Table 9.20 Words illustrating contrasting labial fricatives and approximants in Urhobo

	LABIALIZED VELAR OR LABIAL-VELAR		LABIODENTAL	
FRICATIVE	oy^{w}6	'soup'	evS	'monitor lizards'
APPROXIMANT	ewe	'ponds'	eva	'divination'

of the sound that might be symbolized using one of those symbols is actually g, in, for example, nog A ninth'. A labiodental approximant u contrasts with a labiodental fricative v in Urhobo; this language also has a labialized velar fricative v^{w} as well as a labial-velar approximant w (Ladefoged 1968, Kelly 1969), as illustrated in table 9.20. Ladefoged (1968) had w in place of y^{w}, but we now consider Kelly (1969) to be correct. As Elugbe (1989) has pointed out, the friction is the result of the velar articulation alone.

The neighboring language, Isoko, has a similar set of contrasts. Photographs of the lip positions in three of the four possibilities are shown in figure 9.33. It may be seen that the labialized velar fricative y^{w} in the word ey"e 'hoe' has a very small aperture, with the lips being tightly pressed together. The spectrogram accompanying the photograph shows that this tight constriction produced formant transitions like those in a labial-velar approximant w, but with a great decrease in the intensity of the sound, so that there is a stop-like gap without a following release burst. Unfortunately we do not have comparable data for the labial-velar approximant, which occurs in the word owa 'age-grade'. But we do have photographs of both the fricative in eve 'how' and the approximant labiodental in eve 'breath'. The spectrogram of the fricative ' shows that there is also a considerable decrease in intensity, but without the large formant transitions that occur in y^{w}. In this particular token there is very little fricative energy apparent. The approximant has a much wider lip aperture; but, as may be seen from additional photographs in Ladefoged (1968), the aperture is not as great as that in the surrounding vowels. As the lower lip is so far from the upper teeth and the upper lip, it is not possible to say whether this sound is better classified as a bilabial approximant g, or a labiodental

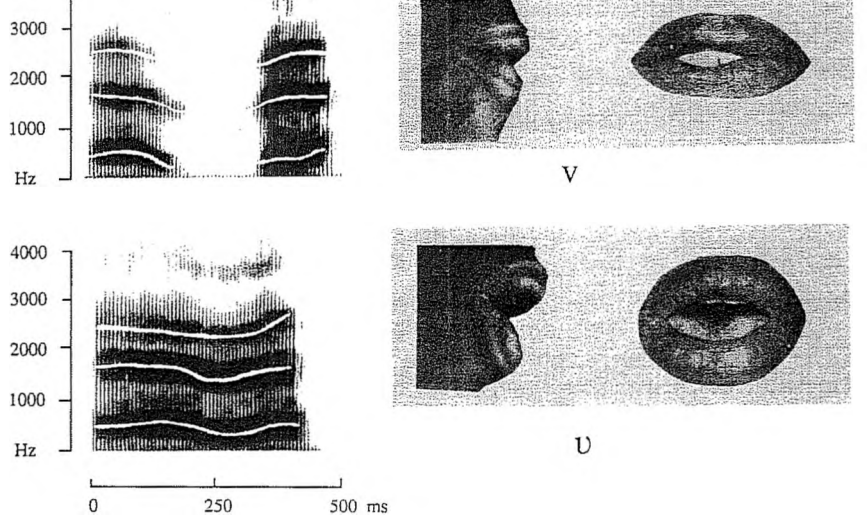

Figure 9.33 Photographs of the lips in the Isoko words ey“e 'hoe', eve 'how' and eve 'breath'. The photographs were determined to be in the middle of the consonants by observing the click of the camera shutter on a simultaneous recording. The spectrograms on the left are of repetitions of these words recorded immediately after the photographic session. Center formant frequencies have been outlined in white.

approximant u. The spectrogram shows that there are smaller formant movements associated with this sound and very little diminution of amplitude.

Many of the semivowels and central approximants that we have been considering in this section also have voiceless counterparts. In addition, two sounds mentioned in the chapter on fricatives, h and fi, should also be discussed here. These sounds have been described as voiceless or breathy voiced counterparts of the vowels that follow them (Ladefoged 1971). But, as Keating (1988) has shown, the shape of the vocal tract during h or fi is often simply that of the surrounding sounds. In saying the word *ahead*, for example, there is

language Musey has been conducted by Shryock (1995). In this language the contrast between h and fi is not primarily encoded as a voicing difference. Both segments are more often than not produced with vocal fold vibration, but fi tends to have a laxer laryngeal setting and a lower fundamental frequency.

The voiceless counterparts of the central approximants j and w occur as contrastive segments in a number of languages, such as Yao (Purnell 1965), Klamath (Barker 1964) and Aleut (Bergsland 1956). They also occur in some dialects of English. Most speakers of English differentiate between words such as ju 'you' and what is usually transcribed as hju *hue.* The onset in the second word is normally a voiceless palatal approximant, j, for which the IPA has no unitary symbol. In some dialects (e.g. most of thos°e spoken in Scotland), the words *weather* and *zvhether* contrast, the latter beginning with a non-fricative AI. No language that we know of contrasts a voiceless labial-velar fricative and a non-fricative AI, just as no language contrasts the voiceless lateral approximant I and the voiceless lateral fricative 1 as discussed in chapter 6. In addition, the voiceless counterpart of w cannot have friction at both the labial and velar places of articulation, as we will discuss in chapter 10, so if it is a fricative, it is better described as a voiceless labialized velar fricative. Other voiceless approximants, such as voiceless laterals are discussed in chapter 6, and voiceless rhotics in chapter *7*

Summary

Finally, we will compare our findings in this chapter with those of the most comprehensive previous survey, that of Lindau (1978). We are largely in accord with respect to the major features Height and Backness, noting only that recent evidence has suggested that there may be as many as five distinctive vowel heights. Our differences on the third major feature, Rounding, are more in form than in substance. We regard Rounding as a feature that dominates both Compression and Protrusion, a possibility that was not open to Lindau before the advent of hierarchical phonological structures, although she recognized the distinction between these two types of lip action. Among the additional vowel properties, nasalization is now slightly better understood, but

Articulatory Gestures

Most consonantal segments can be described by specifying a single oral articulatory gesture, together with its accompanying laryngeal and velic gestures. But there are a considerable number of types of sounds in which more than one articulatory gesture is employed. These sounds will be the topic of this chapter. In the traditional phonetic literature (e.g. Abercrombie 1967), a distinction is made between segments with double articulations and segments with secondary articulations. The basis of this distinction rests on the establishment of a scale of stricture, consisting of three degrees: closure, narrow approximation (such as to produce friction), and open approximation (as in an approximant or vowel). Doubly-articulated segments are those which have two simultaneous articulations of the same degree of stricture, such as two oral closures or two open approximations. When two co-occurring articulations have different degrees of stricture, the one with the greater stricture is labeled primary and the lesser one is labeled secondary. This traditional terminology allows for doubly-articulated fricatives, and for a fricative to be the secondary articulation accompanying a stop. We will argue below that the world's languages do not use segments that combine two fricative elements, and that secondary articulations are actually always approximant-like. Moreover, we will suggest that doubly-articulated approximants, such as [w], are not really parallel to segments with two closures, which is why they were discussed in the chapter on vowels and approximants. This leaves two major classes of segments with multiple gestures: stops and nasals with two closures, and stops, nasals, liquids and fricatives with an approximant secondary articulation. The basic framework of this chapter is to deal with these in turn, together with the issues that arise.

because of phonological considerations, but which are articulatory sequences from the phonetic point of view. That is, one of the articulations leads or lags behind the other by a substantial part of the total time required for their production. These phonetic events are not distinguishable from events which would be accepted as segment sequences in another language that lacked the phonological pattern to motivate their interpretation as single segments. Some of these sequences will be referred to in the course of the chapter in order to clarify what kinds of segments we consider to have phonetic simultaneity.

This chapter is also not concerned with the many situations in which different gestures show degrees of coarticulation and coproduction as part of the regular concatenation of speech sounds. The velar and alveolar articulations in an English word such as *cactus* overlap in time so that the release of the velar closure produces no audible sound; the lip rounding of a rounded vowel in Swedish is anticipated throughout a preceding consonant cluster, producing phonetically labialized clusters (McAllister 1978). However, alveolar-velar doubly-articulated plosives are not part of the phonological inventory of English; rather they are part of a characteristic production strategy by which abutting plosives with different places of articulation both word-internally and across word-boundaries are overlapped in this fashion (Byrd 1994). The degree of this overlap is highly variable, unlike the relatively invariable timing observed between the articulations in multiply-articulated single segments. Similarly, the anticipation of rounding in Swedish is part of a production strategy, rather than a feature that enlarges the contrastive possibilities in the language.

The other preliminary matter to be considered concerns the possibility of multiply-articulated fricatives. It is clear that generation of audible friction at two different locations in the oral cavity at the same time is very difficult. As noted in chapter 3, a fricative requires a more precise adjustment of the articulators than a stop or an approximant. The size of the inter-articulator aperture and the velocity of the airflow must be within critical limits for friction to be generated. To achieve two of these critical adjustments at the same time, especially when the flow requirements might be different for different places, is obviously problematical. From the auditory point of view, even if two sources of friction exist, the one further forward in the mouth is very likely

namely fj. The sound in question is one variant of the pronunciation of the phonological element J, which is highly variable in Swedish dialects, receiving pronunciations ranging from a palatalized bilabial sound to a velarized palato-alveolar one to a fully velar one. As we showed in chapter 5 it is not clear that any of the variants is actually a doubly-articulated fricative.

Another similar example is mentioned by Catford (1977a). He reports that the bilabial-palatal fricatives <j>c, pj. occur in Abkhaz. He notes, of doubly-articulated fricatives in general, that "it is often somewhat difficult to discern whether there actually is turbulent (fricative) air-flow at each of the two stricture locations" (p. 190). Concerning the Abkhaz sounds specifically, he notes that although one may choose to regard them as coordinate fricative articulations, the "impression from hearing two or three speakers of each dialect, is that in the Abzhui (literary) dialect of Abkhaz the labial articulation dominates somewhat - generating stronger turbulence - whereas in the Bzyb dialect the palatal articulation is somewhat dominant." (p. 191).

We have heard recordings of a speaker of each of these dialects and to our ears the sounds in question sound like labialized palato-alveolars, with frication only from the palatal stricture. The two dialects do differ. In Literary Abkhaz there are extended slow rising Fl and F2 transitions from the fricative to the following vowel of the sort that are typical of a w-like secondary articulation accompanying a consonant release. On the other hand, in the Bzyb dialect, the formant transitions are less extensive in duration and in frequency range, and more symmetrical between consonant onset and release, as illustrated in figure 10.1. We believe this is the result of just rounding the lips without any accompanying raising of the back of the tongue. A major effect is to reduce the frequency range of the fricative energy generated at the post-alveolar constriction as it passes through the narrowed labial aperture in front. In neither case do there seem to be two sources of frication; rather, there is one post-alveolar fricative source accompanied by one of two different types of accompanying secondary articulation. The distinction between these two types of labialization is discussed further in section 10.3.

A case where there are clearly two separate sources of friction is found in SePedi (Northern Sotho). Lombard (1985) transcribes the segments fs, ff, 03 in words such as pofsa 'youth', leffe:ra 'coward' and Psalwa 'beer' and describes

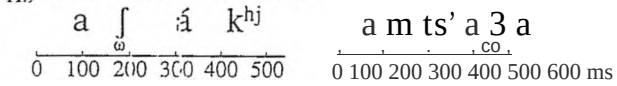

figure 10.1 Abkhaz "bilabial-palatal" fricatives in the words afak^{h}J and amts'aja spoken byamale speaker of the Bzyb dialect.

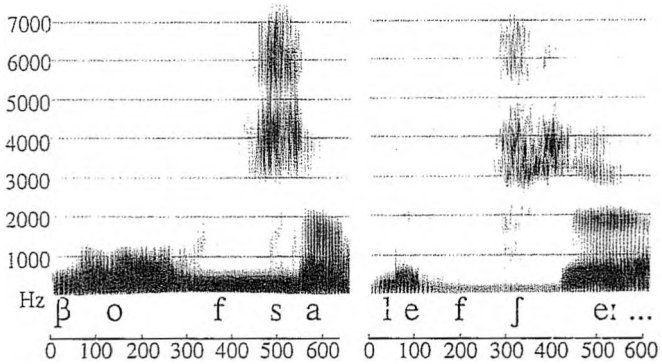

Figure 102 Spectrograms of the SePedi wordspofsa 'youth' and leffe:ra 'coward' spoken by a male speaker.

them as labiodental-alveolar, labiodental-prepalatal and bilabial-prepalatal fricatives respectively. Because of the lack of other sequences in SePedi and the restrictions on their distribution, this description may be appropriate in phonological terms. However, as the spectrograms in figure 10.2 demonstrate, these are phonetic sequences. One articulation follows the other, so that for example, SePedi fs is not very different from the fs in an English word like *offset.* The phonetic description given, namely, that they have two simultaneous fricative articulations, is incorrect. Another similar case is discussed in connection with Tabiodentalization' as a secondary articulation below. Although doubly-articulated fricatives are not impossible to produce, we sus-

a number of different gestural possibilities in each grouping defined by these major features. For example, Labial gestures may be bilabial or labiodental and Coronal gestures may be linguo-labial, dental, alveolar or post-alveolar, as well as being apical, laminal or sub-apical. The features that control these variations are subordinate to the major place features, as indicated in table 2.11. For double (and triple, etc.) articulations, we will take it as axiomatic that multiple gestures may result only from combinations of major place features. Subordinate distinctions among places do not combine to produce multiple gestures. These are the defining characteristics of the major/subordinate distinction and apparent counterexamples require that the feature inventory be adjusted rather than the principle abandoned.

If we consider only the first four (the supralaryngeal) major articulators, there are theoretically six double articulations possible. These possibilities are listed in table 10.1. A further four combinations would be added to the total if pairings of a supraglottal articulator with a Laryngeal articulation were included. These involve the production of glottal stops simultaneously with other articulations. In these cases, however, the role of the larynx as a place of articulation needs to be considered in relation to its role as the initiator of an airstream or as a modification of the phonation, as discussed in other chapters. We will not consider supraglottal-glottal combinations any further here. We will exemplify all those combinations in table 10.1 which we know to occur in languages, and consider if the patterns of occurrence and non-occurrence provide a basis for proposing that the number of such combinations is restricted.

Table 10.1 Possible pairings of major supraglottal articulators

LABIAL-CORONAL		
LABIAL-DORSAL	CORONAL-DORSAL	
LABIAL-RADICAL	CORONAL-RADICAL	DORSAL-RADICAL

stops and nasals with single articulations. This is an important factor in their recognition as single sounds. Measurements of the acoustically determined closure duration of gb, kp and b in Yoruba are given in table 10.3. In another smaller data set, duration of simple k was measured as 134 ms. In these data there is no significant difference between the duration of gb and b; kp is significantly longer than both gb and b ($p < 0.01$) but by little more than is often found for voiceless stops compared to voiced ones.

The closure durations of bilabial, velar and labial-velar stops in Ewe, measured from the acoustic waveform displays of ten tokens each, are shown in table 10.4. Here velar stops are shorter than bilabial ones, and labial-velars are 25-30 ms longer than bilabials.

Table 10.2 Bilabial-velar sounds in Idoma

VOICELESS STOP	akpa	'bridge'
VOICED STOP	agba	'jaw'
VOICED NASAL	agmaa	'body painting'

Table 10.3 Durations of gb, kp and b in Yoruba (two repetitions of nine words each, matched for vowels and tones)

	gt>	b	kp
MEAN DURATION	132	128	148
STANDARD DEVIATION	12.5	17.6	16.5

Table 10.4 Mean closure durations of Ewe bilabial, velar and labial-velar stops in aCa context (ten repetitions from one speaker)

	VOICELESS	VOICED
VELAR	k 142	g 133
BILABIAL	E- 158	b_ 150
LABIAL-VELAR	kp 174	gb 179