Hz for male speakers. Fant (1960) and Bladon (1979) have suggested that Fl varies inversely with the cross-sectional area of the lateral passage. If this were so then laminal Coronal and Dorsal laterals would be expected to share a higher Fl (since the body of the tongue is raised and the lateral passage consequently more constricted) and apical and sub-apical laterals would share a lower Fl. Note that this grouping of laterals on acoustic grounds has no parallel with the groupings established by acoustic properties of stops or nasals. We find at best partial confirmation of Fant and Bladon's theoretical claims in real language materials. We have measured the formants in a large number of laterals in words spoken by one female speaker of Eastern Arremte. Spectrograms of representative tokens of the four coronal laterals in intervocalic position, together with the special retroflex lateral variant which occurs in clusters with stops are shown in figure 6.8. Measured formant values are shown in table 6.4. The apical post-alveolar has a significantly lower Fl than other laterals and the laminal dental and 'palatalized retroflex' (which also appears to have a laminal articulation) have the highest Fl's. However, the apical alveolar and the laminal post-alveolar have similar Fl values and do not follow the theoretical expectations. (Tire other formant frequencies in table 6.4 will be discussed later in this section.)

Data from some other languages also offer no support for the idea that laminal laterals uniformly have a higher Fl. The laminal post-alveolar lateral of Breton has a lower range of Fl than the apical alveolar (Bothorel 1982), and the palatalized lateral of Bulgarian has an Fl 100-150 Hz lower than the plain (apical) lateral (Tilkov 1979). Vagges, Ferrero, Magno-Caldognetto and Lavagnoli (1978) show a mean Fl of 500 Hz for 1 and of 280 Hz for X for ten speakers of Italian. The two laterals of Russian are, however, shown as having the same Fl by Zinder, Bondarko and Berbitskaja (1964), contra Fant (1960).

We would anticipate a high Fl for velar laterals following Fant and Bladon. And, in fact, in our materials from Mid-Waghi (one speaker) and Melpa (two speakers) the highest Fl in a lateral segment is observed in the velar lateral. The relatively high Fl for the velar lateral can be seen in the spectrograms of the three contrasting laterals in Mid-Waghi given in figure 6.9. It may also be noted that the velar laterals in Mid-Waghi are occasionally 'prestopped'. There

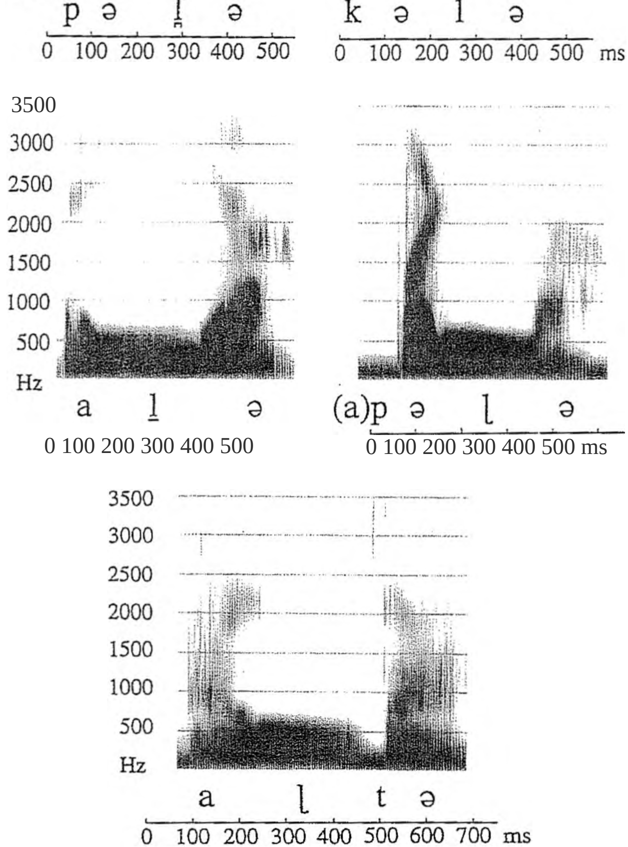

Figure 6.8 Spectrograms of the four (non-labialized) coronal laterals of Eastern Arremte and the variant, traditionally considered a 'palatalized retroflex' which occurs in clusters before stops. The words are pals 'spit', kala 'all right', a]a 'boomerang', apa[a 'father's mother' (initial vowel not shown), ajta 'day'.

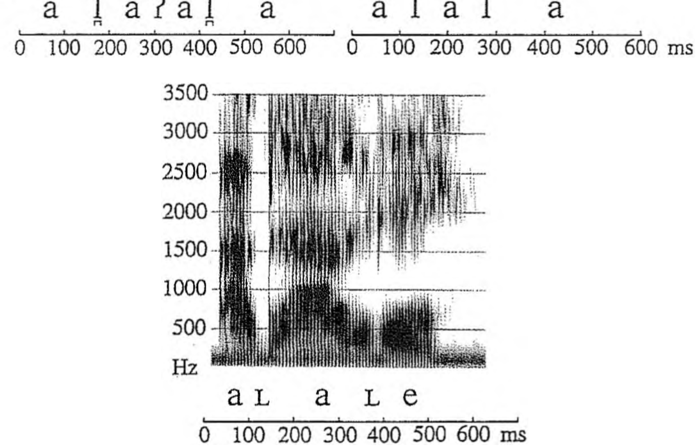

Figure 6.9 Spectrograms of laminal dental, apical alveolar and velar laterals in Mid-Waghi (see Table 6.2 for glosses).

is a brief velar stop closure preceding the first velar lateral in figure 6.9, but the second is entirely approximant in nature.

For laterals without a secondary constriction involving the back of the tongue, the frequency of the second formant seems to be inversely related to the volume of the oral-pharyngeal cavity behind the articulatory occlusion (Bladon 1979). Measurements of F2 for the four laterals of Kaititj and Alyawarra, given in table 6.5, together with the F2 measurements on Arremte in table 6.4 confirm this pattern. The pattern of relative height of F2 is generally similar for all three speakers. It is lowest in the apical alveolar, intermediate in the laminal dental and apical post-alveolar (retroflex) cases, and highest in the case of the laminal post-alveolar (palato-alveolar) laterals, which have the smallest cavity behind the closure. When F2 is similar the laminal dental and apical post-alveolar are presumably distinguishable by the decidedly higher Fl

	Russian	Bulgarian	Albanian
Velarized	900	1000	950
Contrasting lateral	2200	1800	1550

of the dental, as well as by different durations and transitional characteristics. In general, as table 6.4 and figure 6.9 show, F2 and F3 are closer together in laminal laterals than in apical ones.

In Melpa and Mid-Waghi the lowest F2 is again found in the apical alveolars, but F2 is lower in the velar laterals than in the laminal dental type, contrary to expectation. This may be seen for Mid-Waghi in figure 6.9. However, note that F2 is much higher in these velar laterals than it is in *velarized* alveolars (i.e. those in which the back of the tongue is partially raised toward the velum). Values for Albanian, Bulgarian and Russian velarized and non-velarized laterals are given in table 6.6. Although one must be cautious in comparing data across different subjects, it does seem that F2 is lowest in apical laterals with an additional narrowing at the back. F2 will be lower the narrower this constriction becomes, as for the production of high back vowels.

6.3 Other Types of Laterals

The most common laterals are voiced and approximant, as discussed above; but there are also a number of other possibilities. Lateral articulations can be accompanied by most of the different laryngeal settings discussed in chapter 3 and they can occur with various types of stricture. We will discuss these various possibilities in this chapter, and some of the interactions between phonation type and manner that are commonly observed among laterals. Lateral clicks will be discussed in chapter 8, together with other clicks.

laterals are given in table 6.7. A voiceless apical post-alveolar (retroflex) lateral occurs in laai (Ozanne-Rivierre 1976, Maddieson and Anderson 1994), contrasting with its voiced counterpart, and with a pair of voiced and voiceless dental laterals. As seems to be the usual pattern for languages with voiceless lateral approximants, there are also voiceless nasals in laai, but this pattern does not hold true for Toda.

In some instances, linguists have chosen to regard voiceless lateral approximants as phonemically composed of either 1 + h, as in Purnell's (1965) analysis of Mien (Yao), or of h + I, as Smith (1968) does for Sedang, but we believe these segments are in no way distinct from other voiceless lateral approximants. (We do not rule out the occurrence of clusters of h + I or I + h, but simply note that transcriptions such as hl, Ih are often equivalent to 1).

In the case of a substantial number of other languages the available descriptions do not specify if the voiceless laterals occurring in them are approximant or fricative in nature. Perhaps this is because there is a widespread tradition of regarding all voiceless laterals as fricatives, -with turbulence necessarily resulting from the air passing through the lateral aperture (cf. Pike 1943). However, we draw a distinction between voiceless laterals that are articulated with an aperture comparable in area to that of voiced lateral approximants and those produced with a more constricted aperture, comparable to that of other fricatives. We will discuss lateral fricatives more fully below; at this point we would only like to point out that voiceless lateral approximants are distinguishable acoustically from voiceless lateral fricatives in a number of different ways. Maddieson and Emmorey (1984) compared Burmese and Tibetan, which have voiceless lateral approximants, with Navajo and Zulu, which have voiceless lateral fricatives. Their measures showed that the voiceless

Table 6.7 Words illustrating contrasting laterals in Toda

	Alveolar		Retroflex	
Voiceless	kal	'study'	pa[	'valley'
Voiced	kal	'bead'	paj.	'bangle'

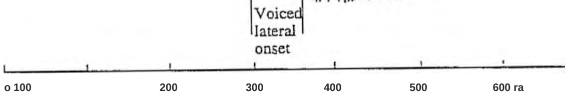

figure 6.10 Waveforms illustrating differences between a voiceless lateral fricative in the Zulu syllable la: and a voiceless lateral approximant in the Burmese syllable la. The lower amplitude and the anticipation of the voicing in the approximant are apparent

Table 6.S Devoicing and frication of final laterals in Melpa

	Laminal dental		Apical alveolar		Velar	
Medial	kialtim	'fingernail'	Iola	'speak improperly'	pata	'fence'
Final	wal	'knitted bag'	bai	'apron'	raL	'two'

approximants typically have a lower amplitude of noise, a greater tendency to anticipate the voicing of a following vowel, and a concentration of energy lower in the spectrum than voiceless fricative laterals do. Waveforms of tokens from Burmese and Zulu illustrating some of these differences are given in figure 6.10. The distinction between Burmese and Tibetan as opposed to Navajo and Zulu is quite clear, but in other cases it is difficult to decide whether a voiceless lateral should be described as an approximant or a fricative. Taishan Chinese, which was also included in Maddieson and Emmorey's study, is usually described as having a voiceless dental lateral fricative, which varies with a central dental fricative, 0. The measurements showed that the lateral variant in this language was intermediate between the clearer cases.

We do not know of a language with a minimal contrast between voiceless lateral approximant and fricative but both types can appear in the same language. Hupa (Golla 1970) has the allophone 1 after h in the word tj"ahi 'frog' as well as the fricative i, e.g. in mil 'when'. It is not unusual for lateral approximants to become substantially devoiced in clusters with voiceless segments, or in final position. All three lateral segments in Melpa and Mid-Waghi devoice in final position, as noted in the Melpa examples given in table 6.8, but in these languages the results of this devoicing process are best described as lateral fricatives.

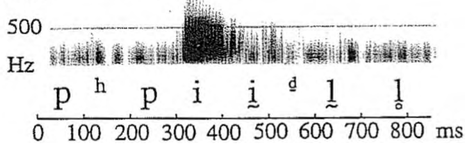

Figure 6.11 Spectrogram of the Montana Salish word ppi] (in a narrow transcription [p^{h}pij^{d}J 1]) 'pint'.

Table 6.9 Words illustrating contrasting alveolar laterals in initial position in Montana Salish

VOICELESS FRICATIVE	laqjalf	'sit down!'
VOICED APPROXIMANT	laq'i	'sweatbath'
LARYNGEALIZED APPROXIMANT	llats	'red raspberry'
EJECTIVE AFFRICATE	tl'aq'	'hot'

Voiced laryngealized lateral continuants occur in several languages, such as Tiddim Chin, Nez Perce, Chemehuevi, Haida, Sedang, Klamath. These last two languages have a three-way contrast of voice quality in laterals, having voiced, voiceless and voiced laryngealized lateral approximants. Montana Salish has modally voiced and laryngealized voiced lateral approximants, as well as laterals of other types. Examples from Montana Salish are given in table 6.9, which also illustrates the lateral ejective which we will discuss later. A laryngealized lateral from Columbian Salish was illustrated in figure 4.5.

In Montana Salish, the lateral approximants, including the laryngealized laterals, tend to be prestopped, and to become devoiced in final position and before voiceless consonants. Thus, as shown in figure 6.11, a laryngealized lateral, which, phonologically, is the final consonant in the word, may be produced as a creaky voiced vowel, followed by a brief stop, a creaky lateral, and finally a voiceless lateral approximant.

This prestopping can also occur in Montana Salish when there is a sequence of identical laterals, as in the example in figure 6.12, which shows the sequence of consonants in the middle of the word p'allitf'tf 'turned over'. Note that these laterals are produced with a considerable amount of (non-distinctive) frication, indicating that the lateral escape channel is very narrow. In the narrow transcription in figure 6.12, the symbol Ij has been used. The first of these

0 100 200 300 400 500 ms

Figure 6.12 The sequence of lateral consonants in the first part of the Montana Salish word p’allitf’tf 'turned over'. In the narrow transcription beneath the spectrogram the prestopping is indicated by a raised ^{d}.

two laterals has a stop closure preceding it, and a burst as this closure is released, similar to that seen in figure 6.11. The second lateral does not have a similar closure interval, but there is a transient in the spectrum, closely resembling that produced by the release of a stop. It is much stronger than the transient produced at the onset of the following vowel by the release of the central closure of the tongue. Exactly how this transient is produced is not clear to us at the moment, but it must involve a very brief obstruction of the lateral escape channel. This would be facilitated by the fact that the channel is already constricted so that only a small movement is required. Furthermore, the constricted airflow will result in an elevated intra-oral air pressure, compared to an approximant production. A very brief closure would therefore impound pressure immediately. Such discontinuities indicate that, in these cases at least, the sequences consist of two separate consonants rather than long consonants.

Breathy voiced laterals occur in a number of languages, notably those that also have breathy voiced stops. Hindi is often considered to have a phonemic contrast of plain and breathy voiced lateral approximants, though Ohala (1983) suggests that 1 should be regarded as a sequence Ih principally because breathy voiced liquids and nasals are limited to medial position. Dixit (1975) showed that although vocal cord vibration continues throughout this segment, there is also a glottal opening gesture. This gesture starts after the oral closure for the lateral is formed, and peaks some 40 ms after the release. In broad terms, this relative timing pattern is similar to that seen for breathy voiced consonants of other types in intervocalic position, hence we consider 1 a genuine lexical segment of Hindi. Although they have not been studied in such detail in any other language, breathy voiced laterals occur in several other Indo-Aryan languages there, contrastive lateral fricatives occur at a variety of places and with different phonation types. They are most frequently voiceless. In addition to the occurrence of lateral fricatives alone, a stop closure can be released into a homorganic lateral fricative, with the combination being considered to form a lateral affricate under the same kind of conditions that would lead to a decision to consider a stop released into a central fricative to be an affricate. In the affricates the stopped portion of the segment is not itself lateral (it could not be a stop otherwise); but the stop is released by lowering some portion of the sides of the tongue, rather than the center. Like lateral fricatives, lateral affricates are more commonly voiceless than voiced, and are frequently ejective. Because these classes of sounds are closely related, we will discuss them together.

A stop closure can also be combined with an approximant lateral. Such combinations usually involve what we would consider a sequence of sounds, as in English words such as *melt, weld, puddle, shuttle.* Clusters consisting of homorganic approximant laterals and stops in either order occur widely in the world's languages. Because the articulatory adjustment required to pass from a lateral to a homorganic stop or vice-versa is a minimal one, these sequences can be closely bound together at the level of articulatory organization. A special term, lateral plosion, is used to describe the release of a plosive directly into a lateral by lowering one or both sides of the tongue. In a small number of languages prestopped laterals have been analyzed as units. In Arabana and Wangganuru (Hercus 1973) di and dl occur as allophones of the (laminal) dental and apical alveolar lateral approximants. These variants occur in word-medial positions after the initial stressed syllable in words which begin with a consonant. Although the distributional pattern of these elements may justify their treatment as single units from the phonological point of view, we know of no evidence in this case that they are phonetically distinct from stop + lateral clusters. We have noted above the allophonic prestopping of laterals in Montana Salish, where there are special phonetic characteristics to observe. We are not aware of any languages for which it has been proposed that a lateral + stop sequence should be analyzed as a single segment, i.e. as a 'prelateralized stop' parallel to the prenasalized stops discussed in chapter 4.

Laterals can also be flaps or taps. We will illustrate these at the end of this voiced alveolar lateral approximant under specific morphological conditions, but because of loanwords the two segments now contrast. A voiceless approximant occurs in clusters after an initial voiceless stop. Examples are given in table 6.10. Ball and Muller (1992) provide measurements on 1 and 1 for two speakers of Welsh. In initial and medial positions 1 is about twice as long as 1 and has no anticipatory voicing. The fricative 1 has a higher second formant than 1 and considerable noise concentrated in the frequency range between about 5000 and 7000 Hz.

Lateral fricatives occurring at different places of articulation occur in Bura, which is unusual in having a contrast between voiceless lateral fricatives at two places of articulation, apical alveolar and palatal. We will use the symbol X for the voiceless palatal lateral fricative. There is also a voiced apical alveolar lateral fricative, and an alveolar lateral of the more usual voiced approximant type. Spectrograms of these four sounds are given in figure 6.13.

Hoffman (1957) and Ladefoged (1968) give examples of an additional lateral, a voiced palatal lateral approximant, making Bura a language with five lateral segments. The two voiceless lateral fricatives differ in that the main noise concentration in the palatal is centered in a higher frequency region than it is in the alveolar. A similar distinction is found between the apical alveolar and laminal post-alveolar voiceless lateral fricatives of Diegueno. A voiced lateral segment described by Shafeev (1964) as a 'prepalatal fricative' occurs in Pashto. This would appear to be the voiced counterpart of the Diegueno segment. As noted above, the Taishan dialect of Chinese has a voiceless apical dental lateral fricative, which for many speakers can vary with a central dental fricative, 6. Gowda (1972) describes a voiced apical post-alveolar lateral fricative in Ao (Naga). We have not heard this sound but the description seems quite clear.

Table 6.10 Words illustrating laterals in Welsh (from Thomas 1992)

Voiceless fricative	Voiced approximant		Voiceless approximant	
lond 'full'	loin	'road'	tluiS	'pretty'
mitdir 'mile'	xwildro	'revolution'	klilSt	'ear'