The study of processes is a basic step toward an understanding of the structure, acquisition, and evolution of phonological systems. Furthermore, since processes operate in the central nervous system, the sound-classes they act on furnish our clearest evidence of the parameters by which perception and articulation are organized in the
Vowels exhibit two conflicting qualities—sonority and color. 

Sonority, the principal quality of vowels and the property most necessary for their functions in speech, is physically associated with high acoustic energy, audibility, and openness of the oral cavity.4 All vowels have a high degree of sonority in comparison to consonants, but vowels also differ from each other by degree of sonority (vowel height): high or close vowels have the least sonority, and low or open vowels have the most.

Color is another quality by which vowels may be distinguished from each other. Color is a cover term for two phonetically and phonologically parallel properties, both of which modify timbre or intrinsic pitch. These are palatality—associated with tongue-fronting, high second formant values, and high intrinsic pitch—and labiality—associated with lip rounding, low second formant values, and low intrinsic pitch.

The following is a diagram of the features and transcription symbols employed in this paper:

| -chromatic | +chromatic |
|---|---|---|---|
| -palatal | +palatal | -palatal | +palatal |
| -labial | +labial | -labial | +labial |
| (-tense) | -tense | +tense | -tense | -tense |
| high | i | y | u | u |
| mid | e | e | e | e |
| low | a | o | o | o |

Symbol values can be deduced from the chart and the examples in the paper; for more exact equivalences, see Donegan (forthcoming).

Sonority and color are phonetically incompatible qualities: close approximation of tongue-front and hard palate or close approximation of rounding of the lips are incompatible with a relatively open oral cavity. Thus, highly sonorant vowels like [e] or [o] have relatively low degrees of palatalization or labialization.5 Conversely, highly chromatic vowels like [i] or [u]—or their even more chromatic counterparts [i] and [u]—have relatively low sonority. Changes in vowel height, then, increase one of these properties at the expense of the other: e.g., raising [e] to [i] increases its palatalization but lessens its sonority; lowering [i] to [e] increases its sonority but lessens its palatalization.

Each natural phonological process is subject to a variety of conditions on its application, and these conditions take the form of implicational hierarchies. For example, Lowering is [!-tense] (read 'especially nontense'): it may apply to lax vowels without affecting their tense counterparts, e.g., [i] → [e] while [i] stays, but its application to tense vowels implies application also to the corresponding lax vowels: [i] → [e] ⊃ [i] → [e]. If the process is optional (variable), the hierarchy reflects itself in its relative frequency of application, so that [i] → [e] ⊃ [i] → [e]. The same relative frequency holds on a cross-language basis. See Donegan, forthcoming.

Hierarchic conditions on process application indirectly reveal the phonetic motivations of the processes they constrain, as I will attempt to show below.

Lowering

Lowering decreases the height of vowels by one degree:

[\[V\] ]

[!-chromatic | +lower]

[!-tense]

[!-tense]

[!+chromatic | -syllabic]

!-Chromat ic

The first of the hierarchic conditions on Lowering favors achromatic (non-palatal, non-labial) vowels, like [a] and [A]. This means that if a palatal or labial vowel lowers, the corresponding non-palatal non-labial vowel must lower, too: [e] → [e] or [o] → [o] entails [i] → [i]. But not the converse: thus many children lower English achromatic [a] but do not lower the corresponding chromatic vowels [e] or [o]. For example, Joan Velten said [had] for hug, [mat] for mat, etc., but she didn't lower (indeed she raised) [e] and [o] (Velten 1943:88-89).

Historically, in English dialects where lax [u] (hut) and [o] (hot) unrounded, their reflexes *[u] and *[o] were lowered to [A] and [a], respectively; vowels which remained labial (as in push, off) did not lower, nor did the corresponding palatal vowels of hit, pet, ep *e in Greek and Latin: G. ἑτερός, L. pater, Skt. pitar; G. στάρας, L. status, Skt. sthitas, while e and o remain: G. φύσις, L. férö, Skt. bharani; G. τοῦσία, L. potis, Skt. patis (Buck 1942: 78-84).

The substitution of [a] for [A] is also a common occurrence in loan phonology—Japanese [maffu] maff, front? lunch, etc. (Lovins 1974:281), and I have observed it in foreign-accented English: Greek speakers' [akl] lucky, [mað] mother—while [e] and [o] remain mid vowels.

!-Tense

Just as achromatic vowels are more susceptible to lowering than palatals or labials, so lax vowels are more susceptible than tense
ones. Thus, lax vowels may lower with no implications for their
tense counterparts, but if a tense vowel lowers, the corresponding
lax vowel must lower also.

An example of this condition on Lowering in children's speech
was pointed out to me by Roy Major, whose daughter Sylvia's
pronunciations of words like 'bit' and 'foot' varied from [bɪt] to

Labov, Yaeger, and Steiner (1972:121 ff and Fig. 23) cite
examples of lax—but not tense—vowels lowering in the current
American speech of Detroit, Buffalo, and Chicago, where [ɪ] falls
to a mid vowel and [ɛ] to a low vowel, while [i] and [e] remain
high and mid.7

Historically, lax-vowel lowering occurred in what Anglists call
"open syllable lengthening": in 13th century Middle English, the lax
(formerly short) vowels ɵ and ɔ, and later also i and u, lengthened
by position in open syllables, lowered, ultimately merging with ME
ɨ, ɨ and ɨ, ɨ, respectively: wɪven 'weave' (OE wexan), ʰuːn 'hope'
(OE hoplan); weəks 'weeks' (singular wɪk, OE wɪcu), sɡes 'sun'
(singular sun, OE sunu) — (Juicik 1964:398, 405); the original tense
ɨ, ɨ or ɣuːs 'goose', ɣuːs 'goose', and ɨ, ɨ of mɪs 'nice', mous
'mouse' did not lower.8 Further historical examples of the lowering of
lax but not tense vowels include the well-known Vulgar Latin
lowering (and subsequent tensing) of lax (formerly short) i and u
to merge with old long ɨ as in [ɬɪt] for Latin 'light', [ɬɪt] for Latin 'light',
minus > mɛnʊ, and ɦəə > ɣəə, multurn > melto (Grandgent 1933:22).

Excursus: Tenseness and Laxness

The similar effects of achromaticity and laxness in lowering
imply a correlation between laxness and lack of color. In fact,
tenseness in vowels is probably relative intensity of color: ceteris
paribus, tense vowels are more palatal or more labial than their
lax counterparts (e.g. [ɪ] is more palatal than [i], [o] is more
labial than [u], etc.). This hypothesis as to the nature of the
tense/lax distinction makes achromatic (non-palatal, non-labial)
vowels lax by definition—a definition supported not only by the
parallel behavior of lax and achromatic vowels but also by the non­
ocurrence of tense/lax contrasts in the achromatic series.9

This is why, when achromatic vowels "color" (Miller 1973: 388
ff.), their immediate reflexes are lax. Thus the nucleus of [ow] as in
house, when palatalized as in most American dialects, is lax
[eː] (the tensed [eː] heard in my native Baltimore is by a secondary
change), and the nucleus of [ou] as in line, when palatalized, as
in the Outer Banks of North Carolina (personally observed, cf. also
also Labov et al. 1972:fig. 41), is lax [ɔː] rather than tense [ɔː].
Similarly, the delabialized nuclei of snow [əʊ] < [ɔː] and two
[ʊ] < [u], in various southern and eastern dialects where these
become palatal, are lax [ɛ] and [ɪ], respectively—not tense [ɛː]
and [ɪː].

When a long/short contrast in a language is recoded as a
tense/lax contrast, the distinction between short and long
achromatics like [æː] versus [æː] is invariably lost, as when Classical
Latin ʊ and ʊ merged as Vulgar Latin ʊ (Romeo 1968:61)—unless one
or both of the achromatic pair palatalize or labialize: when Middle
English [æː] > [æː] (lax palatal) and [æː] > [æː] (tense
palatal) in Early Modern English, the palatalization of both
achromatics allowed a quality distinction of lax/tense to replace the
disappearing quantity distinction of short/long in pairs like bat/ 
hat. Similarly, long ʊ became ʊ while short ʊ remained ʊ in West
Scandinavian (Noreen 1913:112) when in other vowels the Common
Scandinavian length distinction was recoded as a tense/lax
distinction; the tense/lax difference being inapplicable to
ʊ/ʊ, an alternative quality difference—labial/non-labial—was
superimposed on this pair.

The hypothesis that tenseness is intensity of color is also
supported on the phonetic level. Acoustic studies show that [ɪ] and
[ɛː], [ʊ] and [o] consistently have more extreme second-formant values
and lower first formant values) than [i] and [eː], [u] and [o]—
i.e. tense vowels have more of the acoustic qualities which characte­
rize palatality or labiality than do their lax counterparts. In so-called "tense vs. lax" ʊ's, however, no such consistent differences
appear.10

+Long

The next implicational constraint on Lowering is that it favors
long vowels—i.e., a long vowel may lower while its short counterpart
remains unchanged, but if a short vowel lowers, the corresponding
long vowel must lower, too. In the Middle English "open syllable
lengthening," it was the long lax vowels—that appearing in open
syllables—that lowered, not their short counterparts: thus wɪkks,
but wɪcs < OE wɪcu 'week!' and wɪks but wʊd < OE wʊd 'wood'.

Einarsson (1945:11) notes a similar tendency in some dialects of
Icelandic for lengthened [ɪ] and [u] to become eː and oː
in some environments.11 In Yokuts, high vowels lower when lengthened, so that [ɪ] and
[ʊ] alternate with eː and oː Kuroda 1967:11).11 Lengthened
high vowels also lower in the Salish language Twana (personal
communication, Gaberell Drachman).12 The Pashto vowel system also
suggests a lowering of high vowels, since the short palatal and
labial vowels are /ɪ/ and /ʊ/, and the long ones are /eː/ and /oː/
(Shafeer 1964:34). Lowering of long palatals occurs in Menomini,
where Proto-Central-Algonquian *eː] has become [ɛː], while short
*ɛː lowered only irregularly (Bloomsfield 1946:86), and in Delaware,

Apparent counterexamples to the long application hierarchy—
like the lowering of Classical Latin short ɪ and ʊ, but not long ɪ
and ʊ, to merge with long ʊ and ʊ as Vulgar Latin ʊ and ʊ—are due
to the laxing of short vowels. Lax vowels are more likely to lower
and in these cases the process appears to be sensitive to tenseness, rather than length: non-tense vowels—of whatever length—lower.

**Dissimilative Lowering.** The cases cited above, Lowering is a context-free process, but certain environments promote Lowering. While Lowering applies to achromatic or lax long vowels, it is especially applicable to such vowels when they are adjacent to chromatic, non-syllabic (and thus short) vocalic segments.

During her second year Sylvia Major lowered the nuclei of diphthongs of English, pronouncing, for example, me as [mi:] or [me:], boot as [bou] or [boy] (Major 1976:33). Lowering of diphthongal nuclei also took place in the English Vowel Shift; the nuclei of diphthongized /i:/ and /u:/ became, eventually, the a's of Modern English [a:] and [a]: thus [məs] [mais] became mice [mais] and mus [məys] became mouse [mʌs]. There are also modern English dialects in which diphthongal nuclei lower; I have observed speakers from McCaysville, Georgia who lowered I and e before l: we [wel], meet [meɪt], and stay [stɑ:]

In the Mal'm dialect of Swedish, the "long" (tense) vowels are diphthongized; the first mora of each diphthong lowers one degree before a like-colored glide (Bruce 1970:9 (her transcriptions)):

\[
\begin{align*}
/i:/ & \rightarrow [ei] \\
/e:/ & \rightarrow [eː] \\
/ɪ:/ & \rightarrow [eː] \\
/ʊ:/ & \rightarrow [ə] \\
/ʊ/ & \rightarrow [ə]
\end{align*}
\]

Here the labial nuclei bleach and palatalize after lowering.

In some diphthongs, the first mora serves as the catalyst for lowering, and it is the second mora which lowers. Icelandic dialects show lowering of the second mora of long lax vowels: /iː/ → [ei], /eː/ → [eː], /ʊː/ → [əː], /ʊ/ → [ə] (Einarsson 1949:11 (his transcriptions)). McCawley (1971:8) cites a similar process in a Southern Lappish dialect.

In these dissimilations, it appears that chromatic vowels lower when they are adjacent to like-colored glides. Ordinarily, when a vowel lowers, thus increasing its sonority, it loses some color—but if it is part of a complex vocalic nucleus, the color of the vocalism can be preserved in just one element, and this leaves the other element free to lower. Lowering of achromatic vowels may be set off by a glide of either palatal or labial color. In both cases, the motivation seems to be the same—the polarization of the sonorant and chromatic elements of a complex vowel.

**Raising.**

Raising increases vowel height by one degree:

\[
\begin{align*}
+\text{tense} & \rightarrow \text{higher} \\
+\text{chromatic} & \rightarrow \text{higher}
\end{align*}
\]

Raising seems to be absolutely (not merely relatively) limited to chromatic vowels—vowels which are palatal and/or labial. Descriptions of children's speech illustrate this: Joan Velten raised /e/ to [e] to [i] and /o/ to [u] through her 2nd month, while she lowered the achromatic [a] to [ə] (Velten 1943:87 ff.).

In vowel shifts that raise palatal or labial vowels, achromatics are not raised. In the English vowel shift, /e/ > [e] (meat), /e:/ > [eː] (meet), /o/ > [oː] (boat), and /o:/ > [oː] (boot), but /a:/ (mate) was not raised to [æː]. In Scots dialects where /o:/ as in boot had become [ɔː] it raised to [yː] along with the palatals and labials, but the non-rounded Scots reflex of Old English /aː/ as in boat (OE bát), unlike the rounded Southern English reflex cited above, remained low (Wright 1928:8). Raising can be limited to affect only one color. In the next stage of the English shift raised the palatals only: /eː/ < [aː] > [eː] (mate) and /eː/ > [eː] (meet), while /oː/ > [oː] (boat) remained. In Sámi, Miguel Angel had only the labial vowels were raised /u/ > [oː], /o/ > [æː], /aː/ was labialized to [ɔː] but not raised (Rogers 1948:13, 24 et passim).

Sometimes the class of vowels which Raising favors, as in the English Vowel Shift, is referred to as front and back, or peripheral, as opposed to central. But while it is true that labial vowels may be "back" than their nonlabial counterparts, this backness is not the causal feature in Raising. First, in languages with front round vowels, these undergo Raising along with their simple counterparts, as in current Swedish, where tense /uː/ like /eː/ and /oː/, optionally raises (Gunnar Fant, personal communication). The corresponding tense high vowels undergo optional diphthongization by laxing and lowering of the first mora. Here not only /yː/ but also the central rounded high vowel /uː/ undergo the same diphthongization as /iː/ and /eː/. Labiality, not backness, is clearly along with palatality—the causal feature in these processes. This shows that the critical feature of dark-timbed vowels is not, as in the feature system of Jakobson, Fant and Halle, or Chomsky and Halle, gravity or backness, but rather labiality.

\[+\text{tense} \]

In each of the above cases, tense vowels are raised if any vowel is raised. Thus, the second condition on raising: tense vowels may be raised without raising of the corresponding lax vowels, but the raising of lax vowels (as in Joan Velten's child speech) implies raising of their tense counterparts.
I would also like to point out here again the parallel effects of color and tenseness. Only vowels which have some palatal or labial color undergo Raising and, of these, it is the tense ones—those with a high degree of color—that are implicationally favored. Thus, Raising and Lowering are an especially clear case of the general rule that processes with opposite effects are subject to opposite conditions on their application. The more strongly chromatic (and more sonorant) a vowel is, the more it is susceptible to Lowering. And just as tenseness, an increased color, favors Raising, so length, an increased sonority, favors Lowering.

---

**Dissimilative Raising**

This brings us to the next application hierarchy on Raising: as long vowels are especially susceptible to Lowering, so short ones are especially susceptible to Raising. Short vowels were raised in Gothic, when *ã, ɔ > ū, ū while *ã, ɔ remain mj: Prim. Gmc. ɔ > ū, Goth. wiga: OE, OHG weg 'way': Prim. Gmc. ɔ (ç IE *ði) stays; Goth. OS, OE her 'here': Prim. Gmc. ɔ > ū, u: Goth. gub, OHG got, OS, u god, 'god': Prim. Gmc. ɔ stays; Goth. brõðar, OE brôðor, OHG brûder 'brother' (Wright 1954: 26-33). Similarly, Proto-Central Algonquian short /o/ merged as /e/ in Cree and Ojîbwa: *pemaaˈtæsiwaˈ he lives > Fox /pemaaˈtæsiwa/; Cree /pimaaˈtæsiw/, Ojîbwa /pimaaˈtini/, while long */i/* remained mid (and distinct from long */e/): *seekesiwaˈ he is afraid > Fox /seekesiwa/, Cree /seekesiwa/, Ojîbwa /seekini/16 (Bloomfield 1946: 86).

This claim—that short, rather than long, vowels are favored in Raising—may seem surprising, since discussions of vowel shifts (the English one, for example) often refer to the raising of "long" vowels. It is sometimes true that long vowels are raised, but this raising is due, not to length, but to tenseness, a feature that is frequently superimposed on length when changes in the timing system of a language threaten the vowel quantity distinction (Stampe and Donegan, forthcoming).

**Dissimilative Raising**

Raising, like Lowering, may apply dissimilatively, as in Finnish, where the first moras of long mid vowels were raised—thus, e.g. vee + vie (Kiparsky 1968:177)—and in French, where Late Latin *a and *o, when lengthened in open syllables, underwent raising of their first moras to become Gallo-Romance ié and uq (Pope 1934:103).

The environments which favor Raising have exactly opposite features from those which undergo Raising. Vowels are especially subject to Raising when they are adjacent to achromatic or lax vocables, particularly when these adjacent elements are syllabic. That is weakly chromatic, highly sonorant environments favor Raising, while the vowels which are themselves most susceptible to Raising are strongly chromatic and weakly sonorant.

Sylvia Major (at age 2;3-2;8) raised (or tensed) chromatic vowels before schwa-like offglides: [ɾwɛd] 'mæd', [ɾɔd] 'dog'. Vowels without such offglides were never raised (Major 1976:34).

Labov, Yaeger and Steiner (1972) report a number of American dialects in which English /æ/ and /o/ are raised. They propose that schwa-like glides are inserted after the raising of these vowels, but they cite no cases of raising without these "inglides". In many American dialects these 'inglides' follow lax vowels: bid [bɪd], bed [bɛd], good [gʊd], but no tensing or raising occur, so I believe that the achromatic glides format, first, and that the raising in these [ɾwɛd ɾɔd] dialects is a dissimilative raising of tense vowels before non-syllabic schwa.

The raising of Pre-Old High German *ã and *ə to OHG <io> and <u> is a similar first-mora raising (Sauch 1967:89-91). The intermediate spellings, <io>, <i> for <io> (<ã) and <uo>, <u> for <uo> (<ə) suggest an intermediate stage at which the second mora was achromatic. Thus this raising, too, would have affected chromatic vowels standing adjacent to achromatics.

**Vowel Height**

In the examples given above, both for Raising and for Lowering, vowels are lowered or raised a single degree. Feature systems—like Jakobson's, Chomsky and Halle's, and Wang's—which express height in binary features do not, as various linguists have argued (e.g. McCawley 1971), adequately express the linear substitutions involved in Raising and Lowering. I add the processes and examples presented here to the evidence for a non-binary (though discrete) scale of vowel height.

The sort of scalar height feature which these processes and hierarchies seem to require also poses a difficulty for articulatory vowel-feature systems which would replace the admittedly inept "tongue-height" feature with separate features governing "jaw opening", "pharyngeal constriction", etc. (Perkell 1971, Wood 1975). Discovering the articulatory and acoustic correlates of each feature will surely be necessary before thoroughgoing explanations of all processes are possible, but having to divide what is phonologically and acoustically a scale into two features on the basis of separate muscular commands suggests that significant vocalic features may not always reduce to individual muscle commands.

**Function**

The functions of Raising and Lowering are displayed perhaps most clearly when the processes apply in diphthongs. In these two-part vocalisms, we often find a sequencing and polarization of the incompatible properties of sonority and color: when English /0/ becomes [æu] in Cockney (Silvertsen 1960:33), its first mora becomes more sonorant and its second more labial. One half of the diphthong becomes the color-bearing element, and the other
becomes the sonority-bearing element. If Raising and/or Lowering apply, it is the color element which is raised, and the sonority element which is lowered. Note that the element which is raised loses its color; the element which is lowered—the sonority half—often loses its color. In the color-sonority polarizations typical of diphthongization, Raising increases color, and Lowering increases sonority.

These functions are also apparent in the pattern of context-free Raising and Lowering. If Raising were only a matter of decreasing aperture or sonority, it would affect non-palatal and non-labial vowels as well as chromatic ones. The absence of Raising of achromatic vowels suggests that the motivation for Raising is the increase of color. 20

Implications

According to Jakobson, a language with mid vowels of a given color must also have high vowels of that color. The process of Raising explains Jakobson's universal, since in natural phonology, a process not only substitutes—it may also constrain. Until the child learning to speak learns to limit or suppress the Raising process, all his chromatic vowels will be high. Only when and if Raising is suppressed can the child add mid chromatic vowels to his phonemic repertoire. It follows that mid chromatic vowels entail high ones.

But there is also a lowering process, and where Lowering applies instead of Raising—as it may, for instance, when long vowels are also lax—we can expect to find mid rather than high chromatic vowels. And despite Jakobson's law to the contrary, this is precisely what we find in many languages—either for palatals and labials, as in Yokuts, Twana, and Pashto long vowels—or just for labials, which seem to be more susceptible to lowering than palatales, as in the several Amerindian languages (Apachean, Wichita, Potawatomi, etc. (Hockett 1955:84–85)) with /o/ instead of /u/ as the highest round vowel.

More generally, the opposite susceptibilities of chromatic and achromatic vowels to Raising and Lowering create asymmetry even in "quadrangular" systems, like that of Turkish:

```
  i  y  ü  ı
  e  ø  o  a
```

Although the nonhigh vowels alternate in color harmony, distinct from the high vowels, the chromatic partners of low [ı] are mid, not low. In three-vowel systems like those of the Philippines, Australia, Eskimo, Arabic, and so forth, this asymmetry finds its most extreme but classic shape, the vowel triangle:

```
  i  a  u
```

These were the vowels of Sanskrit, and the intuition of the Sanskrit phoneticians (Allen 1953: 57ff, esp. 60–61) that these vowels represented three dimensions—palatality, labiality, and sonority—is confirmed, as I hope this paper has shown, by the nature of Raising and lowering.

Footnotes

1. I would like to thank David Stampe for his many helpful comments and suggestions.

2. The central rather than peripheral locus of processes is evidenced by their application even in unphonated speech (as Jakobson (1973: 419) put it, "The phonetic variables ...are present in inner speech"), by their association in aphasia with certain central lesions (Jakobson 1968 passim), and their quite different effects from dysarthric speech disturbances due to peripheral injuries (Lehiste 1957, Lenneberg 1967:195ff).

3. On the other hand, the synchronous physical phonetic motivation of processes strictly distinguishes them from phonological constraints and alternations lacking such motivation. The vowel alternations of sérène/serénity, drèam/dreamt, and so forth, for example, are not, in modern English, governed by processes—as can be seen from their morpheme-specificity (contrast obese/obesity, or dréam, dreamt), analogical leveling like serénity, etc. "Rules" of this sort are utterly distinct in nature and locus from processes, as is clearly shown by their opposite order relating to "slips of the tongue" which occur in speech processing (Stampe 1973). And since no convincing evidence has been advanced to support the assumption of some generative grammarians (Chomsky and Halle 1968: chapter 9; Hymann 1975: chapter 5) that such rules conform (except by historical accident) to principles of phonetic naturalness, they cannot figure directly in studies of natural processes or, for that matter, of the natural phonological system which underlies the characteristic "accent" of speakers of a language.

4. Other sources include slips of the tongue (Bond 1959, Fromkin 1971, Schourup 1973), mishearings (Garnes and Bond 1975), rhyme (Kwick, this volume), and so on. But these relate to underlying levels of representation, according to evidence cited by Stampe (1973 and forthcoming). Processes, on the other hand, can in principle apply to the (otherwise) terminal level of phonetic representation in a language, and therefore furnish our most direct evidence regarding the mental categorization of sounds as spoken and heard.

5. Ohala (1974) ridicules the categories (including sonority and color) resulting from phonological analysis of this sort, but he provides no substantive discussion of them and shows no awareness of the empirical grounds they are based on. He provides some anecdotal acoustic and articulatory explanations of miscellaneous sound changes, but avoids the question which is prior to any systematic attempt at phonetic explanation, namely the question of determining the nature of phonetic representation. As Baudouin de Courtenay pointed out, sounds do not change, but the mental images of sounds. "The central, though much neglected, problem of phonetics," according to Fant (1969),
is "to work out the rules for predicting the speech event given the output of the phonological component of the grammar." But this output—phonetic representation—is not simply given; it has to be deduced from phonological evidence. Without such evidence, the study of phonetics would be merely a minor branch of physics.

4. These are the traditional associations of sonority (cf. Sievers 1901: 204ff). I am of course aware that no simple articulatory correlate (like tongue height) has been determined, but I will continue "vowel height" etc. because such terms, being in general use, are more easily understood. Acoustically, sonority varies directly with the height of the first formant. Vowels with higher \( F_1 \) have, ceteris paribus, higher sonority than vowels with lower \( F_1 \). But I think that intrinsic intensity may be the principal acoustic correlate of sonority—or the best area in which to seek such a correlate—at least as far as attempts at explaining the functions of sonority are concerned.

5. \( [a] \), the most sonorant of all vowels, is neither palatal nor labial.

6. The pronunciations \( [\beta t\gamma] \) and \( [\phi t\gamma] \), with \( [\theta] \), were particularly emphatic and long. A non-syllabic schwa or "inglide" often develops when a lax vowel is lengthened.

7. Labov et al. do not mention what happens to \( /\alpha/ \), but in their acoustical vowel diagram, according to \( F_1 \), the speaker's \( /\alpha/ \) is as open as her lowered \( /e/ \) (i.e. equivalent to \( /\alpha/ \)). \( /\alpha/ \) has been palatalized in this dialect, and \( /\alpha/ \) has been diphthongized and raised.

8. For a discussion of the proposal that this lowering did not occur (Wolfe 1972:150), see Donegan, forthcoming.

9. The distinction \( /\alpha/ \) vs \( /\alpha:/ \) is one of length; \( /\alpha/ \) vs \( /\alpha:\) is one of height; and \( /\alpha/ \) vs \( /\alpha:\) would be one of backness.

10. In Miller 1974, I reviewed the phonetic literature on tense­ness and laxness. Please see that bibliography for references. While the acoustic correlates of tenseness are fairly clear, the articula­tory correlates are less directly definable. In particular, the theory that identifies tenseness with "advanced tongue root" seems untenable.

11. Greg Lee (personal communication) says that these vowels are lax.

12. I find that Drachman (1969) writes \( \epsilon, \sigma, \varepsilon, \partial \), but he described the system to me as containing \( \bar{\varepsilon}, \bar{\epsilon}, \varepsilon, \bar{\sigma} \).

13. Both Bloomfield and Voegelin used the customary Americanist symbol \( \eta \) for \( [\alpha] \).

14. After this raising, Joan laxed \( /\bar{\varepsilon}/ \) and \( /\bar{\epsilon}/ \), and depalatalized \( /\bar{\varepsilon}/ \), so that for many months her only non-low vowel was \( /\bar{\epsilon}/ \) (but \( /\beta / \) stood for \( \text{break, bed, bead, pig, boat, board, } \)).

15. The question of verifiability arises here. Since tenseness and length favor opposite changes and since long vowels so often be­come tense, historical data is problematic. I realize that I might be accused of calling the same feature "tenseness" when it conditions Raising and "length" when it conditions Lowering. My response to this objection would be as follows: in directly observable speech, tenseness and length are phonetically different—one is a qualitative, the other a quantitative distinction—and tenseness favors Raising and length favors Lowering. Applying this observation to historical data seems reasonable enough, especially since reinterpretations of long/short as 'tense/lax are so often supported by modern reflexes, by patterns of subsequent diphthongization—tense vowels usually seem to become tensing, upgliding, or outgliding diphthongs ([l]—[\varepsilon], [\o], or [\O]), while lax vowels usually seem to become downgliding or ingliding diphthongs ([s]—[\varepsilon] or [\O]), and by timing changes which characteristically accompany—in fact, cause—such shifts from length to tenseness.

16. It is this long /\varepsilon/ which lowers in Menomini: \( /\varepsilon\varepsilon\varepsilon\varepsilon/ \).

17. The "second half" of a lax vowel (particularly a long lax vowel) frequently loses its weak degree of color, becoming a schwa­like offglide, sometimes called an "inglide" (as in Labov et al. 1972). Cf. Lehiste and Peterson 1961 on vowels in American English: "'Lax' vowels, then, are those vowels whose production involves a short target position and a slow relaxation of the hold; for 'tense' vowels the target position is maintained for a longer time, and the (articulatory) movement away from the target position is relatively rapid" (p.274).

18. The implicational hierarchies of application for Bleaching and Coloring (Miller 1973) and Tensing and Laxing (Donegan, forthcoming) also support a scalar height feature.

19. For example, the parallel phonological effects of the features palatal and labial cannot be explained in a framework which would assign to the former an acoustic correlate and to the latter an articulatory correlate (cf. Ladefoged et al. 1972:74).

20. Syntagmatic vowel height changes (like vowel harmony and vowel reduction) may raise achronic vowels, however. The change of short /a/ to [\O] in languages like Sanskrit and Rabararian is a syntagmatic change. Note that one would hardly expect to find that a raising of [\O] to [\O] occurred—as paradigmatic changes often do—in accented syllables only.

References


Diphthongization affects not only high vowels, but any vowel that is tense by being long, whether because it has been tensed through lengthening (the so-called word-final "lengthening consonants", coincident with the set of voiced fricatives), or because it must be considered underlyingly long as an historical residue, or eventually because it would have been borrowed as a long, diphthongized vowel in a number of English loanwords.

This results in a whole set of long, tense vowels alternating with lax, diphthongized counterparts whose syllable nuclei are correspondingly lowered by one notch on the height scale, and are compensatorily onglided in their ending portion:

(1) Long vowel–diphthong alternations (IPA notation throughout)

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(2) Diphthongization

[+ long] → [-tense] / [+ segmental] [+ stress]

QUEBEC FRENCH HIGH VOWEL HARMONY : THE PROGRESSION OF A PHONOLOGICAL RULE
Denis Dumas
Université du Québec à Montréal

In Quebec French, high vowels behave as a natural class with regard to a number of reduction processes that are essentially variable, and active pretty close to the surface in the derivation. The most radical of these go as far as Devoicing or Syncope, but this presentation will be restricted to those reducing vocalic tenseness, namely Diphthongization, Laxing and Harmony. From the start, it is to be noted that in this dialect, high vowels are always recoverable, however extreme the reductions they undergo, either through the alternations they create or from the traces left to adjacent segments as feature transfers : for instance, affrication of the preceding dental stop, palatalization with or without labialization, or velarization.

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