel (see sec. 4.2.2.3 below). Since the change started with the widest consonants, applying them first in chronological terms, we can assume that wideness is nevertheless a catalyzing environment for bleaching.

4.2.2.2. ! Darker.

This context for bleaching refers to the darkness of the color associated with the consonant. The colors referred to here mainly include the retracted colors velar, pharyngeal, and rhotacized. The bleaching statement is then generally intended to exclude advanced colors like palatal and labial.

The loss of rhotacism mainly occurs in vowels, e.g., British and American English "r-less" dialects in which ə (= ər) becomes simply ə . But here is an example of loss of pharyngeality:

- (4.18) a. Maltese Arabic has lost all traces of pharyngeal coloring on consonants, substituting plain (non-colored) sounds for the standard Egyptian pharyngealized sounds (Borg 1973).

Examples of velarity being lost are rarer. Here is an example for one sound in which it typically occurs, namely labiovelar w (= $\text{ɥ}\omega$).

- b. For Yiddish (Judeo-German), Sapir reports that in the Swabian dialects "w seems...to have become b," e.g., [lɛb] 'lion', [ˈiŋbr] 'ginger', both from earlier Middle High German forms with w (Sapir 1915 [1949:264-65]).

I suspect that this w in the last example that "seems to have become" b , is really first a loss of velarity (w to ω) then a subsequent loss of labial color (ω to v). The v so produced might give a b -like effect. At any rate, velarity is lost in either interpretation.

4.2.2.3. ! Around a vowel of a different color.

In the examples which follow, palatal consonants become plain before labial vowels, and labial consonants become plain before palatal vowels. This catalyzing environment represents the "horse" condition, in which color is lost around a vowel of a different color ("horse of a different color").

- (4.19) a. In the northern and midland dialects of American English, palatal t' d' θ' ξ η have become bleached to t d θ s n before the labial vowel u , e.g., tune, dune, enthusiasm, sewer, new. (The palatality is preserved in certain dialects of southern American English, e.g., tune [$tju:n$], etc.)
- b. Based on observations of my own, the labiovelars k^w g^w of Latin have become k g (and then k' g') before the palatal vowels i e in both Italian and Spanish. Yet in both languages k^w g^w remain before (stressed) a . Examples: Latin quid [$k^w i d$] 'what' becomes Italian chè [$k' e$] and Spanish qué [$k' e$]; yet Latin quantu(m) [$k^w a n t u$] 'how much' becomes Italian quanto and Spanish cuanto, both [$k^w a n t o$].

Compare both these changes with the pre-Greek change of Indo-European labial dorsals k^w g^w $g^w h$ to Greek t d th before the palatal vowels i e . Apparently, the labial dorsals took on palatality before these vowels (i.e., colored), lost labiality (partially bleached) and became palatal dorsals before these vowels, fronted to palatal coronals, and these palatal coronals lost their palatality (i.e. bleached). Using k^w as representative, this series of processes may have occurred: $k^w > k^y > k' > t' > t$. Thus two bleaching processes were involved in this Greek change.

This completes the discussion of bleaching.

5. Examples of Lenitions.

5.1. Some sonority lenitions.

The processes which will be discussed in this section all have the four properties of lenitions (syntagmatic processes). These properties are: (1) Lenitions are sequence-optimizing and assimilative, i.e., they are strategies for pronouncing sequences of sounds based on the concept of least effort (cf. Grammont 1933). (2) They are always context-sensitive, unlike fortitions, which can apply in a context-free way. (3) They are weakening, i.e., they generally produce outputs that are wider or laxer than the input. But even when they produce narrower or tenser outputs, such a change constitutes a compromise with the context and is done for the sake of ease of articulation. (4) They are most apparent in hypoarticulate (casual, careless, or lazy) speech.

So, while fortitions shape the conscious half of phonology, lenitions make those fortitive underlying representations into understandable segmented speech. Given a simple phonemic form like $/l i t l e/$ little or $/m a n/$ man, certain lenitions add properties to these forms to make them easier to pronounce. For little, lenitions add flapping of the t , and simultaneously they add loss of schwa, syllabification of the l , and its

"subsequent" velarization. The resulting form is [lɪʀu] little. In the case of man, a nasalization lenition (assimilation) gives [mæn] man. The main purpose of the lenition, then, is to facilitate the pronunciation of segments occurring in sequence.

Naturally, the adjustments that a speaker makes during the progress of the speech event are very numerous and, more than that, vary from one speech event to the next. Aside from such seemingly unnoticeable speech phenomena (whose statement and laboratory analysis would fill volumes), there are certain grosser aspects, or processes, to which we can give some consideration here in this short space. We will accordingly consider six groups of phenomena, to be presented in succeeding subsections: (1) lenitions affecting stricture, i.e., narrowing/widening assimilations, (2) lenitions affecting orientation (to that stricture), i.e., tensing/laxing assimilations, (3) lenitions affecting glottal events, such as aspiration, glottalization, and voice, (4) other lenitions which affect the sonority of the sound to which they apply, e.g., lengthening and shortening, simplification, and loss.

5.1.1. Lenitions affecting stricture.

The two fortitions affecting stricture were narrowing and widening. Accordingly, the two lenitions affecting stricture in opposing ways are called narrowing assimilation and widening assimilation.

5.1.1.1. Narrowing assimilation.

Processes which narrow stricture in a dissimilative way are fortitions, e.g., the change of English of sθ and sf to st and sp, respectively, as in [sɪkst] sixth and [spɪɪ] sphere. But there is another change in English that, while it brings about a narrowing of the stricture, is nevertheless a lenition. I am referring to the change of tɟ to tʃ as in nature, or across a word boundary as in got you (to give gotchoo). The change in nature [n'ɛɪtʃɹ] is a lexicalized phonemic one: /ne'ʃɛɹ/. But that of got you/gotcha is a morphophonemic sandhi rule, generally under the control of the speaker using it. The change of tɟ to tʃ narrows the stricture of the second sound from an approximant ɟ to a fricative ʃ. Nevertheless, it is a lenition since ʃ represents a contextually based compromise of the ɟ in the direction of the stop t.

5.1.1.2. Widening assimilation.

The process changing the combination dt to st, which apparently occurs in an early stage of the development of Indo-European, is a fortition. For instance, the root for 'eat', *ed, combines with the suffix for third person singular, *-ti, to produce *esti 'he eats'; cf. Old Church Slavonic est, 'he eats'. It is a fortition because it dissimilatively widens (and devoices) the d to s.

But a similar change in early Latin which widens t to s before s is a lenition because it acts in an assimilative way. Thus, the combination of ment, the root for 'mind', and the nominative singular suffix (athematic), namely -s, produces not *ment-s but mens-s (which simplifies to mens). (Cf. Stampe 1973.)

While the western Romance change of pt and kt to ft and xt, respectively, as reported on in sec. 3.1.2.1 above, represents what may or may not be a fortition (depending on one's interpretation), the similar

Slovak change of v to u in a closed syllable is clearly a lenition, brought about by the preceding vowel. For example, the Slovak word ovca is pronounced ['outsə] and oblokov 'of windows' is ['oblokou] (Kondrašov 1962: 151).

Also compare the development of f θ x from what must have been three different sources in the early stages of Germanic: (1) The occurrences of p + k plus one of the laryngeals H produced the strong aspirates ph th kh. (2) The voiceless stops p + k were generally weakly aspirated to p^h th^h k^h, except after s and in combinations the p + t + k +, and probably early fell together with the strong aspirates. (3) The combinations p + t + k +, not otherwise affected, dissimilated directly to ft xt, this change becoming phonemic only after the widening of the aspirates, from both sources, to f (θ) x. This last change, the widening of the first element of p + t + k + to ft xt, was probably helped along by the influence of the preceding sound, whether vowel or resonant.

Other lenitions in this category include the Chipewyan "smoothing" of the grooved sounds ts ? ds dz s z to +θ ? +θ d ð θ ð (Goodman 1968), an assimilation to the vowel. Also compare my stepson Arthur's age 5 change of ts to +t, narrowing assimilation which goes in the other direction and constitutes an assimilation of š to the tangency ("touchingness") of the +.

5.1.2. Lenitions affecting orientation.

The two fortitions which affected the orientation, in terms of the tense/lax distinction, of a sound to its stricture were tensing and laxing. Similarly, the two lenitions affecting orientation are called tensing assimilation and laxing assimilation.

5.1.2.1. Tensing assimilation.

The tensing and subsequent devoicing of g to k in combination with a following + occurs in pre-Latin and is an example of tensing assimilation. By way of an example, Latin ag- 'to do, or move' combined with -tos, the marker of the past passive participle (masc. nom. sg.). This combination gives not *ag-tos but actus 'done, moved' in Classical Latin.

This sort of tensing, which is dependent upon the context, is different from the fortitive type, like the tensing and devoicing of Old High German voiced stops, a kind of tensing that affected the whole system.

5.1.2.2. Laxing assimilation.

The laxing of voiceless stops in Danish when they occur around fricatives (Spore 1965) is clearly a fortition, e.g., gisp [gisβ] 'groan' (but Spore states that voiceless β is voiced b in this position!). But the similar laxing of voiceless stops in a postvocalic and pre-stop context, which occurs in southern dialects of American English is probably a lenition. A typical example is the pronunciation of the word Baptist as [bæβtɪst] or even [bæβtɪst]. Cf. the Puerto Rican Spanish laxing, voicing, and widening of p to f in septiembre [sɛβtjembɾɛ] 'September'.

5.1.3. Lenitions affecting glottal events.

The discussion here will be divided into two different sorts of

glottal events: (1) aspiration and glottalization (glottal enhancements), and (2) voicing and devoicing (voice).

5.1.3.1. Aspiration and glottalization.

The early Germanic aspiration of voiceless stops is clearly a fortition, a change that affected the whole system in a general way. And the present-day process that produces aspirated voiceless stops before stressed vowels or initially in English, German, and other Germanic languages is also obviously a fortition. Similarly, the process that produces glottalized voiced stops initially before stressed vowels in French and Spanish is also a fortition.

But the process in English that adds a separate (nonglottalizing) glottal gesture, as for a voiceless stop in sentence-final position, is a lenition. An example is the last t in the phrase "And that's that!" [...ðæt¹] and the t is said to be unreleased. According to Catford (1977) sounds like t^1 actually involve an inserted glottal stop, but timed so as not to produce actual glottalization. Sometimes full glottalization results from this insertion, e.g., "I can't!" [...kæt¹?], or "Just think!" [...θɪŋk¹?]. This is the result of a lenition, which makes the utterance-final stop easier to say by relaxing the requirement to release that stop. Yet something "has to give," so to speak. The result is an inserted glottal closure ?.

A clearer example of this is the lenition of $\text{p} + (\text{k})$, all going to glottal stop ? before a homorganic nasal, in some forms of American English. Examples include cap'm [kæp¹m] 'captain', buttin' [bʌt¹n] 'butting', and I c'n [oʊ¹n] 'I can'. It regularly happens for t before syllabic η in such words as button, cotton, satin, and for some dialects in words like important, sentence, pittance. In some dialects it also applies to t before syllabic l : bottle [bɒt¹l] subtle [sʌt¹l], little [lɪt¹l], etc. All these are the result of a lenition, assimilating the stop in the direction of the previous vowel. As further evidence that this is a lenition, the glottal stop so produced is often lost outright, e.g., little [lɪt¹l] becomes li'l [lɪl].

This same lenition, which might be called glottal lenition, also probably accounts for the weakening or loss in Chinese of final voiceless stops (which existed in Ancient Chinese). The Cantonese dialect preserves the Ancient Chinese final consonants, the Suchow dialect preserves an intermediate glottal stop stage, but in the Peking dialect (Mandarin), these glottal stops are lost (data from Forrest 1948:Appendix II, 307ff.):

Ancient Chinese	Canton	Suchow	Peking	gloss
-jɛp	-ji:p	-jɛ?	\jɛ	'leaf'
-bjɛt	-pi:t	-bi?	/pjɛ	'different'
-tək	-tak	-tə	/tə	'get'

The lines indicate tones. Compare example (4.9f) above in sec. 4.1.2.3.

From my own observations of the dialect of Atlanta, Georgia, we can establish yet another stage for glottal lenition. In that dialect, there is free variation between a glottal stop produced by lenition and a glottal stop accompanied by a partial, approximant-like gesture of the original voiceless stop. So the phrase Atlanta Hawks comes out [ʔæ¹?|æ¹.tə hɒ¹ʔs]

(careful speech) or [æʔ|ǣñə hʊʔs] (casual speech). Notice the partial ʔ gesture, signified by superscript ʔ, and the partial k gesture, signified by superscript ʔ, in the first (careful speech) example. So, for instance, for k we can establish these stages of weakening:

$$(5.1) \quad k \rightarrow kʔ(kʔ) \rightarrow ʔʔ \rightarrow ? \rightarrow \emptyset$$

This series of processes is based on our cross-linguistic observations of English and Chinese.

Aspiration also occurs lenitively. In English, as we have noticed, it typically occurs before a stressed vowel and here it is a fortition. But aspiration lenition occurs when the amount of subglottal air pressure produced by the lungs is greater than that needed to pronounce the word. The result is word- (or sentence-) final aspiration. For instance, Tojolabal, a Mayan language, has an alternation between nonfinal ʔ (and other voiceless stops?) and aspirated word-final ʔ^h, e.g., /čatəʔ/ [catəʔ^h] 'a kind of plant' (Gleason 1965:56).

A similar change, that can be interpreted as sentence-final aspiration lenition, occurs in Spanish of Mexico City, e.g., señor [senjoʔ^h]. This was reported above in sec. 3.2.2) as an example of devoicing. It is just possible that final ʔ becomes aspirated to ʔ^h and then only does the h-aspiration assimilate to the apical grooved ʔ to produce a period of apical grooved voicelessness in the form of ʔ̥.

5.1.3.2. Voice.

The following relationships are probably true: (1) Devoicing of obstruents is often a lenition. (2) Devoicing of resonants (and vowels) is always a lenition. (3) Voicing of obstruents is always a lenition. (4) Voicing of resonants (and vowels) is almost never a lenition. Schematically:

(5.2)	Obstruents	Resonants
Devoicing	often	always
Voicing	always	almost never

The devoicing of obstruents, as in Old High German, has already been discussed (see sec. 3.2.1). ʔ is a fortition. But word-final devoicing of obstruents in languages like German and Russian is a lenition, being an assimilation to the following voiceless pause.

Devoicing of resonants, specifically the change of m n ŋ l r to m̥ n̥ ŋ̥ l̥ r̥, occurs in Welsh in initial position. These voiceless sounds are written mh nh ngh ll rh in Welsh (Lewis and Pedersen 1937:48). This is the result of a lenition, due to the assimilation of these sounds to the voicelessness of the preceding pause. Compare the lack in English of initial zb zd zg even though sp st sk do exist. Also compare the devoicing of vowels in Southern Paiute (Sapir 1933), which is due to a lenition.

The voicing of obstruents in Late Latin, specifically p ʔ k to b d g between vowels, was a lenition (even though p ʔ k were first laxated to b̥ d̥ g̥ by what was probably a laxing fortition, affecting all voiceless stops). For instance, Latin ripa became early Gallo-Roman *riba (later giving Modern French rive 'shore, bank') (Pope 1934:137).

The voicing of resonants is almost never a lenition, but many cases are ambiguous. For example, the voicing of voiceless ŋ ! r in Old English (written hn hl hr) occurred in the context of the ever-present voicing of vowels. Nevertheless, I believe this particular change is an example of a fortition. The voicing of ř to ṛ̌ , produced by the flapping of † in American English, is possibly a fortition.

Voicing assimilation of a regressive sort applies in Russian, changing the voicing of the first of two (or more) obstruents so that it agrees with the voicing of the second (or last) obstruent. This lenition is properly and mnemonically called the "football" rule, since the word football (Russian futbol) has been borrowed from English as [fudbɔl].

Voicing assimilation of a more complicated sort applies to obstruents in Dutch (Kruisinga 1924:11). (1) When a stop and a fricative occur in combination, the voicing of the stop prevails, e.g., uitvorsen [aytʰfɔrsən] 'to investigate'. (2) When two stops occur in combination that differ in voicing, the combination always becomes voiced. When two fricatives occur under the same conditions, they become voiceless. These assimilations can be expressed by the following two processes, the first (a) corresponding to condition (1), the second (b) to condition (2).

- (5.3) a. Fric → αVoi / Stop .
 αVoi
- b. Obs
 αClos → αVoi / αClos .
 -αVoi αVoi

According to (a), a fricative assimilates to the voicing of a stop which immediately precedes or follows it. According to (b), for two obstruents having the same closure but different voicing, the voicing "assimilates" (?) to the feature value (plus or minus) of the closure. In such a way, stops (+Clos) become voiced (+Voi); fricatives (-Clos) become voiceless (-Voi). Process (a) is definitely a lenition; (b) may very well be a fortition.

5.1.4. Other lenitions affecting sonority.

5.1.4.1. Lengthening and shortening.

Compensatory lengthening of vowels is a common lenition, e.g., Common Slavic lōd 'people' becomes lo:d in western Slavic after a hyper-short jer vowel (b) is lost. In other words, the two moras of the long o: come to be timed identically with the two syllables of the original word. In Polish, the long o: produced raises to u: and shortens: Modern Polish lód [lut] 'people' (Kondrašov 1962:123).

An example of consonant lengthening occurs in American English, a process apparently triggered by equal stress on the syllables on either side of the consonant. There are four examples in English, all lengthening the stop *t*, and all involving the names of numbers. The four are: thirteen [θ'eɪt:'i:n] (note the long *t*), fourteen [f'ɔ:t:'i:n], eighteen ['eɪt:'i:n], and nineteen [n'aɪ̯t:'i:n]. Compare English thirteen [θ'eɪti:n], etc.

Shortening, or flapping, of resonants is also a lenition. Flapping in English involves three steps, all lenitions:

- (5.4) a. $+d \rightarrow \text{Short } (\text{ř } \text{ď})$
 b. $\text{ř } \text{ď} \rightarrow \text{Gru (App)} (\text{ř} \text{ ř})$
 c. $\text{ř} \rightarrow \text{Voi } (\text{ř})$.

In (a), the shortening occurs. In (b) these shortened stops become grooved, and thus, in effect, approximants. In (c), the voiceless flap gets voiced.

5.1.4.2. Simplification, loss, and other types of assimilation.

Simplification of clusters is a lenition, since it represents a loss of information. (Fortitions generally simply act to reorganize the information present in a sound system.) An example is the change of Latin initial $p|$ and $k|$ to l' in Spanish (spelled ll). Eventually, the l' delateralized to j , e.g., Latin plover and Spanish llover [$j\text{ɔ}\beta' \text{ɛ} \text{ř}$] 'to rain' (pers. comm., David Griffin); Latin klamare and Spanish llamar [$j\text{am}' \text{a} \text{ř}$] 'to call'.

Of loss, Hyman (1975:165) has said that a lenition is any change on its way to zero. Examples of loss include the deletion of word-final glottal stops in Mandarin (see above) and loss of flapped $+d$ in English child language.

5.2. Some position and color lenitions.

The lenitions to be dealt with will be presented in two sections: first, position assimilations, and second, lenitions affecting color. This last section will deal mainly with the effect of vowel color on consonants. We turn now to the discussion of position assimilation.

5.2.1. Lenitions affecting position.

Hutcheson's (1973) Ph.D. dissertation dealt specifically with the problem of consonant assimilation. He divided such assimilations into three groups: (1) partial assimilations, (2) fortuitous complete assimilations, and (3) complete assimilations. Partial assimilations dealt with clusters, as I have been using the word here. For instance, given a cluster like ks , a partial assimilation might produce xs . Here the stop k has become partially assimilated to the fricative s by becoming the fricative x .

Fortuitous complete assimilations result in geminate consonants (as do, as we shall see, complete assimilations). But they are fortuitous in that the two consonants involved are already similar, requiring the change of but one feature in a statement of the process. In the terms I have been using, fortuitous complete assimilations apply to affricates or co-articulations, or their mirror image clusters. For instance, pf becoming ff (what Hutcheson calls a "one-step change") is a fortuitous complete assimilation, because p and f were already very similar, i.e., differed (mainly) by one feature.

Complete assimilations, on the other hand, convert clusters differing both by sonority and position into geminate consonants, e.g., pn becoming nn or pp. A fourth type, which Hutcheson didn't consider (probably because he didn't consider them assimilations), would be the change of such clusters to a geminate composed of neither of the two members of the cluster but representing a common ground between them, e.g., pn becoming mm, or sk becoming šš. I know of no evidence, however, which would indicate the plausibility of these last two changes as a one-step change (but see below).

It is clear that Hutcheson considers only the last type, complete assimilation, of any theoretical interest. He seems to consider complete assimilation in terms of no intervening steps, all done in one change. However, the concept of two consonants being surreptitiously jammed together, as a case in point, does not seem too elegant.

I am inclined to think that the other two types, partial assimilation and fortuitous (complete) assimilation, are theoretically more significant. The case of partial assimilation tells us something significant about consonant categories. For instance, the change (as above) of ks to xs tells us that x has properties in common with both k and s. It has the position of k and the sonority of s. This is not an altogether obvious fact. The fact that ks becomes xs tells us that the x and s share properties even though x is made with a flat ("smooth") tongue and s with a "grooved" one. This problem is a moot one but ultimately an important one.

The case of fortuitous assimilation is also of significant theoretical interest in that it tells us something about phonetic identity. For instance, the change (as above) of pf to ff reveals that the two instances of ff are both occurrences of the same consonant sound, differing in phonetically predictable ways, i.e., the f's would be treated as instances of the same phoneme. Again, a moot point. But a very basic concept, that of phonemic identity or sameness, is behind it.

The case of complete assimilation then takes on an importance relative to the two preceding types. In this thesis, I have dealt with processes in an atomistic way, i.e., as producing small, discrete changes. The case of complete assimilation is then, to me, an occurrence of two partial assimilations, either occurring sequentially over time (in which case we notice their partialness) or occurring simultaneously in the mind or mouth of the speaker (cf. Donegan and Stampe 1979). In the latter case, of course, no external perception of the simultaneity in question would be possible. Two steps are involved but they both occur together.

The conjecture which supports the simultaneity of a two-in-one change is ineluctably its converse, i.e., the sequentiality of the two changes not occurring simultaneously but separately over a period of time. Two sequential changes show us things that one simultaneous two-in-one change does not. For one thing, they show us the possible "moves" that sounds can make. For another, they show us what "maps" we should draw, as linguistic cartographers, to delineate these changes, and perhaps to explain them.

A case in point is pn, as in Indo-European *swopnos 'sleep, dream'. In Latin it had become somnus, pn having partially assimilated to mn. In Italian the assimilation is complete: Latin somnus has become Italian

sonno, mn have "fortuitously" completely assimilated to nn (cf. French somme with mm). We notice two things: both changes were regressive and both were changes into a nasal, first being partially assimilated and later, completely.

It is altogether possible that pn could have become nn in one "fell swoop," to use Hutcheson's phrase. But rather than think of this as one change, I would consider it two simultaneous ones. The simultaneity of such a change is contingent on such factors as maintaining phonemic distinctions and certain cultural and societal considerations. Phonemic distinctions are, of course, important for keeping messages distinct: if a "fell swoop" change would destroy too many distinctions, it would be suppressed. The simultaneity of "fell swoop" changes, then, is largely happenstance, and sequentiality is more revealing.

I turn now to a discussion of general problems concerned with recognizing lenitions as distinct from fortitions and also to a position assimilation in Mandaic due to Malone (1971, 1972) (and cited by Hutcheson 1973). The Mandaic assimilation is one of glottals to buccals, e.g., ʔt to tt, a change on which I have not previously touched.

5.2.1.1. Recognizing lenitions which affect position.

Based on an atomistic process approach to sound change, we would normally expect only fortitions to be of the "fell swoop" variety. This statement refers only to changes which "jump across" other categories of sound without being affected by them. For the sake of an example, consider the change of $k^{(w)}$ to p. Not so obviously, there are no intervening steps: the labial dorsal stop is replaced by a plain bilabial stop, corresponding in terms of position to the labial coloring that was originally part of the combination $k^{(w)}$. This change is due to the fortition fronting, which especially affects consonants bearing a color. When this occurs, and there are no for-sure examples, the action is that of a fortition.

But the change of $k^{(w)}$ to p could also be viewed as a lenition in that the labial color and stop sonority of $k^{(w)}$ come together, as it were, to produce a "labial" stop, p.

Stampe has suggested (pers. comm.) that the change of $k^{(w)}$ to p is "typically" (I would say "sometimes") the result of an assimilation whereby the labial color w narrows to p to produce kp, possibly a coarticulation at this point. The combination then simplifies to p.

Another possibility that I would consider (and which is not due to Stampe) is this series of changes: $k^{(w)} > kp^{(w)} > p^{(w)} > p$. Nandris (1963:112) cites a case somewhat like this one for the combination b' : $b' > bd' > bd\check{z} > d\check{z}$. (The sequencing of the changes is my own conclusion, based on his observations on Rumanian dialects.) Granted that the change above for $k^{(w)}$ to p is only remotely possible, what makes this last change, of b' to $d\check{z}$, quite possible? The answer is simple: the change of $k^{(w)}$ to p is an instance of fronting; the change of b' to $d\check{z}$ is an instance of backing.

Fronting normally proceeds directly with color; the change of $k^{(w)}$ to p would be obviated by this correlation between fronting and color. Backing normally proceeds without color. The change then proceeds in assimilative increments, eventually "winding up" at a coronal palatal position. I would say on this account that reports of changes involving frontings that go through a variety of stages are probably misfounded. As an example, $k^{(w)}$ proceeds directly to p as a fortition, or $k^{(w)}$ assimilates

to kp and then simplifies to p as a series of two lenitions. Both, I think, are possible, but the lenition solution depends on the existence of intermediate kp in some dialect or speech style.

5.2.1.2. Position assimilation (glottals).

Malone (1971, cited in Hucheson 1973) presents the following data on Mandaic, a language in which glottals assimilate to buccal sounds. In Mandaic, a glottal stop ? or glottal fricative h metathesizes with a preceding consonant C preceded in turn by a vowel:

(5.5) a. C Glot → Glot C / V ____

Then, for glottal stop, it either assimilates completely to the consonant or the vowel:

b. ? C → C C / V ____
V ? → V / ____ C.

For the glottal fricative h, it may assimilate to either optionally. So these three possibilities exist:

c. h C → C C / V ____
V h → V / ____ C
V h C remains.

Hucheson (1973:66) says of this example that instances of both forms of substitution for glottal stop (and presumably all three forms for h) occur within the same dialect. Malone (1972, cited by Hucheson) notes that the change of V? Vh to V generally happens in prejunctional position: otherwise, ?C hC becomes CC (or C in these environments: CCV ____ or VCV ____, i.e., where the preceding C is geminate or the next preceding V is geminate). There are other limitations on the application of this process that need not concern us here.

This gives the idea of glottality as a full-blown position, a point which has not been previously touched upon. Hucheson (1973) also gives examples of glottals becoming buccal sounds in Southern Paiute, Ancient Greek, and Finnish.

We might want to compare this glottal assimilation to the reverse process of introduction of glottals into original geminates. This occurs in Icelandic and there intervocalic pp tt kk become hp ht hk, e.g., kakka [k^hahka] 'to heap up'. Garnes (1976:13-22) describes such changes in connection with other related phenomena, reflected in such words as hekla [h^hhkla] 'to crochet', henta [h^hento] 'to be suitable, convenient', brúnna [br^hutna] 'brown (gen. pl.)', and alla [o^hla] 'all (gen. pl.)'. Here the spellings reflect an earlier form of pronunciation, which has been modified today to the form given in brackets.

5.2.2. Lenitions affecting color.

This topic will be discussed in two parts: (1) color matching and (2) vowel color phenomena.

5.2.2.1. Color matching.

Color matching, a lenition, may be stated this way:

$$(5.6) \quad C \rightarrow \alpha \text{ Color} / \left[\begin{array}{c} V \\ \alpha \text{ Color} \end{array} \right] .$$

An obvious example is consonants becoming palatal before front (palatal) vowels. This situation holds for dorsal k g in English, which become k̟ g̟ before i ɪ e ε æ a (all palatal vowels). This process also produced the situation in the Slavic languages, although the reflexes of the simple palatalizing process have become phonemic, thus making the situation more complex. For instance, in Russian, the high front vowel i has as its nonpalatal counterpart the high central vowel ɨ. All the other vowels ε α ɔ u have palatal counterparts ʲε ʲα ʲɔ ʲu, which palatalize preceding consonants (i varies freely with ʲi) (cf. Kondrašov 1962:86).

Another example is consonants becoming labial before labial vowels (generally back ones). So northern (Mandarin) Chinese -ʂɔ 'say, tell' is realized phonetically as [ʂʷɔ]; hence, the Yale spelling of this word as shwō. This assimilation proceeds regularly for other consonants appearing with -ɔ, regardless of tone. But note that -ʂu 'book' is not *[ʂʷu] but [ʂu]. The process is not triggered by -u itself (cf. Tewksbury 1948).

Another example would be consonants becoming pharyngeal before pharyngeal (low back) vowels. This is not the only source for pharyngeal consonants, however. The reader should try saying the sequence [sxɑ>] quickly; the result generally comes out [sʰɑ>]. This reveals a possible fricative origin for pharyngeal consonants.

Similarly, pharyngeal(ized) consonants may result from sequences of C + α, palatal(ized) consonants from C + j, and labial(ized) ones from C + w.

5.2.2.2. Vowel color phenomena.

Just as consonants can become colored next to vowels of the same color, so vowels can take on the color of an adjacent consonant. This usually applies to vowels that are lengthened, e.g. i becoming i:, and then broken (diphthongized), e.g. i: becoming i̟ or i̠. For the sake of the following statement, let us assume that the vowel broken off is always nonsyllabic ɛ̠. The following is a typical situation:

$$(5.7) \quad \alpha \rightarrow \alpha \text{ Color} / \text{---} \left[\begin{array}{c} C \\ \alpha \text{Color} \end{array} \right] .$$

As an example, consider the following processes (which merely suggest the solution and are not entirely accurate), all of which apply to most dialects of American English:

$$(5.8) \quad \begin{array}{ll} \text{a.} & \begin{array}{l} C \\ \text{Dor} \end{array} \rightarrow \text{Pal} / \begin{array}{l} V \\ \text{Pal} \end{array} \text{---} \\ \text{b.} & V \rightarrow \text{Short} / \text{---} \begin{array}{l} \text{Stop} \\ \text{-Voi} \end{array} \end{array}$$

$$(5.8) \quad c. \quad \left[\begin{array}{c} \text{V} \\ \text{-Short} \end{array} \right] \rightarrow \left[\begin{array}{c} \text{V} \\ \text{Short} \end{array} \right] \quad [\text{ə}] / \left[\begin{array}{c} \text{Pal} \\ \text{-Tns} \\ \text{---} \end{array} \right]$$

$$d. \quad [\text{ə}] \rightarrow \text{Pal} / \begin{array}{c} \text{C} \\ \text{Pal} \end{array}$$

Rule (a) palatalizes the dorsals k g ŋ after a palatal vowel, e.g., sick [sɪk]. Rule (b) shortens vowels before voiceless stops; in effect, it lengthens them everywhere else, e.g., bid [bɪ:d], red [ɹɛ:d]. Rule (c) diphthongizes (breaks) nonshort vowels V to short V plus ə, provided they are palatal and lax. Rule (d), like the process in (5.7), makes ə palatal (typically i following ɪ ɛ: [ɪi] [ɛi], and ə following æ: [æə]). This is similar to the change of vowel V to diphthong Vi before palatals like dž ŋ (tʃ) in Sora and its sister Munda languages (pers. comm., David Stampe). Forms can be derived as follows:

(5.9)	bæg	wɪʃ	sɪk
(a)	bæġ	---	sɪk̟
(b)	---	---	sɪk̟
(c)	bæəġ	wɪəʃ	---
(d)	bæəġ	wɪiʃ	---

The letters (a-d) refer, of course, to the four processes given above.

In the speech of DLH, who grew up in Brooklyn, NY, rule (c) above is modified to read:

$$(5.8) \quad c'. \quad \left[\begin{array}{c} \text{V} \\ \text{-Short} \end{array} \right] \rightarrow \left[\begin{array}{c} \text{V} \\ \text{Short} \end{array} \right] \quad [\text{ə}] / \left[\begin{array}{c} \text{-Tns} \\ \text{---} \end{array} \right]$$

The only change is in the rightmost set of brackets: the feature Pal has been removed. Thus, any lax vowel is affected, but [ə] after labial (back) vowels would only become palatal before ʃ ʒ, as per rule (d) above, since back vowels would not make k g ŋ palatal as front vowels did by rule (a).

So she has the following diphthongs before ʃ: push [pʰuɪʃ], Josh [dʒɔɪʃ], wash [wɔɪʃ]. The combination [əʃ] doesn't occur in her dialect, but I once taught her the Russian word karandaš 'pencil', native pronunciation [kəɾəndəʃ]. She said it correctly several times and then submitted it to substitution: [kəɾəndəʃ] (note the diphthong before s).

Most dialects have different strategies for back lax vowels. For instance, push is [pʰuʊʃ], reflecting the lip-rounding that often occurs with s, e.g., ship [ʃɪp]. Labiality seems to be connected with ɹ also, e.g., rip [ɹɪp], and in fact replaces the expected wash [wɔɪʃ] of such dialects with [wɔɪʃ] 'warsh'. Dialects around Atlanta, Georgia, also have water [wɔɪtə], and ought [ɔɪt].

Retroflexion seems to be connected with r-coloring, retractedness, and palatality, as in the ruki rule. The ruki rule affected eastern Indo-European, mainly Indic (Sanskrit) and Balto-Slavic. In Sanskrit, s became retroflex ś when it occurred after r, u, k, or i. Zwicky (1970) reports that after k, there are no exceptions, all instances of ks being realized as kś. The other cases are more exceptionful.

In Slavic, *s* becomes retracted to *x* (perhaps through intermediate *ʂ*) after *r u k i*, except before the voiceless stops *p t k*. Compare Latin *musculus* '(house) fly' and Old Church Slavonic *mxъ* (or *mǫxŭ*), same meaning (Kondrašov 1962:31).

In Baltic, Lithuanian (but not Latvian) has *s* becoming palatal *š*, but only after *k* and *r*, e.g., Lith. *vērsis* 'ox, calf' but Latvian *vērsis*; Lith. *auštas* 'high' but Latvian *aūsts* (Endzelins 1971:50).

The relationship between *r*-coloring (or retroflexion) and palatality is also reflected in those dialects which have lost *r*-coloring and replaced it with palatality, e.g., *worse* [wəʃs]. There is, then, a reciprocal influence of consonants on vowels and vice versa.

This completes the discussion of lenitions.

6. Conclusion.

The basic premise of natural phonology is that sound substitution proceeds most often due to the nature of the sounds themselves. With this theme in mind, we might expect that the vast phonological differences which exist in the languages of the world are due to a discrete set of relatively predictable and relatively available natural phonological processes which are at the basis of all sound change. To validate this notion, I believe it is sufficient to state what these processes and their explanations are, and I have attempted to do this in this article.

As for the relative predictability of these natural processes, I have dealt with this in the form of the catalyzing environments in the discussion and explanation of the eight fortitions described in sections 3 and 4. As for the relative availability of these processes, I have drawn data from both children's and adults' speech, from both synchronic alternations and diachronic change, and from diverse languages and dialects and styles of speech.

The explanation for the relative predictability of these natural processes is made on the basis of the opposing teleologies of each pair of fortitions, so that half of them predict the augmentation or addition of one phonological parameter and the other half predict the augmentation or addition of some other (opposing) parameter. The explanation for the relative availability of these processes is in terms of their innateness within the individual, being part of the nature of the individual from his birth and being modified in a systematic way by the exigencies of his linguistic experience.

The phonological parameters upon which the predictability of these processes is based consist of these three: sonority, tonality, and chromaticity. Sonority distinguishes consonant from vowel and the various types of consonants and vowels from one another, e.g., obstruent versus resonant consonants or high versus low vowels. Tonality distinguishes position among consonants (and possibly among vowels) so that consonants which have been given a sonority type have also been given a position type, e.g., chelic, coronal, etc. Sonority works as the basic concept of the syllable, more sonorant sounds (e.g., vowels) being the syllable carriers and less sonorant sounds (e.g., consonants) being the syllable satellites. Tonality works within the domain of sonority to arrange the sequences of sounds within carrier and satellite. Chromaticity is most easily identified with color type, e.g., labial, palatal, etc. It works within the domain of tonality to increase the intensity of distinctions based on tonality.

These three parameters just mentioned work on the basis of progressing streams of speech. But such speech is based on, or made up of, various sounds which are differentiated on the basis of their inclusion or non-inclusion within certain classes of sounds. The various instances of sounds which are used by a given language to differentiate forms is called a sound system. The various properties which are inherent in these instances of sounds and which are used to differentiate members of classes of sounds are called sound features. Sound systems are, then, defined by sound features.

Within the sound system and by means of the sound features differentiating the individual members of the sound system, certain sounds or contingent groups of sounds are distinctive. They account for the phonological representation of sounds within a given language, i.e., they are phonemic. Phonological representation is determined on the basis of the typical pronunciation of a given phoneme, e.g., the English phoneme /p/ is a bilabial voiceless stop, typically aspirated. In cases where phonemes appear to "overlap", i.e., fall together in a given context, they are defined in terms of the sound intended (mental intention), represented in fully defined phonemic terms.

Sound systems may change due to shifts (transphonologizations, to use Jakobson's term), mergers (dephonologizations), and splits (phonologizations). As a subset of shifts, we may also consider the changes, typically of position, due to the principle of maximal differentiation, e.g., the backing of *s* in Old Spanish and of *с* *з* in Russian to prevent their merger with fricative sounds.

Fortitions and lenitions apply in a contingent order, either over a period of time (diachronically) or simultaneously (synchronically). The essential unity of diachrony and synchrony can be seen as a free relationship in which pronunciation may vary over time or alternate at one time within the speech of a given individual or group of individuals.

I have attempted in this article to do four main things: (1) to establish the existence and relevance of a set of eight paired fortitions which describe the major class changes of consonant sounds, (2) to establish, at least tentatively, the opposing teleologies of each pair of fortitions, (3) to establish the three parameters on which consonant distinctions are based, and (4) to set up a system of features capable of reproducing these distinctions. In doing so, I have also talked about the basic premises of the study of natural phonology.

The four sonority fortitions, presented in sec. 3, concern changes in stricture (narrowing/widening) or changes in orientation to a stricture (tensing/laxing). The two position fortitions and the two color fortitions, presented in sec. 4, concern changes of tonality (fronting/backing) and changes of chromaticity (coloring/bleaching). They occur under typical relatable ways, i.e., narrowing and fronting typically occur for tense sounds, and widening and backing for lax sounds; and tensing and fronting occur typically for narrower sounds, and laxing and backing for wider sounds.

Lenitions have been dealt with sparsely here; the lenitions that were discussed in sec. 5 are probably only the tip of the iceberg. The fortitions dealt with here certainly do not represent the entire set of such processes. For one thing, they do not account for the metathesis and insertion of consonants.

The study of phonology has in the past decades discredited such ideas as sound changes being due to climate or to racial membership. In the space of this paper, I have attempted to discredit the idea that sound change is formal or mechanical (as opposed to instinctive or intuitive) or that it results from the history of the language (as opposed to the intuition of the individual). Thus, language change is more to be identified with psychology than with computer and information science. And drift is then to be identified with similar linguistic intuitions, bringing about similar changes. The idea that Germanic and Armenian must have had a common Urheimat simply because they exhibit similar sound shifts should now be discredited. With the denial of such ideas, further endeavors concerned with the study of universal phonology should proceed on the basis of the innate availability and teleological predictability of natural phonological processes.

7. Appendix: Summary of processes.

7.1. Fortitions.

C following the name of a fortition means chromatization: S means sonorization.

(7.1) Narrowing (C)

$$\left[\begin{array}{l} \text{C} \\ \text{n narrow} \\ \text{! lighter} \\ \text{! Tns} \\ \text{! Gloz} \\ \text{! /\$ } \end{array} \right] \rightarrow \left[\begin{array}{l} \text{n + 1} \\ \text{narrow} \end{array} \right]$$

(7.2) Widening (S)

$$\begin{bmatrix} C \\ n \text{ narrow} \\ ! \text{ darker} \\ ! \text{ -Tns} \\ ! \text{ Asp} \\ ! \text{ / } ___\$ \end{bmatrix} \rightarrow \begin{bmatrix} n - 1 \\ \text{narrow} \end{bmatrix}$$

(7.3) Tensing (C)

$$\begin{bmatrix} \text{C} \\ ! \text{ narrower} \\ ! \text{ Long} \\ ! \text{ -Voi} \\ ! \text{ / } \underline{\hspace{0.5cm}} \text{ Syl Peak} \\ (\text{gen. \$ } \underline{\hspace{0.5cm}}) \end{bmatrix} \rightarrow [\text{Tns}]$$

(7.4) Laxing (S)

$$\begin{bmatrix} C \\ ! \text{ wider} \\ ! \text{ Short} \\ ! / \text{ wider} \\ ! / \text{ Meas Peak} \\ (\text{gen. } __\$) \end{bmatrix} \rightarrow [-\text{Tns}]$$

(7.5) Fronting (C)

$$\begin{bmatrix} C \\ n \text{ front} \\ ! \text{ Color} \\ ! \text{ Tns} \\ ! \text{ narrower} \\ ! \text{ Dent} \\ ! \text{ /Max Diff} \\ \text{(gen. Ret)} \end{bmatrix} \rightarrow \begin{bmatrix} n + 1 \\ \text{front} \end{bmatrix}$$

(7.6) Backing (S)

$$\left[\begin{array}{l} C \\ n \text{ front} \\ ! -\text{Color} \\ ! -\text{Tns} \\ ! \text{wider} \\ ! / \text{ \#} \\ ! / \text{Max Diff} \\ \text{(gen. High)} \end{array} \right] \rightarrow \left[\begin{array}{l} [n - 1 \\ \text{front}] \end{array} \right]$$

(7.7) Coloring (C)

$$\begin{bmatrix} C \\ - \text{Color} \\ \alpha \text{ Pos} \\ ! \text{ Long} \\ ! \text{ lighter} \\ ! / \begin{bmatrix} V \\ -\text{Color} \end{bmatrix} \end{bmatrix} \rightarrow [\alpha \text{Color}]$$

(7.8) Bleaching (S)

$$\begin{bmatrix} C \\ \alpha \text{ Color} \\ ! \text{ wider} \\ ! \text{ darker} \\ ! / \begin{bmatrix} V \\ -\alpha \text{Color} \end{bmatrix} \\ ("diff.color") \end{bmatrix} \rightarrow [-\text{Color}]$$

7.2. Lenitions.

1. Narrowing & widening assimilation
C → [n narrow] / [n narrow]
2. Partial narrowing assimilation
C → [n + 1 narrow] / [n + 2 narrow]
3. Tensing assimilation (devoicing)
C → [-Voi] / [-Voi]
4. Laxing assimilation (voicing)
C → [Voi] / [Voi]
5. Position matching
C → [α Pos] / [α Pos]
6. Color matching
C → [α Color] / [α Color]

Footnote

*This article represents a revised and corrected version of my 1979 doctoral thesis entitled "Consonants in natural phonology" (available from University Microfilms, Ann Arbor). Most of the material in this article is from Chapters III and IV of that thesis. Section 0 is new; section 1 is from Ch. III, sec. 3.1-3.2; section 2 is from Ch. IV, sec. 4.1-4.2; section 3 is from Ch. III, sec. 3.3-3.4; section 4 is from Ch. IV, sec. 4.3-4.4; section 5 is from Chs. III and IV, sec. 3.5 and 4.5; section 6 is from Ch. V; and section 7, a summary of processes, is new. I would like to thank Chris Farrar and Arnold Zwicky for reading and commenting on the present article. Naturally, any mistakes which remain are mine. I would also like to thank David Stampe for supervising the writing of the original dissertation.

References

The abbreviation CLS refers to Papers from the Regional Meetings of the Chicago Linguistic Society.

- Allen, W. S. (1953). *Phonetics in Ancient India*. London: Oxford University Press.
- Anttila, Raimo. (1972). *An Introduction to Historical and Comparative Linguistics*. New York: Macmillan.
- Biggs, Bruce. (1971). The languages of Polynesia. In J. Donald Bowen, et al., Eds., *Current Trends in Linguistics*, Vol. 8, Part 1, 466-505. The Hague: Mouton.
- Borg, Alexander. (1973). The segmental phonemes of Maltese. *Linguistics* 109.5-11.
- Catford, J. C. (1977). *Fundamental Problems in Phonetics*. Bloomington: Indiana University Press.
- Channon, Robert. (1972). On the Place of the Progressive Palatalization of Velars in the Relative Chronology of Slavic. The Hague: Mouton.
- Chomsky, Noam, and Morris Halle. (1968). *The Sound Pattern of English*. New York: Harper and Row.
- Davison, Alice. (1971). A problem concerning the relative naturalness of phonological rules and phonological representation. CLS 7.332-39.
- Donegan, Patricia Jane. (1978). On the natural phonology of vowels. *Ohio State University Working Papers in Linguistics* # 23.
- Donegan, Patricia Jane, & David Stampe. (1978). The syllable in phonological and prosodic structure. In Alan Bell & Joan B. Hooper, Eds., *Syllables and segments*, 25-34. Amsterdam: North-Holland.
- Donegan, Patricia Jane, & David Stampe. (1979). The study of natural phonology. In Daniel A. Dinnsen, *Current Approaches to Phonological Theory*, 126-173. Bloomington: Indiana University Press.
- Edwards, Mary Louise. (1973). The acquisition of liquids. *Ohio State University Working Papers in Linguistics* 15.1-54.
- Endzelins, Janis. (1971). Janis Endzelins' comparative phonology and morphology of the Baltic language. Tr. by William R. Schmalstieg & Benjamins Jegers. The Hague: Mouton.
- Forrest, R. A. D. (1948). *The Chinese Language*. London: Faber & Faber.
- Garnes, Sara. (1976). *Quantity in Icelandic: Production and Perception*. Hamburg: Helmut Buske Verlag.
- Gleason, Henry A. (1965). *Workbook in Descriptive Linguistics*. New York: Holt, Rinehart & Winston.
- Goodman, Felicitas. (1968). *Proto-Athapaskan Vowels*. Unpublished M.A. thesis, Ohio State University.
- Grammont, Maurice. (1933). *Traité de phonétique*. Paris: Librairie Delagrave.
- Gray, Louis H. (1934). *Introduction to Semitic Comparative Linguistics*. New York: Columbia University Press.
- Harris, James W. (1969). *Spanish Phonology*. Cambridge, Mass.: MIT Press.
- Hockett, Charles F. (1958). *A Course in Modern Linguistics*. New York: Macmillan.
- Hutcheson, James W. (1973). *A Natural History of Complete Consonantal Assimilations*. Unpublished Ph.D. Dissertation, Ohio State University.

- Hyman, Larry M. (1975). *Phonology: Theory and Analysis*. New York: Holt, Rinehart & Winston.
- Jakobson, Roman. (1968). *Child Language, Aphasia, and Phonological Universals*. Tr. by Alan Keiler. The Hague: Mouton.
- Jakobson, Roman, and Morris Halle. (1956). *Fundamentals of Language*. The Hague: Mouton.
- Jones, Daniel. (1914). *The Pronunciation of English*. 2nd ed. London: Cambridge University Press.
- Joos, Martin. (1952). The medieval sibilants. *Language* 28.221-31. Also in Martin Joos, ed., 1957. (see); 372-78.
- Joos, Martin, ed. (1957). *Readings in Linguistics*. Chicago: University of Chicago Press.
- Kondrašov, N. A. (1962). *Slavjanskije jazyki*. 2nd ed. Moscow: Gosudarstvennoe učebno-pedagogičeskoe izdatel'stvo.
- Kruisinga, E. (1924). *A Grammar of Modern Dutch*. London: George Allen & Unwin.
- Ladefoged, Peter. (1971). *Preliminaries to Linguistic Phonetics*. Chicago: University of Chicago Press.
- Lehiste, Ilse. (1970). *Suprasegmentals*. Cambridge, Mass.: MIT Press.
- Leopold, Werner F. (1947). *Speech Development of a Bilingual Child: A Linguist's Record*. Vol. 2. Evanston, IL: Northwestern University.
- Lewis, Henry & Holger Pedersen. (1937). *A Concise Comparative Celtic Grammar*. Göttingen: Vandenhoeck & Ruprecht.
- Major, Roy C. (1977). Phonological differentiation of a bilingual child. *Ohio State University Working Papers in Linguistics* 22.88-122.
- Malone, Joseph L. (1971). Systematic metathesis in Mandaic. *Language* 47.394-415.
- Malone, Joseph L. (1972). The Mandaic syllable-adjustment circuit and its historical origins. *CLS* 8.473-81.
- Mandelbaum, David G., ed. (1949). *Selected Writings of Edward Sapir*. Berkeley: University of California Press.
- Meillet, André. (1936). *Esquisse d'une grammaire comparée de l'arménien classique*. 2nd ed. Vienna: Pp. Mekhitharistes.
- Morris Jones, John. (1913). *A Welsh Grammar: Historical and Comparative*. Oxford: Oxford University Press.
- Moulton, William G. (1972). The Proto-Germanic non-syllabics (consonants). In Frans van Coetsam & Herbert L. Kufner, Eds., *Toward a Grammar of Proto-Germanic*, 141-173. Tübingen: Max Niemeyer Verlag.
- Nandris, Octave. (1963). *Phonétique historique du roumain*. Paris: Librairie C. Klincksieck.
- Nguyen Dang Liem. (1970). *Vietnamese Pronunciation*. Honolulu: University of Hawaii Press.
- Passy, Paul. (1890). *Étude sur les changements phonétiques et leurs caractères généraux*. Paris: Librairie Firmin-Didot.
- Pokorny, Julius. (1959). *Indogermanisches etymologisches Wörterbuch*. Bern: Francke Verlag.
- Pope, Mildred K. (1934). *From Latin to Modern French with Especial Consideration of Anglo-Norman*. Manchester: Manchester University Press.
- Pribsch, R., & W. E. Collinson. (1934). *The German Language*. 6th Ed. London: Faber and Faber.
- Prokosch, Eduard. (1939). *A Comparative Germanic Grammar*. Philadelphia: LSA, University of Pennsylvania.

- Rodrigues, Ada Natal. (1974). O dialeto caipira na região de Piracicaba. São Paulo: Editora Ática.
- Ruhlen, Merritt. (1976). A Guide to the Languages of the World. Stanford: Stanford University Language Universals Project.
- Sapir, Edward. (1915). Notes on Judeo-German phonology. The Jewish Quarterly Review, n.s. 6.231-66. Reprinted in Mandelbaum (1949):252-72.
- Sapir, Edward. (1933). The psychological reality of phonemes. Mandelbaum (1949), (see), 46-60. Originally published as La réalité psychologique des phonèmes. Journal de psychologie normale et pathologique 30.247-265.
- Saussure, Ferdinand de. (1959). Course in General Linguistics. New York: McGraw-Hill.
- Skorik, P. Ja. (1968). Čukotskokamčatskie jazyki: voedenie. Jazyki narodov SSSR, vol. 5, 235-247. Leningrad: Izdatel'stvo "Nauka".
- Spore, Palle. (1965). La langue danoise. Copenhagen: Akademisk Forlag.
- Stampe, David. (1973). A Dissertation on Natural Phonology. Ph.D. Dissertation, University of Chicago. (1980), New York: Garland.
- Tablan, Andrea A. & Carmen B. Mallari. (1961). Filipino-English/English-Filipino Dictionary. New York: Washington Square Press.
- Tewksbury, M. Gardner. (1948). Speak Chinese. New Haven: Yale University Press.
- Thompson, Laurence C. (1965). A Vietnamese Grammar. Seattle: University of Washington Press.
- Trubetzkoy, N. S. (1969). Principles of Phonology. Tr. C. A. M. Baltaxe. Berkeley: University of California Press.
- Velten, H. V. (1943). The growth of phonemic and lexical patterns in infant language. Language 19.281-292.
- Vogt, Hans K. (1974). Armenian language. Encyclopaedia Britannica, 15 ed., vol. 2 (Macropaedia), 23-24. Chicago: Encyclopaedia Britannica.
- Walker, Willard. (1975). Cherokee. In James M. Crawford, Ed., Studies in Southeastern Indian Languages, 189-236.
- Williams, Edwin B. (1962). From Latin to Portuguese. 2nd ed. Philadelphia: University of Pennsylvania Press.
- Wright, Joseph, & Elizabeth Mary Wright. (1924). An Elementary Historical New English Grammar. London: Oxford University Press.
- Wright, Joseph, & Elizabeth Mary Wright. (1928). An Elementary Middle English Grammar. 2nd ed. London: Oxford University Press.
- Zwicky, Arnold M. (1970). Greek-letter variables and the Sanskrit ruki class. Linguistic Inquiry 1.549-55.
- Zwicky, Arnold M. (1972). Note on a phonological hierarchy in English. In Robert P. Stockwell & Ronald K. Macaulay, Eds., Linguistic Change and Generative Theory. Bloomington: Indiana University Press.