tion allows for the possibility of a secondary fricative articulation combined with a primary stop articulation. We suggest that, from a phonetic point of view, secondary articulations are always approximant-like in nature and do not include fricatives superimposed on stops.

When stop-fricative combinations have been treated as single segments for phonological reasons the phonetic descriptions provided often assert or imply simultaneity. An example is Lombard's analysis of SePedi, where psʰ, pf are described as simultaneous plosive and fricative in words like psʰio 'kidney' and yupja 'to dry up'. These words are illustrated by the spectrograms in figure 10.17. In these examples we do not know how early the tongue is positioned for the alveolar or post-alveolar fricative during the closure phase of the bilabial stop. There is certainly some articulatory overlap, since the stop is released directly into the fricative, indicating that the tongue is already positioned for the fricative before the stop is released, but there is no frication before the stop in the SePedi examples whereas there is a relatively steady-state fricative portion after the stop release, indicating that the temporal centre of the fricative gesture is later than that of the stop. The timing seems similar to that found in English words such as *topsheet* or *caption.* Here, despite the syllable break between the two consonants, considerable articulatory overlap

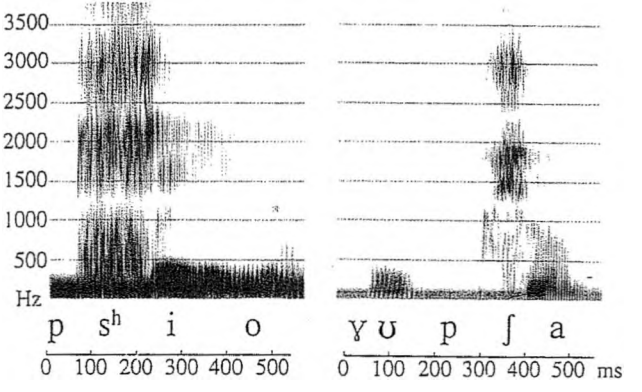


Figure 10.17 Spectrograms of the SePedi words psʰio 'kidney' and Yupja 'to dry up'.

netic possibility distinct from such sequences. It therefore follows, given a three-way partition of degree of stricture, that only the combinations of closure + open approximation, and close approximation (frication) + open approximation remain as ways of combining a primary and a secondary articulation. In other words, secondary articulations will always be approximant or vowel-like in their degree of stricture.

The timing of secondary articulations in relation to the primary ones they accompany is the second general issue that requires more discussion. In the case of double articulations, the scope of the discussion was limited to those phonetic events in which two gestures occur virtually simultaneously. Even though it was argued that small timing offsets between the articulations may have great phonetic importance, the total duration of the gestures does not equal that of a (carefully spoken) sequence of two articulations in a cluster. The same considerations apply to secondary articulations, but the difficulties of demarcating comparable boundaries between a primary and a secondary articulation are greater than for doubly-articulated stops. Formation and release of a closure provide definite landmarks, but approximant articulations lack comparable boundaries. Nonetheless we feel that a useful distinction can be drawn between a consonant with a secondary articulation and a sequence of a consonant and an approximant. In practice, this distinction can be difficult to make, and many published descriptions of languages are written without such a distinction in mind. We will return to this question at several points in the discussion that follows.

There are several different types of secondary articulations which we will describe below. Articulatory gestures involving closure or close approximation can be accompanied by less extreme gestures involving raising the tongue body towards the front or back of the palate or by retracting the root of the tongue, whenever these articulators are not pre-empted for the primary articulation. Such added articulations are customarily referred to as palatalization, velarization and pharyngealization respectively. None of these is as common as labialization, a secondary articulation involving the lips. Since it is most common, labialization will be discussed first.

refer to this complex and propose the term 'simple labialization' to describe instances where lip rounding alone needs to be distinguished. However, the combination of lip rounding and raising of the front of the tongue will be referred to as labiopalatalization. As far as we are aware, labiopalatalization only occurs as an allophonic variant of labialization in front vowel contexts in certain languages. In Akan, for example, labiopalatalized alveolar plosives are the allophonic variants of labialized velars that occur before front vowels (Dolphyne 1987).

Labialization is the most widely found secondary consonantal articulation, both with respect to the number of different types of segments with which it co-occurs, and the number of languages in which it is found. It is especially common with velar obstruents and, relative to their frequency, with uvulars. Many languages, including such varied ones as Amharic, Wantoat and Guarani, permit labialization only of such back consonants. Examples from Kwakw'ala, another language with such a restriction are given in table 10.9. (Note that the velar sounds in this language are more fronted than in many others, and have sometimes been described as palatalized.)

Other languages, including certain Australian and Caucasian languages, permit labialization of a much wider range of consonants, including those whose primary place of articulation is labial. Examples from Eastern Arremte are given in table 10.10.

Table 10.9 Words illustrating the labialized consonants and contrasting plain velar and uvular consonants in Kwakw'ala (from Grubb 1977)

	VELAR	LABIALIZED VELAR	UVULAR	LABIALIZED UVULAR
VOICELESS PLOSIVE	kasa 'beat soft'	k"'esa 'splashing'	qesa 'coiling'	q^{w}e'sa 'peeling'
VOICED PLOSIVE	gisgas 'incest'	g"esu 'P>g'	Gaeas 'grandparent'	G"alas 'lizard'
VOICELESS FRICATIVE	xe'sa 'lost'	'x^{w}asa (a dance)	/asa 'rotten'	'/"at'a 'sparrow'
EJECTIVE STOP	k'ata 'writing'	k^{w}'e'sa 'light (weight)'	q'asa 'sea otter'	q^{w}'asa 'crying'

PRESTOPPED NASALS	pm^{w}ana 'coolamon'	'rock pigeon'	atn"ara 'heel'		atrT'ap 'wild'	krpala 'dog'
PRENASALIZED STOPS	mp"ara 'maggot'	'guts'	jant"ara 'over there'	ant^{w}a 'nest'	mpaiLt'a 'Alice Springs'	rjk"aiL3 'bone'
LATERALS	—	**al "a** 'blood'	al"ara 'swollen'	apaka 'stone knife'	'boulder'	—
RHOTICS AND APPROXIMANTS	—	—	ar"a 'handle of shield'	aj^{w}a 'old man'	a^a 'rock wallaby'	—

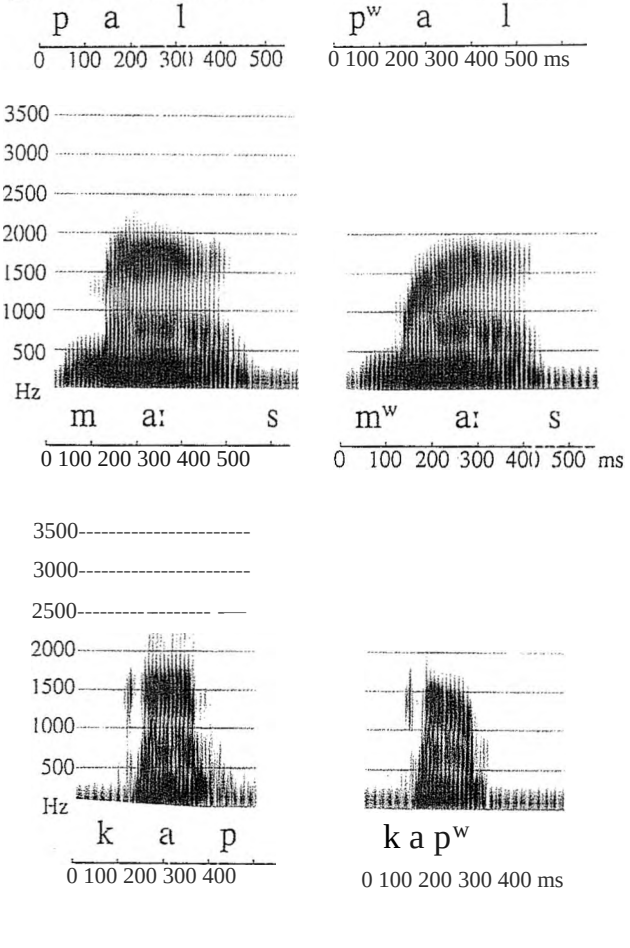
It is interesting to note that in several languages, including Arrernte, linguistic analyses have shifted between interpretation of the rounding feature as a property of the consonant system or of the vowel system. Better data and analysis suggest that, at least for the Arandic languages, rounding plays no role in the underlying system of vowels (Wilkins 1989); instead there are the large number of labialized consonants indicated above. As indicated in chapter 9, we assume an analysis of Arrernte with two underlying vowels, a and a.

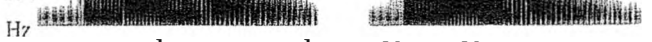
In most languages with which we are familiar a stronger acoustic effect of the lip action is seen at the release of the primary stricture of a labialized consonant than is seen at the onset of this stricture. We believe this arises because of an asymmetry in the timing between the primary and secondary articulations that is not unlike that seen in most labial-velar stops. Thus we can say that labialization is typically concentrated on the release phase of the primary articulation that it accompanies. This observation has both phonetic and phonological significance. Many more languages have a restriction between the presence of labialization and the choice of following vowel, than between its presence and the choice of preceding vowel, and in many languages with labialized consonants the set of syllable-final consonants, if any, does not include labialized ones.

Although it is rare, final labialization does occur. Pohnpeian, for example,

In these words, it can also be seen that the formants of the a vowel are less affected by a preceding labialized consonant than they are by a following one. These effects on the vowel show a further interesting asymmetry. When formants are measured in the center of the vowels, both Fl and F2 are significantly lower after an initial labialized consonant than after a plain bilabial. Before a final labialized consonant, Fl is significantly lower, but F2 is not. Our interpretation of this observation is that the two component gestures involved in the secondary articulation of labialization, lip rounding and tongue back raising, have somewhat different timing in relation to the primary articulation, with the tongue backing starting earlier. Tongue raising can be expected primarily to affect Fl (compare the raising of vowels before velars that occurs in some dialects of English), whereas rounding of the lips can be expected to lower all formants in most vowels.

Simple labialization, not accompanied by any raising of the back of the tongue, is most often found as an "enhancing" feature (Stevens, Keyser and Kawasaki 1986) which supplements a primary contrast of another kind. The example of liprounding in the J segments of English and French (Abry, Boe, Gentil, Descout and Graillot 1979) is well known; a degree of rounding of the lips seems to serve to distinguish the sibilant pair s-f by further lowering the center of gravity of the spectrum of J. However, in Shona there is a pair of rounded fricatives that we will symbolize s , z which are distinguished from unrounded s, z by the presence of simple labialization. In some dialects these are further distinguished from the sequences sw, zw and sw, zw (other dialects pronounce these sequences as skw, zgw etc., see Doke 1931a,b, Maddieson 1990b). The lip positions for s and s' as produced by a speaker of the Karanga dialect of Shona, are shown in figure 10.19 (after Doke 1931b). As mentioned in the discussion of purported doubly-articulated fricatives at the beginning of this chapter, the Abkhaz labialized palato-alveolars may occur with a similar type of simple labialization, but in that language there is no contrast between different types of labialization.

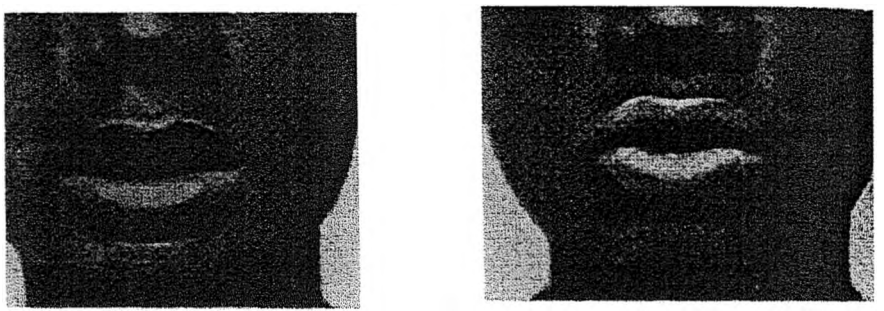

p a l
0 100 200 300 400 500
p^w a l
0 100 200 300 400 500 ms
3500
3000
2500
2000
1500
1000
500
Hz
m a: s
0 100 200 300 400 500
m^w a: s
0 100 200 300 400 500 ms
3500
3000
2500
2000
1500
1000
500
Hz
k a p
0 100 200 300 400
k a p^w
0 100 200 300 400 ms



k a m a m k a m^w a m^w

0 100 200 300 400 500 600 0 100 200 300 400 500 600 ms

Figure 10.1S Spectrograms illustrating contrast of word-initial and final labialized bilabial plosives and nasals in Pohnpeian. The words are pal 'to hack', p”al 'to be slit', mars 'face', m“a:s 'worm', kap 'bundle', kap" 'new', kamam 'to enjoy kava’, kam"am" 'to exhaust[1].



S

Figure 10.19 Lip photographs of Shona [s] and [s] (after Doke 1931b).

Velarization

Velarization, the raising of the back of the tongue, differs from labialization in that it is not so clearly anchored to the release. This leads us to expect patterns of a different type when we have velarization by itself as a secondary articulation: phonologically, more restrictions between consonant and preceding vowel, and, phonetically, more anticipation than is the case with labialization. This anticipation is observed in English 1. This segment is often described as having plain allophones in syllable-initial position and velarized allophones in syllable- final position. While this is true for many speakers, a considerable number of speakers of American English varieties use a velarized

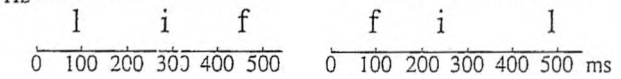


Figure 10.20 Spectrograms of an American English speaker's pronunciation *of leaf feel* using velarized laterals in both words.

pronunciation in all positions. Representative spectrograms from such a speaker pronouncing the words *leaf* and *feel* are given in figure 10.20. The velarization is in this case shown in the acoustic pattern by a low F2 during the lateral. This is somewhat lower in the final lateral, indicating that it is more strongly velarized than the initial lateral. There is also a timing difference in the transitions; in *leaf* the F2 transition at the onset of the vowel is comparatively short, in *feel* the F2 transition before the final lateral is longer and the low F2 value is fully achieved before the consonantal occlusion begins. This pattern is consistent with velarization being anchored nearer the beginning of the consonantal articulation than the end. A different view has been expressed by Sproat and Fujimura (1993) who suggest that a secondary articulation will always be implemented closer to the syllable nucleus than the primary articulation. In their view a secondary articulation is realized closer to the end of an initial consonant, but closer to the beginning of a final consonant. This would predict that, for speakers of the type of English who have velarized laterals in all positions, *leaf* and *feel* should appear more like mirror images of each other than they do. It would also predict that we would not see the asymmetrical results that labialization produces.

The number of languages which clearly involve contrastive velarization is quite small. The set of Russian palatalized ('soft') sounds is often said to be opposed to a set of velarized consonants, but a study of the available x-rays of the articulations in question suggests that the term velarized may be appropriate. only for the laterals. A clearer instance of contrast is provided by Marshallese, which has plain and velarized nasals and liquids. Among stops, the contrast is restricted to bilabials. Some examples of the bilabial nasals, spoken by a male speaker, are provided in the spectrograms and spectra in figure

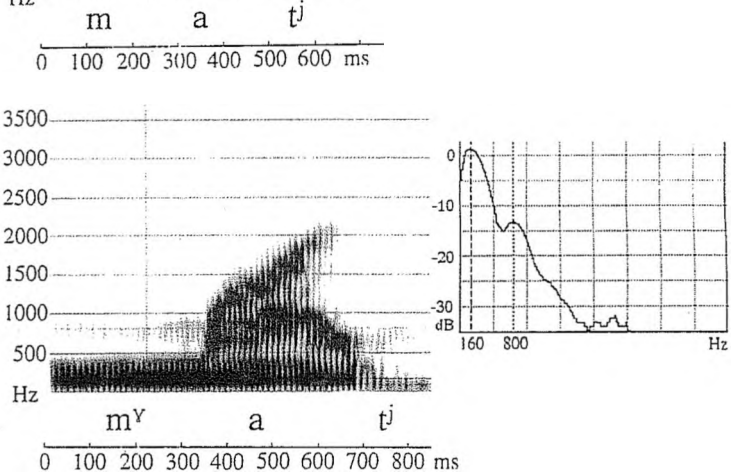


Figure 10.21 Spectrograms of the Marshallese words may 'eye' vs mˠay 'eel, worm', illustrating the contrast of plain and velarized nasals. Panels on the right show spectra of the nasal steady state. Frequencies of spectral peaks are indicated.

10.21. The second peak in the nasal spectrum is low throughout the velarized nasal in 'eel, worm'; whereas the equivalent resonance in the plain bilabial is at about 1500 Hz. In Marshallese, the main properties of short vowels, apart from height, are largely determined by the surrounding consonants, especially by their secondary articulations (Bender 1968, Maddieson 1991, Choi 1992). In the minimal pair illustrated in the figure, F2 has essentially a straight-line interpolation from the initial consonant to the final in both words.

The velarization contrast in Marshallese laterals is illustrated by the spectrograms of a female speaker in figure 10.22. Each of the first three words contains two laterals, but in the first they are both plain, in the second both velarized, and in the third the first is plain but the second is velarized. The fourth word is a form incorporating a reduplication of the third word, result-

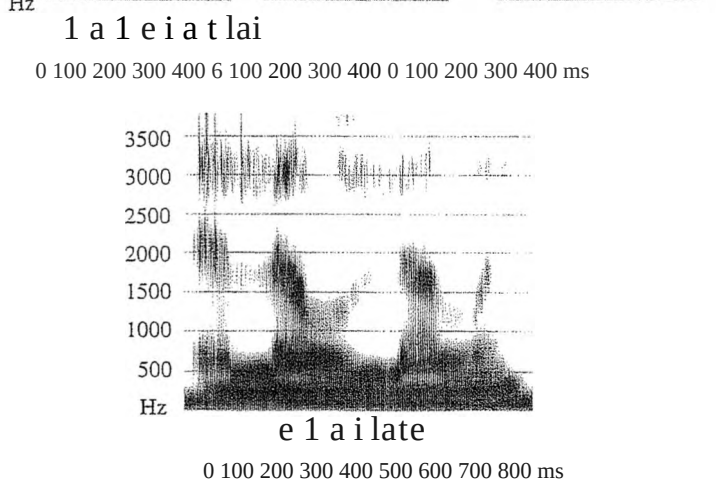


Figure 10.22 Marshallese lale 'check' vs tat 'knock' vs I at 'earth' vs elatlaie 'he's a down-to-earth person'.

ing in a medial cluster of a velarized followed by a plain lateral. In this form, anticipation of the velarization in the first a can be very clearly seen, although it is not so clear that there is more anticipation than perseveration of the velarization of the final lateral. Note also that in the second word there is just about as much perseveration as anticipation. This would indicate that in Marshallese velarization might be realized in the middle of the consonant.

Palatalization

Palatalization is the superimposition of a raising of the front of the tongue toward a position similar to that for i on a primary gesture. Like labialization it is often more apparent at the release than at the formation of a primary