high toned /éé/.

Finally, there is a distinction between long and short vowels in Navajo -- by this is meant that there is a distinction in the Navajo vowel system which depends on the relative duration of a vowel, i.e., the relative length of time it takes to pronounce it. Thus, the vowel of /bááh/ 'bread', is about twice as long in duration as the vowel of /bá/ 'for him'; the /ee/ of /bitsee'/ 'its tail' is about twice as long as the /e/ of /bitse'/ 'his stone'; the /ii/ of /'atiin/ 'road' is about twice as long as the /i/ of /'tin/ 'ice'; and the /aa/ of /bitaa'/ 'his father' is about twice as long as the /a/ of /bita'/ 'between them'. Long vowels are indicated by phoneticians by means of diacritic marks e.g., a macaron over the vowel or by a raised dot or colon following it: [ä], [a'], or [a:]. In the Navajo writing system currently in use, long vowels are indicated by doubling: /aa/. This is extremely convenient, for a variety of reasons. Furthermore, it may be correct from the linguistic point of view to regard the Navajo long vowels as sequences of short vowels -- that is to say, there is some linguistic evidence which supports this analysis. Consider, for example, such words as /hagoónee'/ 'goodbye', with a rising tone /óó/, and /dóóla/ with a falling tone /óó/ -- if we analyze long vowels as sequences of short vowels, then it is possible to define falling tone as a high-toned vowel followed by a low-toned vowel (i.e., as /VV/), and a rising tone as a low-toned
vowel followed by a high-toned vowel (/VV/), thereby making it unnecessary to add two additional tones (falling and rising) to the inventory of phonological features for Navajo. This analysis also correctly predicts the fact that the moving tones (i.e., falling and rising) occur only on long vowels. Since this analysis is supported by linguistic facts of Navajo, we will assume here that there is no feature [long] in the Navajo vowel system -- rather, long vowels are sequences of short vowels.

By combining the feature of nasalization and tone to the basic vowel types, four distinct sets of vowels are generated:

(1) **low toned, oral:** /i, e, o, a/.
(2) **high toned, oral:** /I, é, õ, á/.
(3) **low toned, nasal:** /ɨ̃, è̃, õ̃, á̃/.
(4) **high toned, nasal:** /ɨ̃, è̃, õ̃, á̃/.

In addition to the vowel features mentioned above, the features [continuant] and [voiced] are relevant to the description of vowels -- all Navajo vowels are continuant and voiced.

4. Exercises.

(1) Attempt to describe the English vowels (underlined in the following words) in terms of the dimension of tongue height. (For each vowel, an accepted
phonetic notation is given in square brackets, preceding the illustrative word.)

[ɪ]  beet.
[ɪ]  bit.
[e]  bait.
[e]  bet.
[æ]  bat.

(2) Compare the following vowels with those listed above.

[u]  boot.
[ʊ]  put.
[o]  boat.
[ɔ]  bought.
[a]  bottom.

What are the differences between [ɪ] and [u], between [ɪ] and [ʊ], between [e] and [o], and between [æ] and [ɔ]? What is the difference between [æ] and [a], and between [ɔ] and [a]?

(3) Vowels, like consonants, are given labels corresponding to their positions and manners of articulation. Thus, for example, the vowel [ɪ] is a high front
unrounded vowel. There follow a number of phonetic notations for vowels together with descriptions of their articulations; for each of these, provide an appropriate label.

[ã] "the tongue is in the same position as for [i]; the lips are rounded."

[ɪ] "The tongue is in the same position as for [u]; the lips are unrounded."

[a] "The tongue is at the same height as for [e], but its horizontal positioning is the same as for [a]. The lips are unrounded."

(4) Consonants were described in terms of two major dimensions: position of articulation and manner of articulation. To put this another way, each phonological feature pertains to one or the other of these two dimensions -- thus, for example, the feature bilabial, pertains to the dimension of position while the feature stop pertains to the manner dimension. Of the following vowel features, which pertain to the position dimension and which to the manner dimension?
high
nasal
front
high-tone
back
long
low
rounded
5. Answers.

(1) [i] high
    [ɪ] high mid
    [e] mid
    [ɛ] low mid
    [æ] low

(2) [i] is high front unrounded, while
    [u] is high back rounded.

    [ɪ] is high mid front unrounded, while
    [ʊ] is high mid back rounded.

    [e] is mid front unrounded, while
    [o] is mid back rounded.

    [æ] is low front unrounded, while
    [ɔ] is low back rounded.

    [æ] is low front, while
    [a] is low back; both are unrounded.

    [ɔ] is rounded, while
    [a] is unrounded; both are low back.
(3) [ü] high front rounded. (This vowel is the vowel written u in French and ü in German. It is often referred to as "u-umlaut" or "umlauted u".)

[i] high back unrounded. (This vowel is extremely common in Hopi, where it is written u in the Kennard and BIA orthography.)

[ə] mid back unrounded. (This vowel is referred to by the term "schwa"; it is often said to be a central vowel rather than a back vowel. It is common in English, as in the words but, what, ton; and in Navajo it is a common variant of the short low toned /i/ -- as in /sí'á/, /hikan/.)

(4) high (position)
  nasal (manner)
  front (position)
  high-tone (manner)
  back (position)
  long (manner)
  low (position)
  rounded (manner)
VII. Phonetic Notation.

1. Several times in preceding sections special phonetic symbols were given for certain sounds -- for example, the symbol [ŋ] was introduced to represent the dorso-velar nasal written ng in the English writing system. For the most part, special phonetic symbols were provided in earlier sections only for sounds which do not occur in Navajo; sounds which do occur in Navajo were represented by means of the orthography currently in use among speakers of Navajo and found, for example, in the work of Young and Morgan.

The purpose of the present section is to introduce some additional symbols which are used in phonetic notation to represent certain of the sounds of Navajo. Our purpose in doing this is: (1) to acquaint the student with phonetic symbols which are widely used among linguists who do research on American Indian languages, and (2) to enable the student to read the large body of traditional Navajo literature published by Father Berard Haile, who used a technical phonetic notation rather than the more practical orthography currently in use. The principal difference between the two notations consists in the fact that technical phonetic orthography avoids the use of so-called "digraphs" -- i.e., sequences of letters representing sounds which function as single phonological units. For
example, the voiced dorso-velar fricative is represented by means of the digraph $gh$ in the practical orthography, while in the phonetic notation it is represented by means of the symbol $[\gamma]$ (i.e., the Greek letter called "gamma") -- thus, in the phonetic notation, the word /bighan/ is written [bi$\gamma$an].

The principle of "one symbol for one sound" is used consistently in the phonetic notation. Consider, for example, the way in which the lamino-alveolar fricatives are written. In the practical orthography they are written by means of the digraphs $sh$ and $zh$. One could look upon the $h$ here as a mark representing lamino-alveolar position of articulation; that is to say, in the practical orthography, the $h$ in $sh$ and $zh$ is not interpreted as a segment but rather as a special "diacritic" (i.e., distinguishing mark) representing a particular phonological feature (lamino-alveolar articulation, in this instance). In phonetic notation, such diacritics are not written as segments (i.e., separate letters) but, rather as special marks above or beneath a letter. The feature of lamino-alveolar articulation is represented by means of the diacritic $v$ (sometimes called a "wedge", or "haček"), written above the letter. Thus, the fricatives $sh$ and $zh$ are written $[\check{s}]$ and $[\check{z}]$, respectively. In the phonetic notation, then, the words /shí/ and /názhah/ are written $[\check{s}i]$ and $[ná\check{z}ah]$.

In the practical orthography, a glottalized stop is represented by an apostrophe (which also represents the glottal stop) following
a letter or sequence of letters which stands for the stop articulation. Thus, the apico-alveolar glottalized stop is represented /t'/, i.e., as a sequence of symbols t + '. And similarly for the other glottalized stops. In the phonetic notation, the apostrophe is not written to the right of the stop symbol, but rather on top of it, like a true diacritic mark. Thus, the apico-alveolar glottalized stop is represented in phonetic notation as [t]; the word /t'ah/ is therefore written [tah]. This practice extends to all the stops, and also to the glottalized nasals, written /'m, 'n/ in the practical orthography -- these are [m, n] in the phonetic notation.

The delayed release stops and the laterally released stops are written as sequences of stop plus fricative or lateral in the practical orthography -- e.g., /dz/, /dl/, /ts/, /tl/, and so on. In order to conform to the principle of "one symbol for one sound", a number of special symbols and usages have been adopted to write these phonetically complex segments. The unaspirated affricate /dz/ is represented by the symbol [ʒ]; the aspirated affricate /ts/ is written [c]; and the glottalized counterpart is written [c']. These are, then, the symbols for the apico-alveolar affricates:

<table>
<thead>
<tr>
<th>apico-alveolar delayed release</th>
</tr>
</thead>
<tbody>
<tr>
<td>unaspirated</td>
</tr>
<tr>
<td>/dz/</td>
</tr>
<tr>
<td>[ʒ]</td>
</tr>
<tr>
<td>aspirated</td>
</tr>
<tr>
<td>/ts/</td>
</tr>
<tr>
<td>[c]</td>
</tr>
<tr>
<td>glottalized</td>
</tr>
<tr>
<td>/t'/</td>
</tr>
<tr>
<td>[c']</td>
</tr>
</tbody>
</table>
These symbols are also used as the basic foundation for the symbols representing the lamino-alveolar stops (which are also affricates strictly speaking, as you will recall). The lamino-alveolar articulation is identified by means of the wedge \( \vee \), as in the case of the fricatives -- thus, /j/ is written \([\ddot{\varepsilon}]\), /ch/ is written \([\ddot{\varepsilon}]\), and /ch'/ is written \([\ddot{\varepsilon}]\):

<table>
<thead>
<tr>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>delayed release</td>
<td>(delayed release)</td>
</tr>
<tr>
<td>unaspirated</td>
<td>(\ddot{\varepsilon})</td>
</tr>
<tr>
<td>stop</td>
<td>(\ddot{\varepsilon})</td>
</tr>
<tr>
<td>aspirated</td>
<td>(\varepsilon)</td>
</tr>
<tr>
<td>glottalized</td>
<td>(\varepsilon)</td>
</tr>
<tr>
<td></td>
<td>(or (\ddot{\varepsilon}))</td>
</tr>
</tbody>
</table>

To exemplify the use of these symbols, we present some words written in the current orthography together with their phonetic representations:

<table>
<thead>
<tr>
<th>current orthography</th>
<th>phonetic notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g., Young and Morgan)</td>
<td>(e.g., Haile)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>dzil</th>
<th>(\ddot{\varepsilon}) 'mountain'</th>
</tr>
</thead>
<tbody>
<tr>
<td>tsin</td>
<td>cin 'stick'</td>
</tr>
<tr>
<td>ts'in</td>
<td>cin 'bone'</td>
</tr>
<tr>
<td>(\ddot{\varepsilon})</td>
<td>(\ddot{\varepsilon}) 'day'</td>
</tr>
<tr>
<td>chin</td>
<td>(\ddot{\varepsilon}) 'grime'</td>
</tr>
<tr>
<td>ch'(\ddot{o})</td>
<td>(\ddot{\ddot{o}}), (\ddot{o}) 'spruce'</td>
</tr>
</tbody>
</table>
The basic element used in the phonetic representation of the laterally released stops is [λ] (the Greek letter "lambda"). Without diacritics, this symbol represents the unaspirated laterally released stop /dl/; the aspirated counterpart /tl/ is represented by the same symbol with a bar through the upper part [ƛ], and the glottalized counterpart /tl'/ is represented by this last symbol with a superimposed apostrophe [ƛ']:

\[
\begin{align*}
\text{apico-alveolar} \\
\text{lateral} \\
\begin{cases}
\text{unaspirated} & \lambda \\
\text{aspirated} & \lambda \\
\text{glottalized} & \lambda'
\end{cases}
\end{align*}
\]

These symbols are exemplified in the following words:

<table>
<thead>
<tr>
<th>current orthography</th>
<th>phonetic notation</th>
<th>phonetic notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>dloh</td>
<td>λoh</td>
<td>'laughter'</td>
</tr>
<tr>
<td>tlah</td>
<td>ƛah</td>
<td>'grease'</td>
</tr>
<tr>
<td>tl'oh</td>
<td>ƛoh</td>
<td>'grass'</td>
</tr>
</tbody>
</table>

The rounded dorso-velars of Navajo are also written as digraphs in the current orthography: /kw/ and /hw/. In the phonetic notation, these are written with a superscript w:
In the phonetic notation, the dorso-velar fricative is consistently represented \([x]\); the symbol \([h]\) is reserved exclusively for the glottal spirant.

We now present a chart of Navajo consonants in the phonetic notation introduced in this section.
This is the basic set of consonant symbols used by Father Berard Haile and by a number of other students of the Navajo language. We may add to this the glides and the laryngeals. The glides are represented by the symbols [w] and [y], as in the practical orthography. The glottal stop is normally represented [ʔ] in phonetic notation, but Haile's orthography departs from this practice and uses an apostrophe, as does the practical orthography used by Young and Morgan. All orthographies agree in using the symbol [h] for the glottal spirant. As a final point about the phonetic symbols for consonants, we should mention that there exists a glottalized y-glide in some Navajo verb forms. This is represented /*y/ in the practical orthography -- e.g., /t'óó ahonii'yóí/ 'we are many'. In the phonetic notation, this sound is written with a superimposed apostrophe: [y].

In some of Father Berard Haile's work (e.g., A Stem Vocabulary of the Navaho Language, St. Michaels Press 1950), greater phonetic detail is included than is really needed. For example, as we pointed out earlier, for many speakers the aspiration of /t/ is in fact "velarization" -- i.e., the release is a velar fricative [x]. Haile often writes this velarization as a superscript x, as in his spelling of /tó/ as [t^xó].

It should be pointed out in this connection that velarization is distinctive in the following pair of words:
/bitse/'  'his stone'
/bitsxe'/  'he is strong'

These would be rendered

[bice']
[bicxe']

in the phonetic notation used by Haile.

2. As noted in part VI, the basic vowel-types of Navajo are /a, e, i, o/. These symbols are used both in the current orthography (as found in Young and Morgan) and in the phonetic notation (as found in Haile). And in both writing systems, high tone is represented by /'/ and nasalization by /ː/. There is, however, a difference in the way vowel length is represented. In the practical orthography, long vowels are written as sequences of identical vowels: /aa, ee, ii, oo/. But in the phonetic notation, they are written with a raised dot following the basic vowel symbol: /a', e', i', o'/.

Since long vowels are represented as single segments rather than as sequences of vowels, falling and rising tone must be represented by special diacritic marks -- falling tone is represented by the circumflex accent ^, and rising tone is represented by the wedge ̕.
Thus, for example, the falling tone in the word /dóola/ 'bull' is represented [ô'], hence [dô'la], and the rising tone in the word /hagoónee/ 'goodby' is represented [ô'], hence [xagõ'ne'].

One further remark should be made about the phonetic notation as represented in Haile's work. The sequences /ní/ and /ni/, when occurring before consonants, are often pronounced without the vowel; instead, the nasal becomes syllabic and carries the tone originally carried by the vowel. When this happens, the tone mark is transferred to the nasal -- thus /ní/ is written [ń]; in the case of low-toned /ni/, a special tone mark [\'] is used for the syllabic nasal [ń]. Thus, /níl\'i/ 'you are' is often rendered [ńlî] by Haile, and /nil\'i/ 'he is' is rendered [ńlî].

Finally, Haile sometimes uses a superscript a to represent the schwa actualization of /i/, as in /bimá/, which Haile sometimes writes [bámá].

3. Exercise.

The following story is written in Haile's phonetic notation; it is taken from his Learning Navaho, Vol. 4, pp. 159-161. Read the story and retranscribe it using the current orthography.
šaš ḫī, yice', yišxašgi xani'

1. 'alkidā' ḫī, xaţh-tā ḥini. ṣáko dī ṭā'-dō' 'aţyānī nā-ki yīskā ḥini. 'ákogoš' tahātē', xa'āfī-šľ-lei' blikinšyā ḥini. 'ákoš' dahsānī 'āfī ḥini-zī'. 'ákoš' diye'sxē-li' deş-ţal ūni-zī' ḥini.

2. 'ákogoš' dī šaš yāţšī. 'āfī-goš tā-do bēxoro'si-da. 'ákoş' tā xoletago' čo yah nixe'ha ūni. tā-ako nahlīgo ḫī, dahšišī', bīke' nixišiha ūni. ēi zo'ahago ūlē' kadē' be' zhīne'nhūte' ādīn'i'd ūni.

3. 'ādō' 'ādē', âdah ūndiščī, nixišišnu'od ūni. dako nahi di li'ē, xaţh-goš' ūnēza ūni. dī diš šaš yiščago' ūdō' li'ē, bīči, daśdī-1-y' od, ūnelle' kōl tō bāxāgido yeves'tihlā ūni.

4. tā' čēh ke'zi'ado, xo'nāsdo' kodē' b'mā yīn'yol ūni. xo'nsādo' tō' kōlē' kiznīgū ūni. 'ādō' xaţh-goš' li'ē, yīči, dahdi1-y' ogo' tāko dī li'ē, xaţh-goš' aži'ta'al ūni, nāhā- zhīn'ba'ago ūni, blikidasnezdā dō' ūdō' xol ya'ltāl ūni.

5. 'ādō' khakē' daxit'ē' ūni. tāko dī tō bāxāgido čē-čīl be' axišiškō naxalin ūni, dī' tāk'ya li'ē, xol daxit'ē' ūni. tāko dī čēčilih dī li'ē' biγ'ān tā biγahago' at'īn ūni.

6. 'akoš' dī tō' li'ē, bošiliš gizt'ēgo li'ē, xol yilγ'yol ūni. 'akoš' dī xa'ēq' alco cin xašišdayi-zō' ūni. 'akoš' xa- go'ba'ago ūlē' tā xači'ēli' li'ē, xol ēlγ'yod ūni. tāko ūlē' xa- duhgi naxoćišmi ūni. tā'ako̱hdi tā' akōne' bā li'ē, xol ūndi1-y' od ūni.

7. 'ēiši' naxoćišmi'ē' gone' li'ē, xol e1γ'yod. tā-ako xinah godeg li'ē, nāznes'as ūni. kadē' li'ē, xol xa'ye'do' kodē' xe1γ'yod ūni. 'akoš' li'ē, yice' xači', yišxašla ūni. tāko li'ē, xol yisdēš ūni. 'akoš' tāšq' xo'kēd li'ē, xol xa'sγ'yod. 'ādō' šq' xaţh-goš' li'ē, xol dinē'st'q'.

8. do' xahda 'ūnda li'ē, xol bit'ah nāx'ir'ha dō' 'ūnda li'ē, xol dahna'di1-y' od ūni. 'ēiši' xoγ'andī ūnlē' ūni. 'ādō' 'ādē', li'ē, lai blikidahna'zishil ūni. 'ēiši' 'ādē', nāṭq' li'ē, xol ūnānā1-y' od ūni. ūlē' šaš baždi'ya'hāg'ō. ūnelle' tā'ako' sidālā ūni, biyāši'ē, ēi bixi'me'lčăla ūni.

9. 'akoš' biyāši' (ē'yā xači') yišlēd ūni. tāko dī biyāši' xači' nādi1-y' o. tākoš' dī beveddōndi ādīn ūni. tāko dī-
cin b'ga'n bāh dazdīnē'sbahāgī' tēi be'xał xāl xīnī. tā'xānī dōk't-tdiš' biyāžī bīq' nīšdi'īl xāl xīnī, tāłq' do' tā'dē' ū-nā'dī'l-ye'da xīnī. tākōq' tō bīkīžde'yā xīnī. tēi tā tāxodī xīnī.
shash ḫɪğı ṭitsee' yishxashgi hani'.

1. Ak'iddá' ḫɪği hazhnita' jini. Ako dǐ t'áadoo ajýañí naaki yiski jini. Akogoshí' t'ah nít'ée', ha'at'išshí' léi' bik'ízhniya jini. Akoshipá dašsání át'ı' dziniizí'ł. Akoshipá diyeeshei'le' deeshgał dziniizí' jini.

2. Akogoshí' dí shash yáázhshí' át'išgoshí t'áadoo béňodoosiída. Akoshipá t'áá nohtságóó ch'ó yaah nihee'na' jini. T'áá áko nañjígo ḫí' dah dziztł'ó'o'í' biké' níhiji'na' jini. Éé joonahgo nílles k'adé' bee ji'ne'éh nít'ée' ádiíniid jini.

3. Áądóó ádë' jini. Anah niñisshí' níhizhni'ndóó jini. Ako nahdi ḫí'í' ée háághóóshí' nitseedzá jini. Díšshí' shash yishchág'go. Áądóó ḫí'í' ée bích'í' dashdiilwod, nít'ée' tl'óo'í' t'óó bááhádziido yë'estih lá jini.

4. T'áá ch'ee'h k'eedzi'adgo, hónáásdoó kodée' bimá yilwoł jini. Hónáásdoó t'óó tl'óóšée k'ízhni'gízh jini. Áądóó háághóóshí' ḫí'í' yích'í' dah nídiilwo'go, áko dǐ ḫí'í' ée háághóóshí' adziitaž jini, náhájína'bá'ígo ḫí'í' bik'idasneezdá dóó áądóó hoł yaltázál jini.

5. Áądóóshí' hakéé' dahíite' jini. Ako dǐ t'óó bááhádziido chéch'il bee ahizhnitl'ó nahalin jini, dí akóyaa ḫí'í' hoł dahíite' jini. Ako dí chéch'ilghi' dí ḫí'í' bígháán t'áá bíghahígo atilín jini.

6. Akoshipá dí t'óó ḫí'í' boshk'íish dziztł'ígo ḫí'í' hoł yilwoł jini. Akoshipá dí ha'ée' gé atsó tsiń hakinidayizí'gız jini. Akoshipá hajooba'ígo nílles t'áá hats'ííji' ḫí'í' hoł ch'élwod jini.
Ako niîlé hadáahgi nahodits'q' ni' jiní. T'áá áko ndi t'áá akóne' bá ḫi' hoł nídiilwod jiní.

7. Éishş' nahodits'q' ée góne' ḫi' hoł eelwod. T'áá áko hiina godeg ḫi' názneestxsas jiní. K'adée ḫi' hoł haalgheedgo kodée hwélwod jiní. Akoshş' ḫi' yitsee' hats'áá' yishxash lá jiní. Ako ḫi' hoł yisdqoḥ jiní. Akoshş' t'áá shòq hóok'áád ḫi' hoł haaswod. Háدوșš' hajooba'ígo ḫi' hoł dînéestáá'.


9. Akoshş' biyázhî t'éiyá hach'í' yíi'q'ad jiní. Ako dií biyázhî hach'í' náádiilwo'. Akoshş' dií bee'eldooh ndi áśin jiní. Ako dií tsin bigaan baah dazdíneesbahígíí t'éí beejóóhlá jiní. T'áá áko ndí dikuidishş' biyázhî bits'áá' nísdííhâal jiní, áît'ąą doo áądée' nínááq diilgheedda jiní ákoshş t'oó bik'izhdeeyá jiní. Éį t'áá ákódí jiní.
VIII. Phonetic Alternations and Phonological Rules: Devoicing.

1. The previous chapters have been concerned exclusively with an articulatory phonetic description of the sounds of Navajo. In the process of this description we have discovered that each of the sounds of Navajo, or of any other language, can be described in terms of a list of phonological features. Thus, for example, the Navajo sound which we represent alphabetically as /s/ can also be represented as a "bundle of phonological features" of very roughly the following form:

consonant
apico-alveolar
median
fricative
voiceless

And the sound represented alphabetically as /i/ can also be represented in features as roughly:

consonant
apico-alveolar
lateral
fricative
voiceless

And similarly for each of the sounds of Navajo. In fact, we hope
to show in the discussions to follow that from a strictly linguistic point of view a feature representation of sounds is the correct one and that alphabetic symbols should be regarded as being nothing more than convenient abbreviations for feature representations. We will attempt to show this by considering certain "sound laws", or phonological rules, as we will call them, which function in the Navajo sound system.

To begin, let us consider the behavior of a morpheme like /i'i'i'/ 'horse'. Pronounced in the form just given, it begins in /i/. However, if we put a prefix on it, we find that it begins in /l/ instead of /i/:

<table>
<thead>
<tr>
<th>without prefix</th>
<th>with prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>i'i'i'</td>
<td>bili'i'</td>
</tr>
</tbody>
</table>

One of the purposes of a grammar is to describe all of the things which happen in a language -- hence, one of the purposes of the phonological part of a grammar is to describe the things which happen to the sounds of the language which the grammar describes. This is accomplished by discovering and stating the phonological rules which operate in the language. The behavior of the initial consonant in the Navajo morpheme /i'i'i'/ under different conditions exemplifies one of the phonological rules which must be included

---

5. For a discussion of the term morpheme read Hale, *Navajo Linguistics I* pp. 15-19 et passim.
in the grammar of Navajo -- our task now is to determine the best way to formulate this rule. We will proceed by stating it in the way suggested by the data we have seen so far, and then we will consider more data in an attempt to improve our statement of the rule. We might begin by proposing the following very tentative formulation

The Navajo morpheme meaning 'horse' begins in [l] when preceded by a prefix and it begins in [i] when not preceded by a prefix.

This statement works fine for the morpheme meaning 'horse', since it insures that this morpheme will appear as [lǐ́́] when prefixed (e.g. [shilii], nilii', bii], and so on) and as [ií́́] when not prefixed. However, the statement is not adequate for the grammar of Navajo as a whole, since it fails to account for the fact that many other Navajo morphemes exhibit the same alternation as does the morpheme meaning 'horse'. Some others are the following:

<table>
<thead>
<tr>
<th>without prefix</th>
<th>with prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>lī́d</td>
<td>bilī́d</td>
</tr>
<tr>
<td>lēezh</td>
<td>bileezh</td>
</tr>
<tr>
<td>lōh</td>
<td>bilōh</td>
</tr>
<tr>
<td>lōód</td>
<td>bilōód</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Thus, we have a whole list of morphemes which alternate in the same way. One of the things we wish our grammar to do is to express the true generalizations which exist in the language. And there is a true generalization to be made about the morphemes listed above -- i.e., they all exhibit the same alternation between initial [ɨ] and [l]. We must, therefore, attempt to state this alternation in its most general form. One way to do this would be to pick one alternant as basic and then derive the other by means of a phonological rule. Suppose we say that the forms beginning in /l/ are basic. We could then have a single phonological rule which would account for all of the forms we have observed. The rule might be stated in this form:

\[ 1 \rightarrow ɨ /##_\]  

This is to be read as follows: "turn initial [l] into [ɨ] when it is preceded by word-boundary" (## stands for word-boundary, i.e., it represents the same thing as does the space which appears between words in writing; and the dash represents the position of the sound which undergoes the change; the diagonal / means "under the following conditions" or "in the following environment".) The rule would take a form like /liɨɨ/ and convert it to [ɨɨɨ] if word-boundary, rather than a prefix, preceded it:

\[
\begin{array}{c}
\text{by the } l \rightarrow ɨ \text{ rule} \\
\hline
\text{## liɨɨ} \\
\text{## liɨɨ}
\end{array}
\]
But if the form had a prefix, as /bi-lέ́é̈́/t/, the rule could not apply, since the /l/ would not then be immediately preceded by ##. This gives us precisely the right phonetic output, and the rule applies correctly to all of the relevant forms.

It should be pointed out that we have introduced two notions here. One of these is the notion phonological rule, and the other is the notion basic form, or as we will refer to it more often, underlying representation.\(^6\) In our solution for the \([l\sim\underline{l}]\) alternation, we have picked one of the pair as being the basic or underlying representation, and we derive the other by means of a phonological rule.\(^7\) In the case at hand, the \(l \rightarrow \underline{l}\) rule operates on the underlying representations given in the left-hand column below to derive the phonetic representations given in the right-hand column:

<table>
<thead>
<tr>
<th>underlying representation</th>
<th>phonetic representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>/##lέ́é̈́(\underline{t})/</td>
<td>[##lέ́é̈́(\underline{t})](^8)</td>
</tr>
<tr>
<td>/##l(\underline{1})d/</td>
<td>[##l(\underline{1})d]</td>
</tr>
<tr>
<td>/##l(\underline{e})ezh/</td>
<td>[##l(\underline{e})ezh]</td>
</tr>
<tr>
<td>/##l(\underline{e})ót̂̈́d/</td>
<td>[##l(\underline{e})ót̂̈́d]</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

---

6. See Hale Navajo Linguistics I, pp. 15-36. In that work the term abstract representation is used as an alternative.

7. See Hale Navajo Linguistics II, pp. 57-60 for one suggestion as to why /l/ rather than \(\underline{l}/\) was chosen as the underlying form.

8. We are using diagonals /.../ and square brackets [ ... ] here in one of their widely accepted technical usages, i.e., for /underlying/ and [phonetic] representations, respectively.
These are known as phonological derivations -- they are "histories" of the application of one or more phonological rules to an underlying form. In the event that one of these morphemes is preceded by a prefix, the \( l \rightarrow t \) rule is blocked (i.e., cannot apply), and the phonetic representation is thus identical to the underlying representation, at least with respect to the rule in question:

<table>
<thead>
<tr>
<th>underlying representation</th>
<th>phonetic representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>/bi-l\dddot{e}t/</td>
<td>[bil\dddot{e}t]</td>
</tr>
<tr>
<td>/bi-lid/</td>
<td>[bilid]</td>
</tr>
<tr>
<td>/bi-leezh/</td>
<td>[bileezh]</td>
</tr>
<tr>
<td>/bi-lóód/</td>
<td>[bilóód]</td>
</tr>
</tbody>
</table>

We now have a rule which applies regularly to forms whose underlying representation begins in /l/. What we wish to know now is whether this rule expresses the true generalization which can be made about this type of alternation in Navajo. To answer this question, let us cast our net somewhat wider and look at a few other cases of alternation involving morpheme-initial consonants. Consider, for example, the following:

<table>
<thead>
<tr>
<th>without prefix</th>
<th>with prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>saad</td>
<td>bizaad</td>
</tr>
<tr>
<td>sid</td>
<td>bizid</td>
</tr>
<tr>
<td>see\dddot{t}</td>
<td>bizee\dddot{t}</td>
</tr>
<tr>
<td>siil</td>
<td>biziil</td>
</tr>
</tbody>
</table>
In these morphemes, the alternation is between [s] and [z]; and the conditions for the alternation are the same as for [l ~ İ] -- thus, we find [İ] and [s] after word-boundary (i.e., in the context ##__) and we find [l] and [z] following a prefix. It is natural to attempt to state this new alternation in the form of a phonological rule of the type suggested for the [l ~ İ] alternation. Taking the z-initial form as basic, we would express the rule as follows

\[ z \rightarrow s / ##__ \]

This would operate on an underlying form like /##zaad/ to derive [##saad], and the rule would block in the case of an underlying form like /bi-zaad/, thereby accounting correctly for the form [bizaad].

Now let us compare the two phonological rules we have suggested:

\[ l \rightarrow İ /##__ \]
\[ z \rightarrow s /##__ \]

Notice that they apply in precisely the same environment or context -- i.e., ##__. This makes one wonder whether the two rules might not really be special cases of a single phonological process. If one considers in detail exactly what the rules do, then it becomes rather obvious that there is only one rule involved. What does the first rule do? It changes l into İ. And what is the difference
between ₁ and ₃? The difference is in voicing -- ₁ is voiced while ₃ is voiceless. If we ask the same questions about the second rule, we see that its effect is precisely the same as that of the first -- it changes ₂ into ₄, and the difference between ₂ and ₄ is one of voicing. All of this becomes especially clear if the rules are expressed in feature notation rather than alphabetic notation. In feature notation, the rule

\[ ₁ \rightarrow ₃ /\#\#_-- \]

would be

\[
\begin{array}{c}
\text{consonant} \\
\text{apico-alveolar} \\
\text{lateral} \\
\text{fricative} \\
\text{voiced}
\end{array}
\rightarrow [\text{voiceless}] /\#\#_--
\]

That is, change the voiced lateral fricative into a voiceless lateral fricative. Similarly, the rule

\[ ₂ \rightarrow ₄ /\#\#_-- \]

would be

\[
\begin{array}{c}
\text{consonant} \\
\text{apico-alveolar} \\
\text{median} \\
\text{fricative} \\
\text{voiced}
\end{array}
\rightarrow [\text{voiceless}] /\#\#_--
\]

The feature notation expresses clearly the similarity of the two rules. In fact, it allows us to collapse them into a single rule,
thereby expressing the true generalization. We can collapse the
two rules by simply omitting reference to the feature opposition
[median/lateral]. The feature complex

\[
\begin{array}{c}
\text{consonant} \\
\text{apico-alveolar} \\
\text{fricative} \\
\text{voiced}
\end{array}
\]

stands for either /l/ or /z/, since it is noncommittal with respect
to whether or not the segment is lateral or median. Therefore,
the rule

\[
\begin{array}{c}
\text{consonant} \\
\text{apico-alveolar} \\
\text{fricative} \\
\text{voiced}
\end{array} \rightarrow [\text{voiceless}] /##_\_
\]

expresses in a single statement what could only be stated as two
separate rules in the alphabetic notation:

\[
\begin{align*}
l & \rightarrow \text{i} /##_\_ \\
z & \rightarrow \text{s} /##_\_
\end{align*}
\]

The correctness of this approach is further suggested by the
fact that the rule appears to generalize to all fricatives -- thus,
in addition to the alternations exemplified above, we also find:
<table>
<thead>
<tr>
<th>without prefix</th>
<th>with prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>héeɛ</td>
<td>bighéeɛl</td>
</tr>
<tr>
<td>hosh</td>
<td>bighosh</td>
</tr>
<tr>
<td>shéeɛ'</td>
<td>bizhéeɛ'</td>
</tr>
<tr>
<td>sháázh</td>
<td>bizháázh</td>
</tr>
</tbody>
</table>

This allows us to generalize the rule to accommodate dorso-velar and lamino-alveolar fricatives as well as apico-alveolars. The rule now reads:

\[
\text{[consonant]} \quad [\text{fricative}] \quad \downarrow \quad [\text{voiceless}] \quad / \quad / //
\]

That is, a voiced fricative becomes voiceless word-initially. This appears to be the true generalization.

2. The forms used above to illustrate the devoicing of word-initial fricatives were nouns. There is an identical process which applies in the case of verbs, but the environment is somewhat different. What we will be concerned with here is the initial fricative in the verb-stem -- consider the stem-initial alternations in the following imperfective verb forms; the stem-initial consonant is underlined:
<table>
<thead>
<tr>
<th>3rd person</th>
<th>1st singular</th>
<th>2nd non-singular</th>
</tr>
</thead>
<tbody>
<tr>
<td>dizééh</td>
<td>dissééh</td>
<td>dohsééh</td>
</tr>
<tr>
<td>yayíizíid</td>
<td>yaassíid</td>
<td>yaohsíid</td>
</tr>
<tr>
<td>niíziíh</td>
<td>niissorsíh</td>
<td>noohsííh</td>
</tr>
<tr>
<td>yiíziíh</td>
<td>yiissorsíh</td>
<td>woohsííh</td>
</tr>
<tr>
<td>yíizeés</td>
<td>yisséés</td>
<td>woohséés</td>
</tr>
<tr>
<td>haidizóóh</td>
<td>hadisgóóh</td>
<td>hadohsóóh</td>
</tr>
<tr>
<td>iiizóóš</td>
<td>iissóóš</td>
<td>oohsóóš</td>
</tr>
<tr>
<td>iiízá</td>
<td>iisszá</td>
<td>ayohsá</td>
</tr>
<tr>
<td>náyíiílááh</td>
<td>náháshíílááh</td>
<td>náhohíílááh</td>
</tr>
<tr>
<td>yíileeh</td>
<td>yishléeh</td>
<td>wohléeh</td>
</tr>
<tr>
<td>níílí</td>
<td>níshíí</td>
<td>nohíí</td>
</tr>
<tr>
<td>nahale'</td>
<td>nahashlé'</td>
<td>nahohle'</td>
</tr>
<tr>
<td>k'i'idílé</td>
<td>k'i'idishlé</td>
<td>k'i'idohlé</td>
</tr>
<tr>
<td>alííh</td>
<td>ashlííh</td>
<td>ohlííh</td>
</tr>
<tr>
<td>yiíyiíloh</td>
<td>yíshlíloh</td>
<td>wohlíloh</td>
</tr>
<tr>
<td>adízheeh</td>
<td>adíshsheeh</td>
<td>adohsheeh</td>
</tr>
<tr>
<td>dizáah</td>
<td>disheah</td>
<td>dosheah</td>
</tr>
<tr>
<td>yózhí</td>
<td>yíñishshí</td>
<td>yínóshshí</td>
</tr>
<tr>
<td>yíighá</td>
<td>yíshxá</td>
<td>wohxága'⁹</td>
</tr>
<tr>
<td>yíigháád</td>
<td>yíshxáád</td>
<td>wohxáád</td>
</tr>
<tr>
<td>yíiyíghas</td>
<td>yíissxas</td>
<td>wohxas</td>
</tr>
<tr>
<td>yíighozh</td>
<td>yíshxozh</td>
<td>wohxozh</td>
</tr>
</tbody>
</table>

9. Except for [yíissxas] these forms can be written with /h/ rather than /x/ -- I use /x/ here merely for consistency in the examples.
These verb forms illustrate the same alternations as the nominal forms did -- i.e.,

\[ z \sim s \]
\[ l \sim \mathfrak{f} \]
\[ zh \sim sh \]
\[ gh \sim h, x. \]

Again, this is an alternation in voicing. However, the environment is different. In the verb forms, the voiceless initial appears after /h/ or /sh/ \(^{10}\), while the voiced initial appears after a vowel. Or to state it slightly differently, we could say that the voiceless initial appears in the following contexts:

\[ h \_ \]
\[ sh \_ \]

while the voiced initial appears in the context

\[ v \_ \]

i.e., after a vowel. Now suppose that we say that the voiced initial is basic, as we did in the case of the nouns; we can then formulate two rules to give us the results which correspond to the facts:

\[
\begin{array}{c}
\text{consonant} \\
\text{fricative} \\
\text{voiced}
\end{array}
\rightarrow [\text{voiceless}] / sh _\]

---

10. The first person singular subject marker has the underlying form /sh-/. However, this /sh/ becomes /s/ under the influence of stem-initial or stem-final apico-alveolar median fricatives or affricates. This accounts for why one says [dissee\~n] rather than *[dishse\~n] and [yiisxas] rather than *[yiishxas].
Now notice that these two rules might be collapsed into a single one if we expressed the environment in feature notation. Can this be done? It appears that it can, because the segments /sh/ and /h/ share a great many properties — they are both voiceless fricatives. Thus, if we represent these two segments by means of the feature complex

\[
\begin{array}{c}
\text{[fricative]} \\
\text{[voiceless]}
\end{array}
\]

we can then collapse the two rules into the following single rule:

\[
\begin{array}{c}
\text{[consonant]} \\
\text{[fricative]} \\
\text{[voiced]}
\end{array} \rightarrow \text{[voiceless] / [fricative] / [voiceless]}
\]

This rule says:

A voiced fricative becomes voiceless if a voiceless fricative immediately precedes it.

Thus, the rule operates on an underlying form like

\(/ni\text{-}sh\text{-}lʃ/\_\]

to convert it to

\([nishıf]_\]

because the stem-initial /l/ here is immediately preceded by the voiceless segment /sh/. However, the related 3rd person form /ni-lı₇/ does not undergo the rule, because the stem-initial fricative is here preceded by a vowel rather than by a voiceless fricative -- this form, then, appears in phonetic representation as:

[nilı₇].

But the 2nd nonsingular form /n-oh-lı₇/ must undergo the rule, since the /l/ is preceded by the voiceless fricative /h/. Application of the rule in this instance gives:

[nohlı₇].

Similarly, the rule applies to the forms

/di-sh-zah/
/d-oh-zah/

to give

[dishzhah]
[dohzhah]

but it does not apply to the 3rd person form /di-zah/
which, therefore, appears in phonetic representation with a voiced stem-initial:

[dizhah].

In this chapter, we have examined two phonological rules, one which applies to nouns:

\[
\begin{align*}
\text{consonant} \\
\text{fricative} \\
\text{voiced} & \rightarrow \text{[voiceless]} /##\
\end{align*}
\]

and another which applies to verbs

\[
\begin{align*}
\text{consonant} \\
\text{fricative} \\
\text{voiced} & \rightarrow \text{[voiceless]} /\left\{ \text{fricative} \right\} /\text{[voiceless]}\
\end{align*}
\]

The two rules do exactly the same thing -- i.e., they devoice fricatives -- but they apply in different environments. It is possible to collapse the two rules into a single one by using the so-called "braces convention". The rule would now appear as follows:

\[
\begin{align*}
\text{consonant} \\
\text{fricative} \\
\text{voiced} & \rightarrow \text{[voiceless]} /\left\{ ##\right.\
\end{align*}
\]

This can be interpreted as follows:
A voiced fricative becomes voiceless if word-boundary or a voiceless fricative immediately precedes it.

We can refer to this composite rule as **Fricative Devoicing**.

3. Exercises:

(1) Give derivations for the following forms:

[disseéh]
[náháshízááh]
[yahsííd]
[nahohie']
[iéécháa'í]

(2) Attempt to provide an explanation for why the stem in the form

[yiixozh]

'it tickles him'

begins in [x] (also written h in the current orthography), while in the related form

[yighozh]

'he is ticklish'

the stem begins in [gh].
(3) The following are some imperfective verb forms. Put them into the perfective. State what happens to the stem-final consonant in the perfective:

yish'eesh 'I string them (beads)'
yish'aaž 'I chew it'
ch'ínísbaas 'I drive it out'
yishch'iish 'I file/saw it'
naashdeel 'I drop it(rope)'
yishdleesh 'I paint it'
disdzížis 'I start to pull it along'
disdzíž 'I strain'
yishxaaž 'I beat it (drum),
I shell it (corn)'

(4) In the following lists, English nouns are given in their plural forms. The plural ending is written s in the English words, but on the nouns in the left-hand column, the plural ending is phonetically [s], while in the right-hand column it is phonetically [z]. Attempt to explain why the plural ending is phonetically [s] in one case, but [z] in the other.
<table>
<thead>
<tr>
<th>[s]</th>
<th>[z]</th>
</tr>
</thead>
<tbody>
<tr>
<td>bats</td>
<td>lads</td>
</tr>
<tr>
<td>hats</td>
<td>rods</td>
</tr>
<tr>
<td>pots</td>
<td>pods</td>
</tr>
<tr>
<td>hoops</td>
<td>tubs</td>
</tr>
<tr>
<td>caps</td>
<td>cabs</td>
</tr>
<tr>
<td>hips</td>
<td>ribs</td>
</tr>
<tr>
<td>sacks</td>
<td>bags</td>
</tr>
<tr>
<td>socks</td>
<td>tags</td>
</tr>
<tr>
<td>mechanics</td>
<td>rugs</td>
</tr>
<tr>
<td>exits</td>
<td>catalogues</td>
</tr>
</tbody>
</table>
4. Answers

(1) All of these forms have undergone the **Fricative Devoicing** rule:

/\text{dis-zééh}/ → [disséén]
/\text{náhásh-lááh}/ → [náháshíaánh]
/\text{yaoh-zííd}/ → [yaohsííd]
/\text{nahoh-le'}/ → [nahoh že']
/\text{lééch}_{\text{čč}}'í/ → [lééch_{čč}'í]

(2) This form also appears to have undergone **Fricative Devoicing**. Notice that if we assume that the stem having to do with tickling begins in the voiced dorso-velar fricative, then the underlying form of 'he tickles him' would be

/\text{yí-í-ghozh}/

As the rule of **Fricative Devoicing** is now stated, it would correctly apply to this underlying form to give

[yílxozh].

This is so because /\text{í}/ is a voiceless fricative; therefore, the underlying /gh/ here is in the
context

\[
\begin{array}{c}
\text{fricative} \\
\text{voiceless}
\end{array}
\]

It therefore undergoes the rule of Fricative Devoicing. This gives further evidence of the correctness of the analysis suggested in this chapter.

(3) The perfectives are:

shé'eezh
yí'aal
ch'ínhábágz
yích'iizh
nááidéél
shédléézh
dédzíłz
désdzil
yífixaal

The generalization to be made here is that the stem-final consonant becomes voiced in the perfective.

(4) The difference between [-s] and [-z] is, of course, one of voicing. The principle which governs the
choice of alternant here is, roughly:

The voiceless ending [-s] is used on nouns ending in voiceless stops, and the voiced ending [-z] is used on nouns ending in voiced stops.

The nouns in the left-hand column end in voiceless stops [p, t, k]; those in the right-hand column end in voiced stops [b, d, g].

5. We will depart slightly from our usual format and present a problem based on material which will be discussed in the next chapter.

The following are words containing (1) the first person singular possessive prefix /shi-/ and (2) the verbal prefix /si-/ (appearing in the neuter forms of verbs derived from s-perfectives). Assume that the underlying forms of these prefixes are /shi-/ and /si-/ respectively. Notice, however, that the possessive prefix /shi-/ sometimes appears phonetically as [si-] and that the verbal prefix /si-/ sometimes appears phonetically as [shi-]. Study the examples and attempt to state the principle which governs the alternations you observe:
<table>
<thead>
<tr>
<th>possessive</th>
<th>s-perfective verb form</th>
</tr>
</thead>
<tbody>
<tr>
<td>/shi-/</td>
<td>/si-/</td>
</tr>
<tr>
<td>shi-má</td>
<td>si-dá</td>
</tr>
<tr>
<td>shi-béézh</td>
<td>si-gan</td>
</tr>
<tr>
<td>si-ziiiz</td>
<td>shi-jaa'</td>
</tr>
<tr>
<td>shi-taa'</td>
<td>si-tí</td>
</tr>
<tr>
<td>shi-gaan</td>
<td>shi-jéé'</td>
</tr>
<tr>
<td>si-k'is</td>
<td>shi-téézh</td>
</tr>
<tr>
<td>si-dzilil</td>
<td>si-í-tsocoz</td>
</tr>
<tr>
<td>si-tslîts'iin</td>
<td>shi-béézh</td>
</tr>
<tr>
<td>si-tse'</td>
<td>si-do</td>
</tr>
<tr>
<td>shi-cheii</td>
<td>si-k'az</td>
</tr>
<tr>
<td>shi-doh</td>
<td>si-ts'îl</td>
</tr>
<tr>
<td>shi-tl'îzh</td>
<td>si-zí</td>
</tr>
<tr>
<td>si-tsii'</td>
<td>si-tí</td>
</tr>
<tr>
<td>shi-bid</td>
<td>si-'eez</td>
</tr>
<tr>
<td>shi-da'</td>
<td>si-t'e</td>
</tr>
<tr>
<td>si-wos</td>
<td>si-t'éêé'</td>
</tr>
<tr>
<td>si-k'os</td>
<td>si-k'ê</td>
</tr>
<tr>
<td>shi-ch'îf'</td>
<td>si-lá</td>
</tr>
<tr>
<td>shi-lah</td>
<td>si-sîf'</td>
</tr>
<tr>
<td>si-tsóí</td>
<td>si-'é</td>
</tr>
<tr>
<td>shi-jool</td>
<td>si-yî</td>
</tr>
<tr>
<td>shi-zhoozh</td>
<td>shi-jîzh</td>
</tr>
</tbody>
</table>
| shi-zhah             | }
IX. Phonetic Alternations and Phonological Rules: Assimilation.

1. In the last chapter, we observed that verb-stem-initial fricatives, which we assume are voiced in underlying representation, become voiceless if they are immediately preceded by another voiceless segment. Another way to refer to this process is to say that:

   Stem initial voiced fricatives assimilate to the voicelessness of an immediately preceding voiceless segment.

And that is the way linguists typically refer to this sort of thing—that is, if some segment becomes more like another in terms of its feature composition, it is said that the one assimilates to the other. Thus, when the rule of Fricative Devoicing applies to an underlying sequence

   /sh + l/

and turns it to

   [sh + l]

it makes the second segment more like the first by causing it to agree with it in voicing -- to this extent, the second segment assimilates to the first. This becomes especially clear when the
segments are represented in feature notation. Before the rule
applies, the first segment is [voiceless] and the second is
[voiced]; but after the rule applies, both segments are [voiceless],
and therefore more alike in feature composition.

The behavior of stem-initial fricatives in Navajo provides
one example of the phenomenon of assimilation, so common in the
phonologies of the languages of the world. In this Navajo example,
the assimilation is in the feature of voicing -- voicing assimilation
is also found in English, as is shown by the data used in the
final exercise of chapter VIII above. But voicing is not the only
feature which participates in the assimilation process. In this
chapter, we will examine certain other cases of assimilation in
Navajo.

2. In Navajo a number of verbal prefixes can be said to
have the vowel /a/ in underlying representation. Some of these
prefixes are listed here:

   /ná/-  'iterative'
   /na/-  'around, about'
   /da/-  'plural'

These appear in phonetic representation with the vowel [a] in such
forms as the following:
náshjah
'I (repeatedly) grease it'
nání'á
'You are carrying it about'
dajicha
'They are crying'

But when these prefixes are immediately followed by the vowel /i/, they appear phonetically with the vowel [e] instead of [a]. Thus, consider the following forms:

néiljah
'We (repeatedly) grease it'
neit'á
'We are carrying it about'
deilicha
'We are crying'

Assuming, as we have, that these prefixes have /a/ in underlying representation, we must then propose that Navajo has a phonological rule which turns this /a/ to [e] when it is immediately followed by /i/. We might formulate this rule as follows:

\[ a \rightarrow e / _{i}. \]

The rule would operate on an underlying form like
/ da-iid-á/  

to give  

[deiidá]  
"We eat it!"

But an underlying form like  

/da-ji-cha/  

would remain unaffected, because the /a/ of the prefix is not here immediately followed by /i/; hence the phonetic representation has [a]:  

[dajicha]  

Now consider exactly what the rule proposed above does. To see more clearly what its effect is, let us formulate the rule in feature notation rather than alphabetic notation:

\[
\begin{align*}
\text{vowel} & \quad \rightarrow \quad [\text{front}] / \quad [\text{vowel}] \\
\text{back} & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \qu
becomes [e] it becomes more like /i/, since it then agrees with the latter with respect to the dimension of horizontal tongue position. We can say, therefore, that the effect of this rule is to cause the back vowel /a/ to assimilate to the "frontness" of /i/.

3. Perhaps the best known, and most widely cited, example of assimilation in Navajo is one which involves the position of articulation of the apical and laminal median affricates and fricatives (i.e., the segments / dz, ts, ts', s, z; j, ch, ch', sh, zh/). We will begin our study of this case of assimilation by considering the behavior of the prefix /shi-/ 'first person singular (possessive)' appearing in forms like the following:

shibid
shimá
shidaa'
shitaa'
shit'og
shinii'
shich'ah
shijáád
shicheii
shizhé'é
shíllí'$
shigod
shigaan
shikee'
shik'él

In all of these forms, the prefix has the phonetic representation [shi-] -- notice in particular that it begins in the lamino-alveolar fricative [sh]. Now consider the following first person singular possessive forms:

siziiz
sizooł
siziō
sizéé'
siṣii'"'
siṣiił
siṣço'"'
siṣco'í
siṣi'"'isi
siṣ'ée'
siṣ'īís
siṣ's'oos
siḳ'īís
siḳ'ōos
siqhos
In these forms, the first person singular possessive prefix has the phonetic representation [si-] instead of [shi-] -- notice especially that in these forms the prefix begins in the apico-alveolar fricative [s]. What is happening here is the following -- the possessive prefix /shi-/ has two alternants i.e., [shi-] and [si-]; what is interesting about this is that the initial fricative alternates between lamino-alveolar and apico-alveolar position of articulation. The question is: what is the principle which governs this alternation? To answer this question it is appropriate to attempt to determine what there is in common among the environments in which each of the two alternants appears. For example, consider the words in which the alternant [si-] appears. What do they have in common? Notice that the alternant [si-] only appears if somewhere else in the word one of the following consonants appears:

\[
\begin{align*}
  & \text{dz} \\
  & \text{ts} \\
  & \text{ts'} \\
  & \text{s} \\
  & \text{z}
\end{align*}
\]

Otherwise, the alternant [shi-] is used. A natural way to accommodate this fact in the grammar of Navajo is to assume that the basic form of this prefix is /shi-/ and that there is a rule of roughly the following effect:
The prefix /shi-/ appears phonetically as [si-] if one of the consonants /dz, ts, ts', s, z/ follows somewhere in the same word.

Now, if we consider more carefully what is happening here, we see that the lamino-alveolar fricative /sh/ in the prefix changes its position of articulation to apico-alveolar when one of the consonants /dz, ts, ts', s, z/ appears in the same word:

\[
\text{sh} \rightarrow s / \quad \begin{cases} 
\text{dz} \\
\text{ts} \\
\text{ts}' \\
\text{s} \\
\text{z}
\end{cases} 
\]

(The symbol X here stands for whatever other segments appear between the /sh/ of the prefix and the consonant which conditions the change; we must also stipulate that X cannot contain the word boundary ##, in order to ensure that the /sh/ is in the same word as the conditioning consonant.) Now notice that the consonants /dz, ts, ts', s, z/ have something in common -- they are all apico-alveolar median affricates or fricatives. Therefore, when /sh/ changes to [s] it becomes more like these consonants by virtue of the fact that it then agrees with them in position of articulation. This becomes clear when we express the rule in feature notation:
\[
\text{[lamino-alveolar] median fricative} \rightarrow [\text{apico-alveolar}] _/\text{X}_{\text{fricative}} [\text{affricate}]
\]

That is to say, a lamino-alveolar fricative becomes apico-alveolar when followed by an apico-alveolar median fricative or affricate. This again is a clear case of assimilation -- in this instance, the assimilation is in position of articulation.

The alternation exemplified above is one in which underlying /sh/ becomes [s] by assimilation to a following apico-alveolar fricative or affricate. It is reasonable to ask whether or not the inverse of this also happens -- i.e., are there cases in which underlying /s/ becomes [sh] by assimilation to a following lamino-alveolar? Consider in this regard the verbal prefix /si-/ 'superfective mode' which appears as phonetic [si-], i.e., unchanged from the underlying representation, in the neuter verb forms listed immediately below:

\begin{align*}
\text{sidá} \\
\text{sigan} \\
\text{siṭˈ} \\
\text{siṭsooz} \\
\text{sido}
\end{align*}
sik'az
sits'il
sisé
sité
sitleé'
siké
silá
si'á

The same prefix appears in the following neuter verb forms as well, but in this case, it has the phonetic representation [shi-] i.e., with a lamino-alveolar rather than an apico-alveolar fricative:

shijaa'
shijéé'
shitéézh
shibéézh
shijool
shizhoozh
shijizh
shizhah

Notice that the stems in these verb forms all contain lamino-alveolars--clearly what is happening here is that the initial fricative of the
prefix is assimilating in position of articulation to the lamino-alveolar consonants in the stem. Thus, apparently, Navajo has a rule of roughly the following form:

\[
\begin{array}{c}
\text{apico-alveolar} \\
\text{median} \\
\text{fricative}
\end{array} ~ \rightarrow ~ \begin{array}{c}
\text{lamino-alveolar} \\
\text{median} \\
\{\text{fricative}\} \\
\{\text{affricate}\}
\end{array}
\]

Or, to say this in prose: an apico-alveolar median fricative becomes lamino-alveolar when followed by a lamino-alveolar median fricative or affricate.\(^{11}\) Notice that the effect of this rule is precisely the inverse of the rule given earlier. The only formal difference between the two rules is in where the features [lamino-alveolar] and [apico-alveolar] appear in them -- by one rule, [lamino-alveolar] is changed to [apico-alveolar] in the context of an [apico-alveolar], while by the other [apico-alveolar] is changed to [lamino-alveolar] in the context of a [lamino-alveolar]. This situation could be expressed much more effectively in our feature notation if we could represent the fact that [apico-alveolar] and [lamino-alveolar] enter into a "feature opposition", that is, that they are in some sense the opposite poles of a single feature.

\(^{11}\) The feature [median] is mentioned in these rules in order to exclude the laterals -- laterals do not undergo this rule. To be sure, our usage is somewhat redundant when we specify lamino-alveolars as median, since there are, in Navajo, no lateral lamino-alveolars.
dimension. This is, in fact, what is done in most current phonological work which makes use of feature representations. In the next chapter, we will introduce the student to this conception of phonological features and attempt to formulate the assimilation rules just discussed in their maximally general form.

4. Exercises.

(1) In the speech of many people, the verbal prefix /ji-/ 'fourth person subject' appears phonetically sometimes as [ji-] and sometimes as [dzi-]. Examine the following verb forms and attempt to explain this alternation:

jicha  
jiní  
jiyá  
dzizí  
jileeh  
dzisdá  
dzíts'ééh  
jishé'éh  
dzisééh  
dziztí
jiłnaáh
jiilt'o'
dzitsid

(2) Consider the imperfective paradigm of the verb meaning 'to bat off into space':

abįjįshxaaż
abįdzį́xaaż
ayįdzį́xaaż
abįdziilghaaż
abįdzó́xaaż

Attempt to explain why the first person form is abįjįshxaaż
instead of abįdzį́shxaaż.

(3) Normally, the first person singular subject prefix /sh-/ appears as phonetic [sh-], as in

naashnìsh
naashá
naashbé
yáshti'
naash'á
na'nishtkaad
Attempt to explain why it appears as phonetic [s-] in the following verb forms:

\begin{verbatim}
disbqas
yismsas
naas'iz
disdziij
nasdzid
yistsid
yists'eéh
\end{verbatim}

(4) Explain why, in many people's speech, the word for 'mule' begins in [dz] rather than [j].
5. Answers.

(1) The initial lamino-alveolar affricate /j/ of the fourth person prefix becomes apico-alveolar [dz] if an apico-alveolar fricative or affricate follows in the same word. This is clearly the same assimilation rule that turns underlying /sh/ to [s] -- we must, therefore, extend the rule to accommodate affricates as well as fricatives; hence the rule should be formulated as follows:

\[
\begin{align*}
\text{[lamino-alveolar]} & \quad \text{median} \\
\{\text{fricative}\} & \quad \rightarrow [\text{apico-alveolar}] / \_X \quad \{\text{fricative}\} \\
\{\text{affricate}\} & \\
\text{[apico-alveolar]} & \quad \text{median}
\end{align*}
\]

(2) These verb forms contain an adverbial prefix /dzi-/ 'off into space' whose underlying initial apico-alveolar affricate /dz/ becomes [j] by assimilation to a following lamino-alveolar fricative or affricate. Since the first person singular subject prefix is a lamino-alveolar fricative /sh-/ , the prefix /dzi-/ becomes [ji-] in the first person singular verb form. The same thing can be observed in the imperfective paradigm of the verb meaning 'to kick into space, to let fly a kick':

ajishtaaż
adzítaaż
adzitaal
adzitaal
adzohtaał

The assimilation here is clearly the same as that according to which underlying /s/ becomes [sh]; the rule which accomplishes this assimilation must, therefore, be extended to accommodate affricates as well as fricatives:

\[
\text{apico-alveolar} \quad \text{median} \quad \{\text{fricative}\} \quad \{\text{affricate}\} \rightarrow \text{[lamino-alveolar]} / \_X \\
\text{lamino-alveolar} \quad \text{median} \quad \{\text{fricative}\} \quad \{\text{affricate}\}
\]

(3) The underlying lamino-alveolar fricative of the first person subject prefix /sh-/ assimilates to a stem-initial or stem-final apico-alveolar affricate or fricative. Thus:

/yi-sh-mas/ \rightarrow [yismas]
/di-sh-dzííʃ/ \rightarrow [disdzííʃ]

(4) For many people, the word for 'mule' is [dzaanéez], instead of [jaanéez]. The underlying lamino-alveolar affricate /ʃ/ of /-jaaʃ/ 'ear' becomes [dz] by assimilation to the apico-alveolar /z/ of /-néez/ 'long'.
X. Feature Opposition

1. When we described the difference between /z/ and /s/ in an earlier chapter, we pointed out that the first was characterized by the presence of voice, (i.e., vocal band vibration), while the second was characterized by the absence of voice -- i.e., the first is voiced while the second is voiceless. It is clear that the features [voiced] and [voiceless] are directly opposed to one another -- or, to put it another way, [voiced] is the opposite of [voiceless]. And this appears to be the correct way to think of phonological features; they enter into binary oppositions in which one is, so to speak, on the plus side of the opposition while the other is on the minus side. So, for example, instead of using the terms [voiced] and [voiceless], we could reflect the fact that they are opposites by using the single feature designation [voiced] together with the prefixes plus (+) and minus (-) to indicate the two sides of the opposition. Following this suggestion, which in fact conforms to current practice in phonological investigations, we would represent voiced as [+voiced] and voiceless as [-voiced].

It should be pointed out that the use of [+voiced] and [-voiced] in place of [voiced] and [voiceless] is only a notational difference -- [+voiced] means exactly the same thing as did [voiced] in our earlier usage, and [-voiced] means exactly the same thing as our
earlier [voiceless]. And, for the most part, the feature notation which will be introduced in this chapter is only notationally different from the one used in previous chapters. There are cases, however, where the conception of phonological features as entering into binary oppositions will require some revision of our earlier treatment. Furthermore, it will become evident that there are positive advantages to the feature notation which uses the coefficients plus and minus -- specifically, using this binary feature notation, it will be possible to formalize certain phonological rules in such a way that the notational expression reflects, to a greater extent than would otherwise be the case, the true linguistic generalizations involved. There is another reason for presenting this second feature notation -- it is advisable for students who may continue in the study of phonology to be thoroughly familiar both with the more traditional terminology used in previous chapters and with the binary feature notation; the former is widely used, but the latter is appearing with increasing frequency in published and unpublished works on the sound systems of a variety of languages. The particular binary feature notation which will be presented here conforms more or less to that used in Richard Stanley's The Phonology of the Navaho Verb (M.I.T. Dissertation, 1969).
2. The features voiced and voiceless, being direct opposites, translate naturally into the binary feature notation as [+voiced] and [-voiced]. Similarly, lateral and median can be represented as [+lateral] and [-lateral], respectively; and the features nasal and oral (or nonnasal) can be represented as [+nasal] and [-nasal].

The three series of stops in Navajo are identified by the presence or absence of aspiration and by the presence or absence of glottalization. These oppositions are very naturally represented by the feature notations [+aspirated]/[-aspirated], and [+glottalized]/[-glottalized]. Accordingly, the distinctions among the three series of apico-alveolar median stops can be presented in tabular form as follows:

```
d            t            t'
aspirated    -            +            -
glottalized  -            -            +
```

That is to say, /d/ is marked minus for both the feature dimension [aspirated] and for [glottalized]; in other words it is

\[
\begin{bmatrix}
-\text{aspirated} \\
-\text{glottalized}
\end{bmatrix}
\]

On the other hand, /t/ is marked plus for the first feature and minus for the second:
[+ aspirated]
[-glottalized]

while /t'/ is marked minus for the first and plus for the second:

[- aspirated ]
[ + glottalized ]

The tabular arrangement presented above is very commonly employed in presenting the feature composition of the sounds of a language.

The production of stop consonants is characterized by complete interruption of the outward flow of breath; and this characteristic distinguishes stops from other major classes of sounds, like nasals and fricatives, which do not involve complete stoppage of the breath. These latter are sometimes referred to as continuants, and this term has given rise to the binary feature representation in which [+continuant] is opposed to [-continuant]; nasals and fricatives are [+continuant], and stops are [-continuant].

The features we have at this point can be illustrated in the following table:
Among the stops, it is necessary to distinguish those with abrupt release (i.e., "pure" stops like /d/ and /t/) from those with delayed release (i.e., affricates like /dz/ and /ts/). Many linguists use the feature dimension [delayed release] to distinguish these, and this is phonetically appropriate, as we pointed out earlier. However, there is another usage which emphasizes the relationship between affricates and the corresponding fricatives. Recall that the affricates are complex consonants consisting of a stop component followed by a fricative component. Thus, /dz/ consists of a stop onset roughly like [d] followed by a fricative release roughly like [z] (and, correspondingly, in lamino-alveolar position, /j/ consists of a stop onset followed by a fricative release roughly

---

12. Richard Stanley, in his Phonology of the Navaho Verb regards the unaspirated stops as [+voiced]. This permits him to eliminate the feature [aspirated] altogether, since the voicing feature will, in his system, serve to distinguish /d/ from /t/, /dl/ from /tl/, and so on.
like [zh]). Now, it is a characteristic of median affricates and the related median fricatives that they are accompanied by the acoustic property of stridency, i.e., relatively greater noisiness than other sounds. This greater noisiness is caused by the fact that, when sounds like /z/, /s/, /zh/ and /sh/ are produced, the breath or air stream is not only forced to pass through a constricted passage but it is forced over a highly uneven and irregular surface as it exits, due in large measure to the fact that the teeth are directly in its path and also to the particular exaggerated angle of the narrow passage which is produced against the alveolar ridge. In this respect, the apical and laminal median fricatives are quite different from the dorso-velar ones which, because of the rather evenly surfaces involved, are much less "noisy" or strident. The lateral fricatives are also less strident than the median ones. Accordingly, the apical and laminal median affricates and fricatives will be classified as [+strident], while all of the other sounds of Navajo will be identified as [-strident]. Within the apico-alveolar position of articulation, these features are applied as follows:

<table>
<thead>
<tr>
<th></th>
<th>d</th>
<th>t</th>
<th>t'</th>
<th>dz</th>
<th>ts</th>
<th>ts'</th>
<th>dl</th>
<th>tl</th>
<th>tl'</th>
<th>s</th>
<th>z</th>
<th>ʃ</th>
<th>l</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>continuant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>nasal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>lateral</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>strident</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>voiced</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>aspirated</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>glottalized</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Navajo has four positions of articulation, to which four names have been given in accordance with traditional practice. However, it is not the case that any one position of articulation can be said to be the exact opposite of any one of the others. Because of this, we have to think about the positions of articulation in a somewhat different way. In this connection, we will follow the usage of Chomsky and Halle in their *The Sound Pattern of English* (Harper and Row, 1968). Sounds produced with the front part of the tongue — i.e., both apical and laminal sounds — will be identified as [+coronal] (from the Latin word *corona* "crown" used in reference to the upper part or head of an object). Sounds which are not produced with the front part of the tongue — i.e., bilabials and dorso-velars — will be identified as [-coronal]. The way these features are used can be illustrated by the following table:

<table>
<thead>
<tr>
<th></th>
<th>b</th>
<th>d</th>
<th>j</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>coronal</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

They divide the four positions of articulation into two directly opposed sets — the set which involves the front portion of the tongue as opposed to the set which does not.

Within each of these two sets, we may distinguish those sounds which are produced at a relatively *anterior* (or forward) position from those which are produced at a relatively *posterior* (or back) position. For example, the [-coronal] sounds include the bilabials and the dorso-velars; among these, the most forward are the bilabials —
accordingly, these will be classified as [+anterior], while the dorso-velars will be [-anterior]. Among the [+coronal] sounds, the apicals are produced with a portion of the tongue (namely, the tip) which is forward by comparison to the part of the tongue used in producing laminals (i.e., the blade). Hence, apicals will be designated [+anterior] and laminals will be designated [-anterior]. The following table illustrates the use of the anteriority features together with the coronality features:

<table>
<thead>
<tr>
<th></th>
<th>b</th>
<th>d</th>
<th>j</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>coronal</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>anterior</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

To sum up, the four positions of articulation are represented as follows in the binary feature notation:

**bilabial**

[-coronal]  
[+coronal]  
[+anterior]  

**apico-alveolar**

[+coronal]  
[+coronal]  
[+anterior]  

**lamino-alveolar**

[+coronal]  
[-anterior]  

In attempting to distinguish the class of consonant sounds from the class of vowel sounds, we pointed out that consonants typically involve some degree of obstruction in the oral cavity, while vowels are characteristically free from such obstruction. We will classify as [+consonantal] those sounds which are consonants under this definition, and all other sounds will be designated [-consonantal]. But this is not quite enough. Stops, fricatives, and nasals are [+consonantal], and this seems reasonable; however, the glides, the laryngeals, and the vowels are classified together as [-consonantal]. We need, therefore, some feature opposition to distinguish the vowels, which are clearly a class unto themselves, from the glides and laryngeals. The prevailing characteristic of vowels is that they are **syllabic**, in the sense defined in chapter VI above. We will therefore designate vowels as [+syllabic], while other sounds will be designated [-syllabic].

13. This is a slight departure from Stanley's usage. Stanley, together with many other linguists, uses the term **vocalic** instead of **syllabic**.
dimensions classify sounds in the following way:

<table>
<thead>
<tr>
<th>consonants</th>
</tr>
</thead>
<tbody>
<tr>
<td>+consonantal</td>
</tr>
<tr>
<td>-syllabic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>-consonantal</td>
</tr>
<tr>
<td>+syllabic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>glides and laryngeals</th>
</tr>
</thead>
<tbody>
<tr>
<td>-consonantal</td>
</tr>
<tr>
<td>-syllabic</td>
</tr>
</tbody>
</table>

Glides, nasals, and vowels (and also liquids) have a property in common which is not reflected in the feature system developed so far. What they have in common is the fact that they are produced in such a way as to allow the breath to exit with complete ease (through the mouth in the case of vowels and glides, through the nose in the case of nasals, and through both the mouth and the nose in the case of nasalized vowels). In addition, these sounds are
typically voiced. We will identify these sounds as [+sonorant] as opposed to other classes of sounds, designated [-sonorant], which are either produced with a degree of constriction which prevents completely free and easy passage of the outward flowing breath or else are typically voiceless. The term sonorant (based on Latin sonor "sound") is not to be equated with voiced, since some sounds, e.g., voiced fricatives like /z/ and /zh/ for instance, are [+voiced] but do not qualify as [+sonorant] because they are produced with a rather narrow and constricted passage in the oral cavity. Instead, fricatives are included with stops among the obstruents (i.e., [-sonorant] segments). The sonority opposition serves to distinguish the glides /w, y/ from the laryngeals /', h/ -- the glides are [+sonorant], while the laryngeals are [-sonorant].

14. In this, we disagree with Stanley, who classifies the laryngeals as [+sonorant].

15. The classification given here conforms closely to the phonetic facts. Recall, however, that from a "relative" point of view /e/ and /o/ are [+low] and [+high], respectively.
In addition, the rounding opposition classifies /o/ as [+rounded], while the other vowels are [-rounded]. This opposition also serves to distinguish rounded and unrounded dorso-velar consonants -- /kw/ and /hw/ are [+rounded], while /k/ and /h, x/ are [-rounded]. And the nasality opposition also functions in the vowel system -- Thus, /ɨ, ŋ, a, ə/ are [+nasal], while their oral counterparts /i, e, a, o/ are [-nasal]. Finally, high-toned vowels are designated [+high tone], while low-toned vowels are [-high tone]. And, speaking from a strictly phonetic point of view at least, the long vowels, written (and perhaps to be analyzed) as vowel sequences, are [+long] while their short counterparts are [-long].

3. We will return now to the subject of assimilation and in particular we will reconsider our treatment of the assimilation process in which laminal affricates and fricatives become apico-alveolar, and vice versa. The first of these processes which we considered was, in our earlier feature notation, expressed in a rule of roughly the following form (as revised in the exercises at the end of the last chapter):
The effect of this rule is to convert underlying phonological representations like

/shi-tsii'/
/shi-k'is/
/ji-z'i/

into phonetic representations in which the affricates and fricatives within the word agree in position of articulation:

[sitsii']
[sik'is]
[dziz'i].

Let us now consider how this rule would be expressed in the binary feature notation introduced in this chapter. The class of lamino-alveolar median affricates and fricatives can be identified in the following way -- they are all lamino-alveolar, which, in the revised feature representation, is defined as [+coronal] and [-anterior]; they are median, i.e., they are not laterals, hence [-lateral]; and finally they have in common the property of stridency, so they are [+strident]. Since laterals are [-strident], we do not need to
include the feature [-lateral] in referring to the consonants relevant to this rule, since laterals (as well as nasals, vowels, glides, liquids and "pure" or unaffricated stops) are excluded from the class at issue here by virtue of the fact that the feature specification [+strident] is included. If we omit the specification [-lateral], the class of consonants which undergoes the rule can be defined by means of just the following features:

\[
\begin{array}{c}
+\text{coronal} \\
-\text{anterior} \\
+\text{strident}
\end{array}
\]

Notice that by using the feature [+strident] we do not have to refer individually to affricates and fricatives, as we did in the earlier feature representation, since both these classes are characterized by stridency. Now, the effect of the rule is to change the appropriate segments from laminal to apical -- i.e., from [-anterior] to [+anterior], in the revised feature system. This process takes place in the context of a following apico-alveolar median affricate or fricative -- that is to say, in the context of a following segment

16. Omission of the feature [-lateral] may be a mistake, because the voiceless laterals, including the lateral affricates /dl, tl, tl'/ as well as the lateral fricative /ʃ/, may prove to be [+strident] upon detailed acoustic analysis. We also omit from this feature representation such "higher-level" specifications as [-syllabic], [+consonantal], [-sonorant]. For technical reasons, which we will not go into here, these should actually be included. We omit them for space-saving reasons only -- the rules should, however, be understood as including these feature specifications as well as those for position of articulation and stridency.
which is

\[
\begin{array}{c}
\text{[+coronal]} \\
\text{[+anterior]} \\
\text{[+strident]}
\end{array}
\]

The complete rule would now be expressed as follows:

\[
\begin{array}{ccc}
\text{[+coronal]} & \rightarrow & \text{[+anterior]} / \_X \\
\text{-anterior} & \rightarrow & \text{[+anterior]} / \_X \\
\text{[+strident]} & \rightarrow & \text{[+anterior]} / \_X
\end{array}
\]

Recall that Navajo also has a rule which is the inverse of this. In our earlier feature notation it was expressed roughly as follows:

\[
\begin{array}{c}
\text{[apico-alveolar]} \\
\text{[affricate]} \\
\text{[fricative]}
\end{array}
\rightarrow
\begin{array}{c}
\text{[lamino-alveolar]} \\
\text{[affricate]} \\
\text{[fricative]}
\end{array}
\]

This rule applies to underlying representations such as

/si-jié’/  
/si-béézh/  
/'a-dzi-sh-taaž/  

and converts them to phonetic

[shijéé’]
[shibéz̜h]
['ajishtaaż]

In the revised feature representation, this rule would appear as

\[
\begin{array}{c}
+\text{coronal} \\
+\text{anterior} \\
+\text{strident}
\end{array} \rightarrow \begin{array}{c}
-\text{anterior} / \_\_X
\end{array}
\begin{array}{c}
+\text{coronal} \\
-\text{anterior} \\
+\text{strident}
\end{array}
\]

We pointed out in our previous discussion of these two rules that they have very similar effects and that, most likely, they constitute a single process. If this is so, then our description, or grammar, is missing a generalization by having two separate rules. If they really are one process, then there should be only one rule. The actual generalization seems to be roughly the following:

If there are two strident segments in a word, the first must agree in position of articulation with the second.

More accurately, the first of two strident segments must agree with the second in terms of the feature dimension \([\text{anterior}]\). Thus, in the phonetic output of the rule, a strident segment will be \([+\text{anterior}]\) before another strident segment which is \([+\text{anterior}]\), and it will be \([-\text{anterior}]\) before another strident segment which is \([-\text{anterior}]\). Now, with the revised feature notation, using the
coefficients plus and minus, we are in a position to express the true generalization involved here by collapsing the two rules into a single one. Notice first, that we can collapse the initial portion of the two rules (i.e., the affected segment; the portion of the rule which is to the left of the arrow) by simply omitting the feature specification for anteriority, since for the process we are considering, it does not matter whether the affected segment starts out laminal or apical -- what matters is how it ends up after the rule applies. Thus, we can represent the affected segment as simply:

\[ \text{[+coronal]} \]
\[ \text{[+strident]} \]

This embraces both laminal and apical affricates and fricatives.

Now, the effect of the desired rule is to assign the same value (i.e., the same plus or minus prefix) to the anteriority specification in the affected segment as that present in the conditioning segment (i.e., the segment appearing to the right of the diagonal /). We can accomplish this by using a variable in place of the coefficients plus and minus. The symbol commonly employed for the variable in a case like this is the Greek letter alpha (\( \alpha \)). The two rules can now be collapsed into a single rule of roughly the following form:

\[ \text{[+ coronal]} \quad \rightarrow \quad [\alpha \text{ anterior}] / \quad X \quad \text{[+ coronal]} \]
\[ \text{[+ strident]} \]

17. Accordingly, such rules are often nick-named "alpha-rules".
The rule can be read as meaning approximately:

Let the value for the feature [anterior] in the affected segment be the same as the value for the feature [anterior] in the conditioning segment, whatever that value may be.

This is evidently the correct formulation of this process, since it clearly reflects the fact that an assimilation is involved -- the affected segment (to the left of the arrow) assimilates in position of articulation to the conditioning segment (to the right of the diagonal).

4. For your convenience, we include here three tables giving the binary feature specifications for Navajo sounds. At the top of the first two tables, the sounds are given in their alphabetic notation according to the current (i.e., Young and Morgan) orthography; at the bottom, the sounds are given in the technical phonetic (or Haile) orthography.
Stops, Affricates, and Fricatives

|        | b | d | t | t' | dz | ts | ts' | z | s | j | ch | ch' | zh | sh | dl | tl | tl' | l | /twitter | g | k | k' | gh | x, h |
|--------|---|---|---|----|----|----|-----|---|---|---|----|-----|----|----|----|----|----|----|---|----|---|----|----|----|---|
| syllabic | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| consonantal | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| sonorant | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| coronal | - | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| anterior | + | + | + | + | + | + | + | + | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + |
| continuant | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + | - | - | + | - | + | + | + | + | + |
| nasal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| lateral | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | + |
| strident | - | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| aspirated | - | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | - | + | + | + | + | + | + | + |
| glottalized | - | - | + | - | - | + | - | - | - | + | - | - | + | - | - | - | - | + | + | + | + | + | + | + |
| voiced | b | d | t | t' | d | c | c | z | s | ž | c | č | ž | š | ě | ć | ě | ž | ě | ž | ć | l | l | g | k | k' | y | x |
## Sonorants and Laryngeals

<table>
<thead>
<tr>
<th>Category</th>
<th>m</th>
<th>'m</th>
<th>n</th>
<th>'n</th>
<th>w</th>
<th>y</th>
<th>'y</th>
<th>'</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>syllabic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>consonantal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>sonorant</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>coronal</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>anterior</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>continuant</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>nasal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>lateral</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>strident</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>aspirated</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>glottalized</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>voiced</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

m m n n w y y '/' h
## Vowels

|       | i | e | a | o | ï | ë | æ | å | í | é | á | ó |
|-------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| syllabic | + | + | + | + | + | + | + | + | + | + | + | + | + |
| consonantal | - | - | - | - | - | - | - | - | - | - | - | - | - |
| nasal | - | - | - | + | + | + | - | - | - | - | - | - | - |
| high tone | - | - | - | - | - | - | - | + | + | + | + | + | + |
| high | + | - | - | - | + | - | - | - | - | - | - | - | - |
| low | - | - | + | - | - | - | - | - | - | + | - | - | - |
| back | - | - | + | + | - | - | - | + | - | - | + | - | - |
| rounded | - | - | - | + | - | - | - | - | + | - | - | - | - |
5. In identifying any given phonological segment, certain features are redundant. Because of this, it is not necessary, in writing rules, to list all of the phonological feature specifications which pertain to the phonological segments involved -- only those features which distinguish the segments from all others in the language need be mentioned. In this section, we will provide a partial definition of 'redundant feature'.

Given the general class to which a segment belongs, if all members of the class are marked in the same way for some feature, then that feature is redundant and need not be mentioned in the feature representation of the segment. This is so unless the feature is specifically mentioned in the rule. Thus, for example, in giving the feature specifications for the low-toned oral vowel /a/, the feature [+syllabic] identifies its general class -- i.e., vowel. All vowels are [-consonantal], [+sonorant]; and for Navajo at least, all vowels are [+continuant], [-strident], [+voiced], [-aspirated], and [-glottalized] -- hence, these features are redundant in the feature representation for /a/ once this segment is identified as a vowel by virtue of the feature specification [+syllabic].\(^{18}\) However, nasality, the tonal features, and the features having to do with tongue height and horizontal positioning, and the feature of lip rounding, are relevant to the identification of a vowel, since not

\(^{18}\) We do not know whether vowels should be specified for coronality and anteriority -- this is one of the very many areas where our understanding of phonological features is still incomplete.
all vowels have the same value for these feature dimensions.

One more example might be provided to illustrate the omission of redundancies from feature representations. The glottal stop in Navajo can be uniquely identified by means of just four features:

\[
\begin{array}{c}
\text{-syllabic} \\
\text{-consonantal} \\
\text{-sonorant} \\
\text{-continuant}
\end{array}
\]

The feature [-syllabic] distinguishes the glottal stop from the vowels, [-consonantal] distinguishes it from the consonants, and [-sonorant] distinguishes it from the glides. Finally [-continuant] distinguishes it from the only other laryngeal segment /h/. Other features, like [-nasal], [-strident], and such feature dimensions as coronality, anteriority, are either redundant in the sense defined earlier or else are totally irrelevant to the feature representation of laryngeals.


(1) Below are given a number of feature representations for Navajo phonological segments. For each of these, provide the corresponding alphabetic notation:
1) [ -syllabic  
   +consonantal  
   -sonorant  
   +coronal  
   +anterior  
   +continuant  
   -nasal  
   +lateral  
   +voiced ]

11) [ -syllabic  
   +consonantal  
   +sonorant  
   -coronal  
   +anterior  
   +continuant  
   +nasal ]

111) [ -syllabic  
       -consonantal  
       -sonorant  
       +continuant ]

1v) [ +syllabic  
      +nasal  
      -high tone  
      +high  
      -low  
      -back ]
(2) Supply feature representations for each of the following segments:

/n, t, s, q, k', gh, z/.

(3) The linguistic validity of feature representations consists in the fact that they allow reference to natural classes of phonological segments. Segments belong to a natural class if they can be referred to by means of a single "feature" bundle. Thus, for example, the sounds /b, d, dl, dz, j, g/ constitute the natural class of unaspirated stops, which is expressed in feature notation as:
-syllabic
+consonantal
-sonorant
-continuant
-aspirated
-glottalized

By contrast, the following assemblage of sounds is not a natural class: /b, i, k', zh/. Accordingly, there is no single feature bundle which is capable of referring to all and only these four segments -- instead, four separate feature bundles must be used.

Below are listed several assemblages of phonological segments; determine which constitute natural classes and, for each natural class, supply a correct feature representation:

1) /i, e, a, o/
2) /k', m, n, t'/
3) /s, z, sh, zh/
4) /b, g/
5) /b, t/.

(4) The following rule is expressed in alphabetic notation. Formulate the rule in feature notation:

\[ a \rightarrow e / \_ \_ 1 \]
(5) Show how the following rules can be collapsed into a single rule using the feature notation:

\[
\begin{align*}
    z & \rightarrow s / \{ \begin{array}{c}
        s \\
        \{ \begin{array}{c}
            \lambda \\
            \text{sh} \\
            x
        \end{array}
    \end{array} \} \\
    l & \rightarrow 1 / \{ \begin{array}{c}
        s \\
        \{ \begin{array}{c}
            \lambda \\
            \text{sh} \\
            x
        \end{array}
    \end{array} \} \\
    zh & \rightarrow \text{sh} / \{ \begin{array}{c}
        s \\
        \{ \begin{array}{c}
            \lambda \\
            \text{sh} \\
            x
        \end{array}
    \end{array} \} \\
    gh & \rightarrow x / \{ \begin{array}{c}
        s \\
        \{ \begin{array}{c}
            \lambda \\
            \text{sh} \\
            x
        \end{array}
    \end{array} \} 
\end{align*}
\]

(6) What does the following rule say? It is a rule of Navajo phonology -- can you provide an example of its application?

\[
\begin{align*}
    \text{-syllabic} & \\
    \text{+consonantal} & \\
    \text{-sonorant} & \\
    \text{+continuant} & \\
    \text{+voiced} & \\
\end{align*}
\rightarrow [-\text{voiced}] / \#\#_.
\]
7. Answers.

(1) /ə/
  /m/
  /n/
  /ŋ/
  /tʃ/
  /tl'/.

/n/

(2) -syllabic +consonantal +sonorant +coronal +anterior +continuant +nasal

/t/

-syllabic +consonantal -sonorant +coronal +anterior -continuant -lateral -strident +aspirated
/s/
  -syllabic
  +consonantal
  -sonorant
  +coronal
  +anterior
  +continuant
  -nasal
  -lateral
  +strident
  -voiced

/q/
  +syllabic
  +nasal
  -high tone
  -high
  -low
  +back
  +rounded

/k'/
  -syllabic
  +consonantal
  -sonorant
  -coronal
  -anterior
  -continuant
  +glottalized
(3) i)  

+syllabic

-nasal

-high tone

ii) not a natural class
iii)  
- syllabic  
+ consonantal  
- sonorant  
+ coronal  
+ continuant  
- nasal  
- lateral  
+ strident  

iv)  
- syllabic  
+ consonantal  
- sonorant  
- coronal  
- continuant  
- aspirated  
- glottalized  

v)  
not a natural class.

(4)  

+syllabic  
- nasal  
- high tone  
- high  
+ low  
+ back  

→  
- back  

/  

+syllabic  
- nasal  
- high tone  
+ high  
- back
(5) 

\[
\begin{array}{c}
\text{-syllabic} \\
\text{+consonantal} \\
\text{-sonorant} \\
\text{+continuant} \\
\text{+voiced}
\end{array} \rightarrow \begin{array}{c}
\text{-syllabic} \\
\text{+consonantal} \\
\text{-sonorant} \\
\text{+continuant} \\
\text{-voiced}
\end{array}
\]

(6) The rule says, approximately:

"Devoice a voiced fricative word-initially."

An example is: /##z\&s/ \rightarrow [##s\&s].