bial-alveolars, Margi and Bura (Hoffman 1963, Ladefoged 1968, Hale 1983), on closer examination prove to have labial + alveolar sequences rather than double articulations (Maddieson 1983, 1987). For example, bd is considerably longer than b or d. Moreover, a labial release can be detected well before the alveolar one.

In view of these findings, Maddieson (1983) expressed doubts about whether contrastive labial-alveolar segments occurred in any language and proposed that the only true double articulations are labial-velar ones. However, phonemic segments with simultaneous bilabial and alveolar closures do occur in Yeletnye, spoken on Rossel Island, Papua New Guinea. This language has plosives and nasals at bilabial, front alveolar, slightly post-alveolar and velar positions. Bilabial articulation can co-occur with the three other places, producing bilabial-alveolar, bilabial-post-alveolar and bilabial-velar stops and nasals. Examples are given in table 10.7 based on our own fieldwork, with

Table 10.7 Single and double articulations in Yeletnye

	Bilabial	Alveolar	Post-alveolar	Velar
Voiceless stop	paa 'side'	taa 'knife'	too 'tongue'	kaa 'spear'
Prenasauzed voiced stop	mbee *'carry'*	nde 'food'	nde 'firewood'	rjkaa '(tree)'
Voiced nasal	maa 'road'	nii 'juice'	naa 'feast'	ga 'lease'

	Labial-alveolar	Labial-post-alveolar	Labial-velar
Voiceless stop	tpana 'lung'	tpana 'hom'	kpene 'coconut bag'
Prenasauzed voiced stop	nmdboo 'pulp'	nmdboo 'many'	ijmgbo 'fog'
Voiced nasal	nmo 'bird'	nmo 'we'	fmo 'breast'

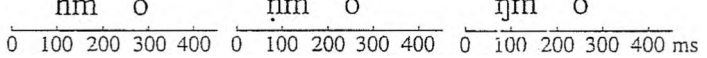

Figure 10.11 Spectrograms of the three Yeletnye doubly-articulated nasals in the words on the last row of table 10.7 as spoken by a female speaker.

some additional words taken from Henderson and Henderson (1987). Prenasalized examples are included in this table. The language also has a full series of nasally released stops including at least two of these double places of articulation (see chapter 4).

Spectrograms illustrating the three doubly-articulated nasals are given in figure 10.11. In these spectrograms, which represent careful citation forms of these words, the effects of separate releases of the two closures can be seen in each case. This is because these are nasals. As the more rearward closure is released, a transient is produced and the resonance characteristics of the cavity in front of the nasal escape are altered. Note that this result would not occur if the labial closure was the first to be released, since this would leave the shape of the cavity which gives the nasal its characteristic quality unchanged. Spectrograms of the three doubly-articulated stops are given in figure 10.12.

We are not aware of any language which has plosive or nasal sounds involving simultaneous Coronal and Dorsal articulation, such as alveolar-velars. Some accounts of Kinyarwanda and of certain dialects of Shona have been interpreted as indicating the occurrence of segments such as tk, dg. Although phonological arguments can be marshalled in favor of treating these events as single segments (Sagey 1986, 1990), they are phonetically quite unambiguous. They are sequences of two stops. This point is made by Jouannet (1983) for Kinyarwanda and can be shown in our own data from the Zezuru dialect of Shona (Maddieson 1990b). Figure 10.13 shows audio waveforms and records of the pressure of the air in the mouth behind an alveolar closure but in front of a velar closure during the phrase tkwana tkwangu 'my little child'. The release of t preceding k can be clearly seen, both in the acoustic record and in the fact that the intra-oral pressure, sensed in a location between the alveolar and the

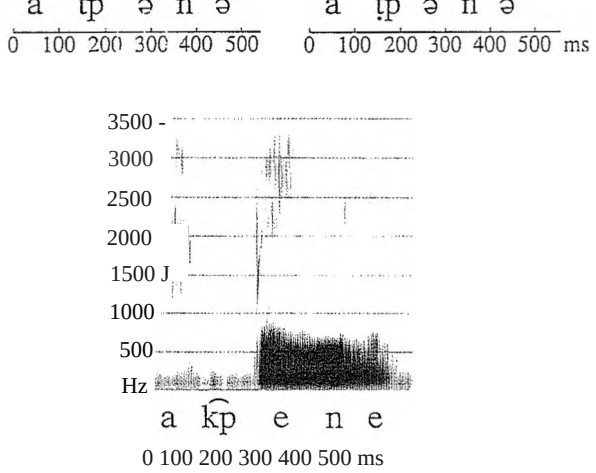

Figure 10.12 Spectrograms illustrating the three Yeletnye doubly-articulated plosives in stem-initial position of nouns preceded by the first person singular possessive prefix a-.

velar closures, falls well before the burst for the velar release. The alveolar and velar closures do not overlap at all.

Dental-palatal articulations occur in some dialects of Isoko (Elugbe 1989) and have also been reported in some Australian languages, such as Maung (Capell and Hinch 1970). Most dialects of Isoko have lamina! dental plosives and nasals contrasting with apical alveolar plosives and nasals as exemplified in chapter 2. But Elugbe notes that in some dialects the laminal dentals are realized with two simultaneous articulatory contacts, one in the dental and one in the palatal region. We regard these sounds, which do not contrast with either dental or palatal sounds, as having accidental contacts in two articulatory regions, rather than as having double articulations. The dental-palatal segments reported in Australian languages are variants of the laminal post-

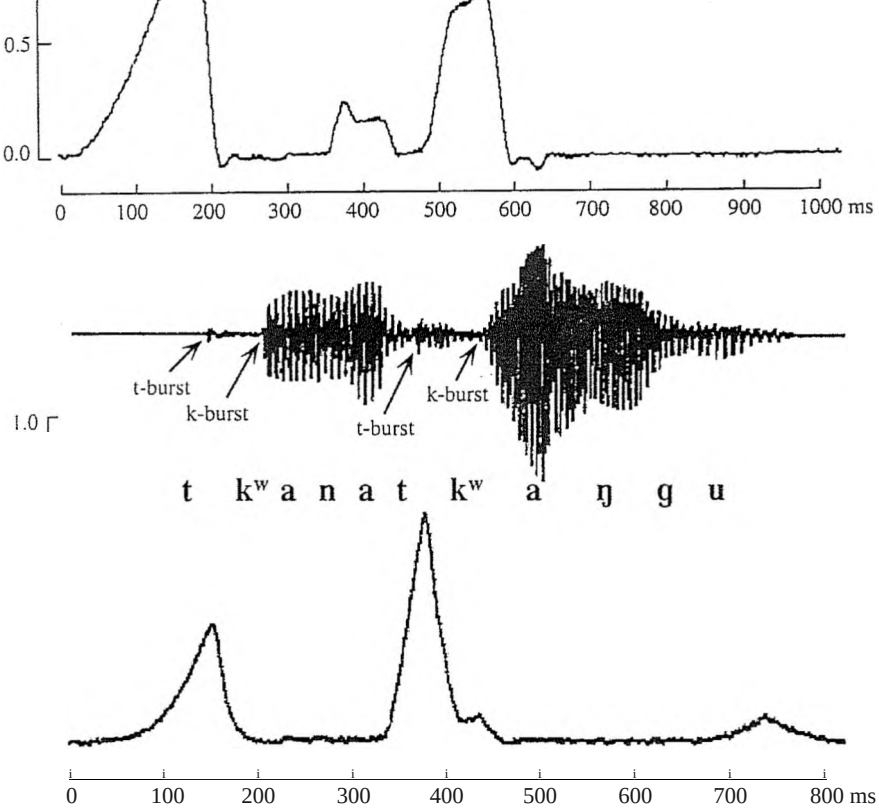

Figure 10.13 Waveforms and intra-oral pressure records of tk duster in Shona from two male speakers. The pressure records are calibrated in terms of the speaker's maximum (= 1).

Coronal-Dorsal combination that might be expected from the articulatory independence of the tongue tip/blade and tongue body is to be found in click articulations. Clicks, of course, require a double closure for their production. However, the place of articulation given for a click has traditionally referred only to the location of the front closure, and the back closure has not been considered as a place of articulation. The velar closure involved in producing a click is usually regarded by phoneticians solely as the basis of the airstream mechanism employed, hence the name velaric airstream mechanism (Pike 1943). We believe that this view is mistaken in that it allocates only one role to the back closure. The distinction drawn in chapter 8 between click type and click accompaniment is convenient for expository purposes, but the expository device of conflating several properties together as an 'accompaniment' should not be taken as indicating that the properties cannot be separated. We take the view that Halle is correct and clicks have (at least) two places of articulation, one of which is provided by the back closure. A precursor of this point of view is found in Chomsky and Halle (1968: 319), who argued that clicks are stops produced with 'extreme velarization' and assigned the features [+high, +back] to them. These features are shared by velar and velarized sounds in the SPE scheme, and so clicks are described as velar in place. The one argument cited by Chomsky and Halle for their view is that in Nama the back closure can vary in its manner of release, and that the resulting abrupt versus affricated contrast is an articulatory difference. There are at least two other points that can be added. In Bantu languages with clicks, such as Zulu and Xhosa, nasal + stop clusters must be homorganic. Prefixes which contain a final nasal undergo a place assimilation rule when the nasal abuts a stop (or almost any other consonant). When such a prefix abuts a click, the nasal is not assimilated to the dental, alveolar or palato-alveolar place of the front closure of the click but rather to the velar place (Doke 1926: 78). Illustrative examples from Zulu are given in table 10.8.

Doke argues that before a click "with the back of the tongue touching the velum ... the nasal homorganic to the clicks must be the pure velar nasal rj." While it is true that when a nasal is *simultaneously* articulated with a click the effective closure for that nasal must be the back closure for the click, it is important to note that a nasal *preceding* a click need not necessarily be produced

with a velar articulation. The velar closure could be formed later than the front closure, i.e. not until the click itself is being produced. Given what actually happens, it is clear that the velar closure is not acting solely as the initiator of the airstream for the click but is also functioning as a place of articulation whose influence spreads to the adjacent pulmonic nasal segment.

The second additional argument is based on the contrast that occurs in some of the Khoisan languages, such as 1X66, 4=H6a and | |Ani, where the back closure itself may differ in place, being either velar or uvular. Contrasts from !X66 have been illustrated in table 8.4 above. Not only does !Xob have contrasting velar and uvular accompaniments to the clicks, but the language also contrasts abrupt with affricated release of the back closure in the velar place. Hence, the back closure in clicks is an articulatory gesture, with contrasts in both place and manner dimensions, even though it also forms the basis of the airstream mechanism. Since the back closure of a click must be viewed as parallel to place of articulation features in other segments, we may confirm that Coronal-Dorsal double articulations occur, since they are commonly found in clicks. We will mention clicks again when we turn to discussion of sounds with three simultaneous articulations.

Our treatment in chapter 2 of the tongue root and epiglottis as another major articulatory region suggest the possibility of double articulations combining a Radical articulation with one at the Labial, Coronal or Dorsal positions. However, within the terms of our present discussion - limited to closure articulations - very few cases would be expected. Recall that nasals with Radical articulations are not possible and stops are rare. Given that double articulations are themselves uncommon, the chances of a Radical articulation co-occurring with another closure would therefore seem to be very slight. Though there are a number of well-known languages, such as Arabic and Ubykh, with stops that are produced with an accompanying secondary constriction of the pharynx, we know of no language which has a doubly-articulated stop including a Radical closure. It does not seem improbable that, through an intensification of the pharyngeal articulation accompanying an alveolar stop (as in Arabic) or a bilabial or uvular one (as in Ubykh), a language could develop

of conceivable triple combinations increases. However, we do not know of any linguistically contrastive segment which is regularly produced with a triple closure, and we would argue that none should be expected. This expectation has to do with how the presence of multiple articulations can be perceived. Recall that in the case of a double articulation on the pulmonic airstream, onsets and releases of the two closures are usually not exactly coterminous but slightly staggered, as indicated schematically in figure 10.14 (a). For example, in a labial-velar stop, formation of the velar closure fractionally precedes the labial one and the labial one is released fractionally after the velar one. This enables different transitional cues to be heard at the onset and offset of such segments and these reveal that the segment has a complex articulation. If, say, the velar closure was both formed earlier than and released later than the labial one, only velar transitions would be apparent. On the other hand, in a click the back closure is usually formed before and is always released after the front closure, as shown in figure 10.14 (b). In this case the front closure *must* be released first in order for the velaric suction mechanism to produce an audible burst. This release produces the place cues relating to the front closure of the click. The place of the back closure is perceived because of cues that are carried in the pulmonic (or glottalic) airflow that surrounds the click articulation. The two places involved are perceived because their cues are carried in two separate airstreams. Hence in both these types of doubly-articulated segments the two contributing closures can be readily perceived from separate cues.

Now, consider what would happen if three closures were involved. The onsets of the three closures can be staggered, but this strategy does not produce a clear indication of the complex articulation involved. When only pulmonic air is used, a closure whose duration is entirely contained within the duration of a longer closure will have no acoustic transitions in adjoining segments and under most circumstances its presence will be imperceptible. This includes the case in figure 10.14 (c) where closure 2 is included within the longer duration formed by the overlap of closure 1 and closure 3. Rescheduling the timing, say, as in figure 10.14 (d) does not help. Under no possible arrangement can more than two transitions occur; one at the beginning of the first closure and a second at the release of the last closure.

Of course, transitions are not the only acoustic cues to the presence of a

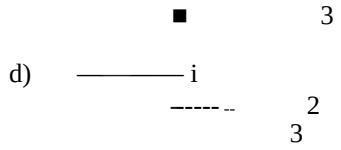

figure 10.14 Some relative timing possibilities among multiple closures.

particular type of articulatory closure. We must also consider the burst phenomena heard when a closure is released and the resonance characteristics of the sound produced while the closure is maintained. In the case of stops, the burst characteristics are more important, whereas in nasals the resonance characteristics (of the nasal murmur) are more important. When a plosive with multiple closures is produced, only the last closure to be released can have the full character of a burst, since only that one can have both a build-up of pulmonic air pressure behind the closure and the opportunity for the sound to be radiated into the air outside the speaker's mouth. A closure released while another is maintained further forward in the mouth will not radiate the burst energy. One that is released while another is maintained further back in the mouth will not have a pressure build-up behind it and hence will have little or no acoustic energy. No arrangement of three overlapping closures can avoid one or other of these situations, so place cues inherent in bursts will be ineffective supplements to the transitional cues.

In nasals, the particular quality of the nasal murmur depends principally on the size of the oral cavity in front of the velo-pharyngeal port. When there are multiple oral closures, the size of this cavity is determined by the closure closest to the velar region. It is therefore theoretically possible for changes in the quality of the nasal murmur to provide cues to complex articulations as closures are added or released. For example, if figure 10.14 (c) represents a nasal in which closure 1 is labial, closure 2 is alveolar and closure 3 is velar, then at the onset of the nasal a rapid shifting of the nasal murmur from a quality characteristic of labial place to a quality characteristic of alveolar place and finally

Figure 10.15 Palatograms of 1X66 bilabial clicks from five speakers, based on data in Traill (1985). The three in the upper row show the only lingual contact to be in the velar region. The lower two have a tongue front contact as well as the labial and velar contacts and are those described as having "three points of articulation" by Traill.

to a quality characteristic of velar place might be observed. The brief alveolar portion would provide the cue to the presence of an articulation which would not be cued by transitions to and from surrounding segments. We do not know how long this portion would need to be in order for its presence to be noticeable, but, given the relative difficulty of discriminating between nasal murmurs, we suspect that it may need to be quite long or its presence will be missed. And if it is long enough to be perceived, then conflict may arise with the principle that single complex segments have duration comparable to that of simple segments of the same phonetic class in the same environment. Instead of a single multiply-articulated nasal, a sequence of several nasal segments may be perceived (and production adjusted to that program). In either case, it is easy to see that circumstances do not favor the development and stability of triply-articulated nasals any more than plosives.

As for clicks, there are two ways in which they could be produced with triple closures. One way is to have two closures, one Labial and the other Coronal, in front of the velar or uvular closure required for the click mechanism. It is possible to imagine that these closures could be timed so that the first is formed just before the back closure is made, thus providing a transitional cue on the pulmonic airstream. If this closure is released first, the second forward closure would then be the place of articulation of the velaric airstream, and the back closure would be released into pulmonic airflow. All three closures would then have audible cues to their presence. However, we know of no clicks that are produced without the back closure overlapping the

shows the cavity between the two closures before the tongue is lowered. The position before release is shown by the lower tongue outline.

forward oral closure. With this overlap, if two forward closures are formed only the second to be released is likely to produce an audible burst. The presence of the other closure contributes little or nothing. In fact, palatograms of !Xdo bilabial clicks show that two of five speakers also formed a closure in the dental-alveolar region during the click (Traill 1985: 103). The palatograms are shown in figure 10.15. Although Traill says that these 'bilabial-dental' clicks have "three points of articulation" there is no indication that these variants sound any different from the bilabial clicks of other speakers. From his discussion, it is clear that the dental contact is released well before the labial one is, since cavity expansion for labial clicks is achieved "by a lowering and retraction of the front part of the tongue" (Traill, 1985: 106). Tracings from x-ray films of the same two subjects who show dental closure on the palatograms indicate that the labial closure is maintained after the tongue tip is well away from the upper teeth. A figure based on these tracings is shown as figure 10.16. The third closure for these clicks is consequently of no significance, as we would predict.

The second way that a click can be formed with three closures is for a Radical or Glottal closure to be added behind the back closure for the click. We know of no cases with a Radical closure, but clicks produced with an accompanying glottal closure are relatively common in Khoisan languages. The relative timing of the gestures involved is discussed in chapter 8, where we interpret the glottal closure as either contributing an accompanying glottalic airstream, modifying the release of the back closure, or as forming a separate glottal stop that is released about 150-200 ms after the click. In neither case is it a place of articulation of the click segment.

In summary, we would argue that for pragmatic reasons a contrastive function for segments with three oral closures is not to be expected. Our arguments will apply *a fortiori* to segments with four simultaneous closures. We now turn to discussion of cases with articulations of differing degrees of stricture.