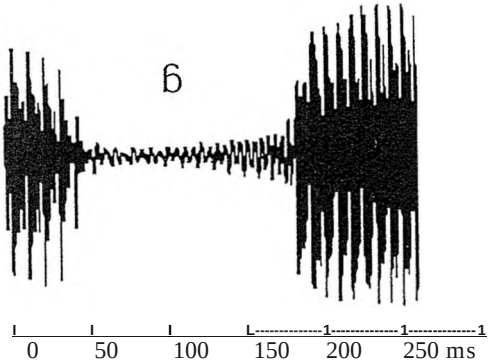

Figure 3.18 Waveforms of Degema showing contrasts between voiced plosive and voiced implosive.

Lindau (1984) studied implosives in Kalahari, Degema and a number of other languages spoken in the southeast of Nigeria. Her examination focused on the bilabial and alveolar voiced plosives compared to the voiced implosives made at the same places of articulation. She did not have any aerodynamic data, but her acoustic records indicate that the implosives in these languages are very similar to those in Sindhi. These acoustic records showed that in the implosive (in the lower part of figure 3.18) the amplitude of vibrations typically increased during the time that the oral closure was maintained, indicating that the lowering of the larynx (added to any other cavity-expanding maneuvers during this interval) was more than sufficient to counteract the pressure build-up in the oral cavity. In contrast with the voiced plosives, exemplified in the upper part of figure 3.18, voicing was not only sustained, but grew in amplitude. Examination of the shape of the waveforms in detail suggests that the manner of this voicing is generally modal; there are only a few signs of a biphasic pattern and the waveform is not at all heavily damped. Compare these waveforms with those in figure 3.3 where one can see a clear biphasic pattern. There is nothing in these data to indicate that a description of these

figure 3.19 Intra-oral pressure records of the Hausa words bardoo 'longtailed dove' and hardoo 'Fulani man' (courtesy of R. Schuh).

segments as having a feature [constricted glottis] would match the phonetic facts.

Lindau also studied the implosives produced by a number of speakers of Hausa. All but one of these speakers produced stops in which there was considerable glottal constriction. Lindau notes that "Five out of the 14 speakers produce a voiceless beginning of the closure, presumably from a glottal closure as the larynx descends. One speaker had an implosive just like those in the Niger-Congo languages. The 8 remaining speakers produced an implosive [in which the] closure displays highly aperiodic vibrations" (Lindau 1984:151).

We have observed sounds of this kind not only in Hausa, but also in other Chadic languages such as Bura, Margi and Ngizim. For many speakers, implosives are produced as in the token illustrated on the right of figure 3.19. In this case substantial negative pressure builds up in the mouth while the oral closure is held, but the vocal folds are too tightly closed for vocal fold vibration to occur during the closure. Voicing does begin shortly before the release, as the oral closure begins to be relaxed. Implosives of this type can be described as creaky voiced implosives, and could be transcribed as 6, rf and so on. In contrast, the voiced plosives from the same speaker, as shown on the left of the figure, have voiced vibrations throughout the stop closure, even though intra-oral pressure is positive.

Another view of this Hausa type of implosive is given in figure 3.20 which illustrates the difference between the plosives b, d and the implosives 6, rf in utterance-initial position. The data is from a different speaker. All these stops are voiceless during most of the closure in these examples. The differences are primarily in the onset of the vowel. In both 6 and rf the few periods of voicing during the closure and those at the onset of the vowel are irregular. The Hausa implosives with creaky voice seem to be similar to those in Mixtec as described by Hunter and Pike (1969). It may also be that, as the majority of Hausa speakers have some form of glottal constriction in their implosives, these sounds are

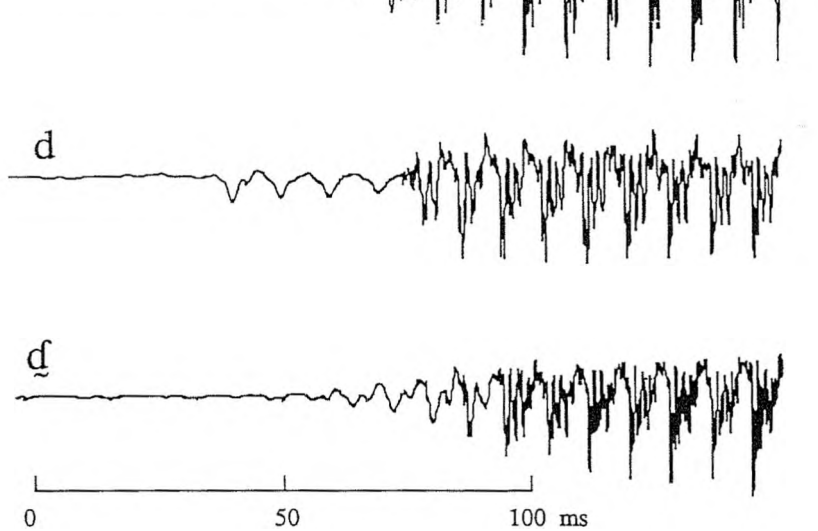

Figure 3.20 The difference between the releases of the modal voice and creaky voiced stops in Hausa.

Table 3.20 Words illustrating the set of so-called globalized sounds in Hausa, and contrasting non-globalized sounds

GLOTTAUZED	baitai 'spoil'	daime: 'tighten (belt)'	k'a:rai 'increase'	k"'a:ra: 'shea nut'	s'aira: 'arrange'	?^{j}a: 'daughter'
PLAIN	ba:ta: 'line'	daime: 'mix thoroughly'	ka:ra: 'put near'	k"a:ra: 'pour'	saira: 'cut'	ja: 'he' [comp.]

primarily distinguished from their voiced counterparts by being laryngealized, rather than by having an ingressive airstream. As illustrated in table 3.20, Hausa has ejectives at some places of articulation and implosives at others. This set of sounds, together with ?, has been called globalized by Camochan (1952), so as to provide a label for a group of sounds that are subject to the same phonotactic constraints.

implosives and implosives with modal voicing. This would mean that this language contains both implosives such as Hausa 6, d and Kalahari 6, cf. Examples in accordance with Goyvaerts' interpretation are shown in table 3.21. However, Demolin (1995) has a different interpretation, preferring to interpret the distinction as one between voiced and voiceless implosives, as we will discuss below.

Implosives with glottal closure (voiceless implosives)

For a considerable time implosives were generally regarded as having only one possible laryngeal setting, namely that for voicing. But, as we have just noted, implosives can vary between modal voice and a more constricted phonatory setting. Both Catford (1939) and Pike (1943: 92) mention the possibility of voiceless implosives in the early literature on these sounds. By this, they meant implosives produced with a full glottal closure.

Voiceless implosives occur in Owerri Igbo (Ladefoged et al. 1976). The Owerri dialect of Igbo has a larger number of laryngeal distinctions among oral stops at one place of articulation than any other known language. We have already discussed the four-way phonation type contrast; in addition there are both voiced and voiceless implosives, making a total of six bilabial stops, as shown previously in table 3.6.

Figure 3.7 illustrated the difference among the Igbo bilabial stops. The implosive 6 is clearly a voiceless glottalic ingressive stop. After the lips close, airflow out of the mouth ceases, and the pressure inside the mouth increases very slightly. Then, probably at the time when the small mark on the oral pressure record occurs, the glottis closes. The closed glottis is lowered so that the pressure in the mouth decreases considerably. When it is about -4 cm H_2O the vocal folds start vibrating and the oral pressure starts increasing. Shortly afterwards the lips come apart and air flows out of the mouth.

These implosives are nearly always slightly voiced during the last part of the closure, with voicing beginning about 25 ms before the closure is released. The decrease in oral pressure is about 5 cm H_2O. We may assume that the pressure

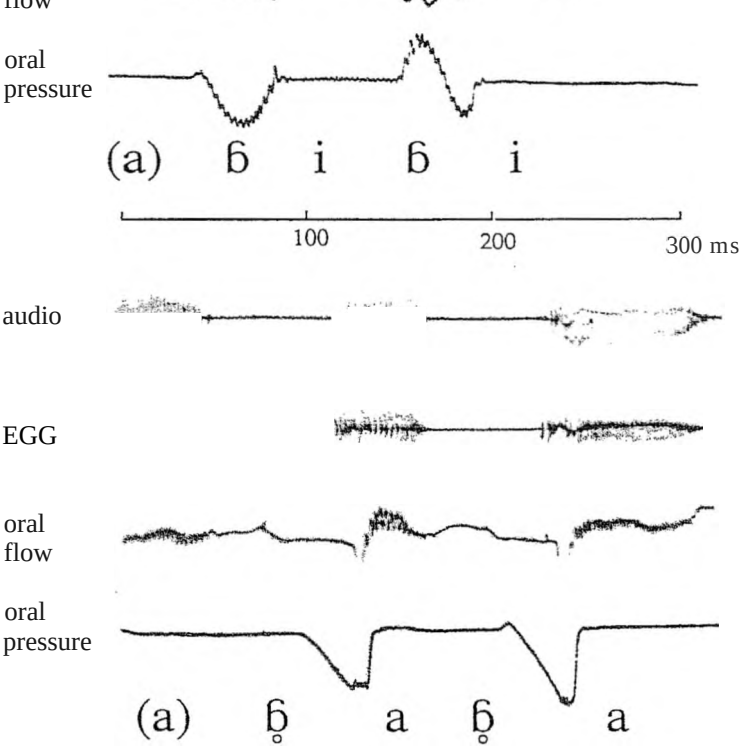

Figure 3.21 Aerodynamic records of Lendu implosives. In the words (a) 6i 6i 'eaten by insects', and (a) 6a6a 'attached to'. From data supplied by Demolin (personal communication).

below the vocal folds during these implosives is very slightly higher than in other sounds, as the descending closed glottis will cause a slight (less than 1 cm H2O) increase in the pressure of the air in the lungs. The pressure of the air in the lungs during plosives is typically about 8 cm H2O for the speaker whose speech is illustrated in the figure. Consequently the pressure drop across the

Both the voiced and the voiceless bilabial implosives in Owerri Igbo also seem auditorily to be velarized. This is not surprising, as they developed historically from the labial-velars found in other dialects.

Voiceless implosives also occur in the Uzere dialect of Isoko (as well as in several other dialects), in for example oBa 'rooster' (Donwa 1982). Donwa's thesis contains oral pressure tracings for these voiceless implosives.

According to Demolin (1995), the implosives in Lendu which Goyvaerts describes as laryngealized are voiceless implosives, as Kutch Lojenga (1991) had earlier suggested. The lower part of figure 3.21 illustrates the implosives of this type in the Lendu word meaning 'attached to' which here, following Demolin, is transcribed BaBa. These sounds are in contrast with the voiced implosives, which are illustrated in the upper part of figure 3.21 in the word Bi 61 'eaten by insects'. In BaBa the lowering of the oral pressure, lack of voicing during most of the closure, and the small ingressive airflow at the release of the closure suggested to Demolin that these are voiceless implosives. Note, however, that voicing starts slightly before the release of the closure, as is particularly evident on the EGG (electroglottograph) recording. This voicing may also be slightly creaky. Demolin notes that the pre-voicing is a consistent feature of these sounds. In view of this property it seems to us that Goyvaerts might be correct, and that these sounds are very similar to those in Hausa. If this is the case, then Lendu would be an example of a language that distinguishes between laryngealized stops and modally voiced implosives.

Pinkerton (1986) has a good discussion of the glottalic airstream mechanism in Kichean (Mayan) languages. In these languages, there is considerable variation across dialects and across speakers in the realization of glottalized stops as implosives, or ejectives or pulmonic stops. Thus, in some towns glottalized uvular sounds are voiceless implosives while in others they are voiceless ejectives. The voiced bilabial stop is produced as an implosive or as a voiced pulmonic stop, or as a voiceless bilabial implosive. The glottalic alveolar stop appears as a voiceless ejective, a voiced implosive and a voiceless implosive. In each case, therefore, some distinct characteristic separates the glottalized consonants from the unaspirated voiceless pulmonic stops with which they contrast. The common feature is a constriction of the glottis, and it is this laryngeal

considered a part of the release burst of the stop. Affricates are stops in which the release of the constriction is modified in such a way as to produce a more prolonged period of frication after the release. As with many of the types of sounds we have discussed, the class of affricates has no sharp boundaries. Affricates are an intermediate category between simple stops and a sequence of a stop and a fricative. It is not always easy to say how much frication should be regarded as an automatic property of a release; some places of articulation seem to be often accompanied by considerable frication (see chapter 2). At the other extreme, a combination of a stop and fricative that both happen to have the same place of articulation do not necessarily form an affricate. Phonological considerations must play a part in any decision as to whether a stop and a following homorganic fricative is to be regarded as an affricate which is a single unit, or as two segments (or two timing slots), forming a sequence of a stop and a fricative.

Affricate releases may involve only a slight widening of the articulatory constriction of the stop, so that stop and fricative components have identical place of articulation. Some affricates, however, involve a small forward or backward adjustment of the active articulator position. An example is the affricate pf in German, usually described as labiodental in place. For many speakers the stop component of this sound has a bilabial closure for which the upper lip is actively lowered to meet the raised lower lip (the position is subtly different from that in simple p, in that the lower lip is slightly retracted). The closure is released by raising the upper lip and pulling the lower lip further back into the normal position for f. The details of these gestures can be well observed in the photo-strips of lip positions published by Bella and Valaczkai (1986).

The most common affricates are voiceless and sibilant; the palato-alveolar affricate tf occurs in approximately 45 percent of the world's languages and dental or alveolar sibilant affricates are also quite common (Maddieson 1984a). Less common affricates occur in Standard Chinese, which has a voiceless aspirated alveolo-palatal affricate, in addition to a voiceless aspirated sibilant affricate which is traditionally called retroflex, as illustrated in table 3.22. The fricative components of these sounds and their place of articulation will be discussed in chapter 5.

The Athabaskan language Chipewyan has one of the largest and most com-

	UNASPIRATED		ASPIRATED		EJECTIVE	
STOPS	bes	'knife'				
	dene	'man'	t^heli	'pail'	t'o0	'paddle'
	gah	'rabbit'	k^he	'moccasin'	k'i	'birch'
AFFRICATES	dOe0	'hide'	$t0^h$e	'pipe'	t0'ai	'dish'
	dzeke	'rubbers'	ts^haba	'money'	ts'i	'canoe'
	djie	'berries'	tj^he0	'duck'	if OY	'quill'
	dlie	'squirrel'	t^es	'lard'	tfuli	'rope'

plex sets of voiceless affricates, as shown in table 3.23. Other unusual affricates are said to occur in Beembe, which we infer from Jacquot (1981) to have a voiceless aspirated labiodental affricate contrasting with a voiceless unaspirated affricate at the same place in, for example, pf^huri 'cotton' vs. pfina 'duvet'.

Most of the distinctions that can distinguish unaffricated stops also occur with affricates. Slack voiced affricates were illustrated in the discussion of Javanese, and breathy voiced affricates in the discussions of Hindi and Sindhi. Palatal implosives which sire usually affricated were noted in the discussion of Sindhi. Other implosive affricates have been described by Hoard (1978) in Gitskan, a dialect of Tsimshian. Affricates with mixed voicing (which we would rather regard as sequences of voiced stops plus affricates) were illustrated in Zhu|'h6asi. Lateral affricates and ejective lateral affricates are discussed in chapter 6.

3.4 Length

Stops, like most other sounds, can contrast in length. In fact, long or geminate stops have been referred to earlier in this chapter in examples from Arabic, Ilwana, Icelandic and other languages. The most widely used measure of the length of a stop is the closure duration as measured from acoustic records. In

not be separated by an epenthetic vowel or other interruption, neither will one half of them undergo a phonological process by itself (Hayes 1986, Lahiri and Hankamer 1988). They often alternate with short consonants in processes of morphological derivation. Geminate affricates are very clearly different from an affricate sequence, since the sequence has two stop and two frication portions, while a geminate affricate has a long stop closure followed by one fricative portion.

Geminate stops in many languages are limited to word-medial positions where they usually close the preceding syllable, shortening its vowel to some degree, as well as serving as the onset of the following syllable (Maddieson 1985). Japanese exemplifies the rare case where a preceding syllable is essentially unaffected by a long following stop (Homma 1981, Smith 1992). The acoustic record does not reveal whether a long stop is produced with two separate articulatory gestures, the first corresponding to the syllable-closing part and the second corresponding to the syllable-opening part, as was proposed long ago by Sievers (1876). A number of studies have looked at this issue using either electromyography or methods of tracking articulatory movements over time. An electromyographic study by Lehiste, Morton and Tatham (1973) showed that two peaks of activity of the orbicularis oris muscle can occur both for word-medial geminate pp in Estonian and for p#p across a word boundary in English for one speaker of each of these languages. On the other hand Barry's (1985) dynamic palatographic data on English k#k sequences did not show any evidence of two articulatory peaks and Smith's (1992, 1995) x-ray microbeam study of word-medial geminates in Italian and Japanese did not show double peaks in the articulatory movement of the lips for geminate bilabial stops in either of these languages, nor was there evidence of any double peaks in the tongue blade movements for alveolar geminate stops in this study. Typical trajectories showing the tongue back movement (for the vowels) and the changes in lip aperture in the production of single and geminate bilabials in Italian are shown in figure 3.22.

It thus seems evident that geminates can be produced with a repeated articulatory movement under some circumstances, but that this is unlikely to be the most common articulatory pattern. Moreover, the presence or absence of a second articulatory peak cannot be taken as diagnostic of whether a long

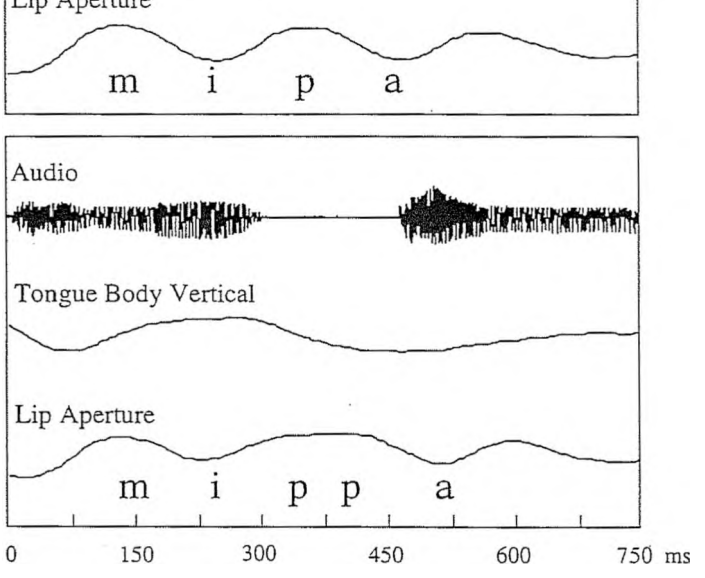

Figure 3.22 Articulatory trajectories for lips and the tongue in the nonsense words mipa and mippa spoken by one of the Italian speakers in Smith (1992).

closure represents a geminate stop or a sequence of two identical stops.

Most languages with a distinction of consonant length have only two distinctive lengths. Estonian and Sami are among a handful of languages that have been claimed to have three distinctive lengths for consonants. At least in the Lule dialect of Sami (Engstrand 1987) the third consonant length ('Grade III') is actually realized as a consonant sequence containing an epenthetic vowel with predictable quality. In Estonian (Lehiste 1966, Eek 1984-5) the third length is created by further lengthening of long consonants in a stressed syllable.

Word-initial long stops are rare, but they exist, for example, in Pattani Malay (Abramson 1986, 1991), which has a length distinction for initial consonants.