illustrative contrasts are given in table 3.24. Abramson reports that the mean duration of the closures for the long stops in word-initial and word-medial position measured in a carrier phrase is three times longer than that for the short consonants. Of course, the onset of closure of an utterance-initial voiceless stop has no acoustic signature, and hence the durational differences cannot be readily perceived in this position. Nonetheless, Pattani Malay speakers can reliably recognize words contrasting in initial consonant length in isolation. Abramson (1986) suggested that the perceptual cues that compensate for the lack of information about closure duration in initial voiceless unaspirated stops might include intensity of the stop burst, rate of formant transitions, fundamental frequency perturbations, and relative amplitude of the following vowel. In a more recent report (Abramson 1991), he has shown that Pattani Malay listeners are indeed sensitive to amplitude differences in the initial syllable in forming their judgments about the category of utterance-initial stops.

LuGanda also has long and short consonants which contrast in initial and medial position (Ladefoged, Glick and Criper 1968: 40). Initial contrasts are shown in table 3.25. The initial long consonants can be shown to be moraic (they were separate syllables historically, when they were accompanied by a high front vowel). Phonologically speaking these consonants are tone-bearing, although they may be voiceless, as in the examples cited in table 3.25. The audible difference between the words in the two columns in table 3.25 is largely in the pitch of the first vowel. The words in the second column have a lowered high tone because of the influence of the preceding (silent) low tone. The release of the stops in these words is also stronger than in words with simple initial voiceless stops. Long stops in word-medial position in LuGanda are differentiated more straightforwardly by duration but still have an underlying tone.

In addition to the distinctive use of long and short consonant lengths, there are many factors that affect the durations of stops in both their articulatory and acoustic domains. These include speaking rate and style, position in a word and other prosodic structures, the context of surrounding sounds, as well as certain inherent properties in the consonant itself. Since other durational variations are, for the most part, not distinctive we will not discuss them in this

3.5 Strength: Fortis vs Lenis Stops

The terms fortis and lenis have been used with very diverse meanings in the literature. We will discuss two of these uses; in one of these uses the term 'fortis' indicates increased respiratory energy applied in the production of a segment, in the other 'fortis' indicates greater articulatory energy. In both cases, lenis indicates less energy.

The use of increased respiratory energy at a segmental level is a comparatively rare event. The best known example occurs in the Korean stiff voice stops discussed above, in which heightened subglottal pressure accompanies the more constricted glottis and tenser walls of the vocal tract. We have also observed consistent subglottal pressure increases in some (but only in some) contrasts involving aspirated stops, such as those in Igbo, described above.

There is also a heightened subglottal pressure in the formation of some long stops, such as the long initial stops in LuGanda. But these stops may not have an actual increase in respiratory effort. If the volume of air in the lungs is being decreased at a steady rate and a stop closure occurs, then the pressure of the air in the lungs will be increased in proportion to the duration of the closure. This effect in itself may be sufficient to account for the strong release burst of the long stops in LuGanda.

The question of articulatory strength as a parameter of distinctive consonantal contrast has been raised much more often. Many writers prefer to describe the two series of stops in Germanic languages such as English, German and Dutch as 'fortis' and 'lenis' rather than as voiceless and voiced. This is in part because there is often no vocal fold vibration in consonants of the 'voiced' series, so that reference to voicing can be considered misleading, but also because it was felt that the complex of measurable properties which distinguish these series - especially matters of timing such as the longer stop closure and shorter preceding vowel - could all be accounted for on the basis of the strength of the articulation. Alternative terms were used in the nineteenth century, when 'tense' and 'lax' were substituted for voiceless and voiced, a use

McLean-Muse (1987) showed that the peak closing velocity for postvocalic p was significantly greater than for b in a study of eight speakers of American English, and Slis (1971) had earlier shown EMG activation levels 12 percent higher for the lip-closing activity of the orbicularis orbis muscle in a word-medial p than for b for a speaker of Dutch. Engstrand (1989) showed a more extended contact area for t than for d in Swedish in a dynamic palatographic study.

Such differences in the purely oral articulatory movements between consonants that are commonly described by reference to their laryngeal settings are not confined to Germanic. In fact, we believe they are widespread. For example, the Ewe bilabial stops p and b also differ from each other in their articulatory gestures, as the movement tracks in figure 3.23 illustrate. The closing movements of the upper and lower lips are markedly faster for p than they are for b, and the peak of the p gesture is flatter, indicating more compression of the Ups. In the terms of Browman and Goldstein's articulatory phonology, the gesture for p has greater stiffness. Older phoneticians might have said it was fortis. Because the lips reach closure earlier, this difference also relates to the longer closure duration of p (158 vs 150 ms in these data).

Voiceless stops have a greater mean oral pressure than voiced stops, and also often have a greater peak oral pressure. Accordingly, the greater degree of articulatory activity in the formation of the closure may be an anticipation of this need to make a firmer seal. In principle, the parameters of voicing and gestural stiffness could vary independently. When they co-vary either one might be regarded as primary. As little is known about the articulatory dynamics of most languages, we would caution against making the assumption that phonological voicing differences are associated with articulatory strength differences in any particular case.

Only a relatively small handful of languages have been proposed as possibly having articulatory strength differences that are independent of voicing. Among salient examples are Dagestanian languages such as Tabasaran (Kodzasov and Muravjeva 1982), Archi (Kodzasov 1977) and Agui (Kodzasov 1990: 338-41). Stops, affricates and fricatives in Archi, according to Kodzasov, show a contrast of strength. In the strength groupings that he sets up, weak stops are usually voiced but weak fricatives are voiceless and weak affricates

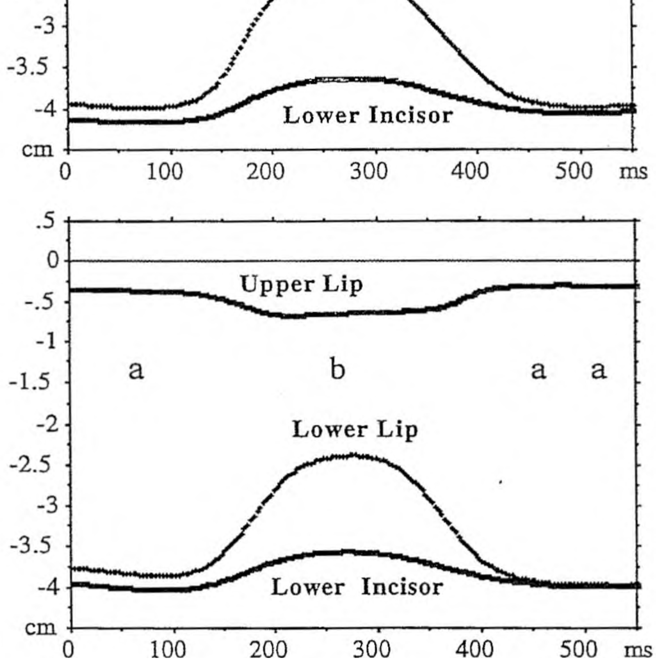

Figure 3.23 Vertical movement trajectories of the lips and jaw in production ofapaa and abaainEwe. Mean of ten repetitions by one speaker (from Maddieson 1993).

are ejective, so there is no overall association of the strength and voicing parameters. Although strength is associated with durational differences, Kodzasov argues that the strength is the primary factor involved. In his view 'Strong phonemes are characterized by the intensiveness (tension) of the articulation. The intensity of the pronunciation leads to a natural lengthening of the duration of the sound, and that is why strong [consonants] differ from weak ones by greater length" (p. 228). However, "the adjoining of two single weak sounds does not produce a strong one... Thus, the gemination of a with short consonants in Ojibwa. Jaeger (1983) also found length to be a significant factor. She summarized the range of phonetic events that have been claimed to produce a fortis/lenis contrast, and concluded that in two quite different languages she was investigating, Zapotec and Djauan, the phonetic factors underlying the contrast were primarily duration, glottal width and possibly closure width. She suggests that in both these languages the prototypical fortis obstruent is long, voiceless, has no variation in stop closure, and has higher amplitude noise; the prototypical lenis obstruent is short, usually voiced but often voiceless, has much variation in closure type, and lower amplitude noise. McKay (1980) concludes that the stops in Rembarmga, another Australian language spoken in the same region as Djauan, are better described as single vs geminate rather than as fortis/lenis or voiced/voiceless, but measurements from spectrograms show that the closure durations for single stops can be extremely short, especially for coronals. Short stops are often voiced but by no means invariably. McKay comments (p. 346) that the spectrograms show "the geminate stops to be characterized by a more abrupt closure ... and by a more prominent burst of noise at the point of release, with greater interval before voice onset after the release ... than the corresponding single stops. These characteristics of the geminate stops may be considered indicators of fortis or tense articulation." There are thus indications that the long and short stops are not produced with articulatory movements that are identical apart from their timing. Neither McKay nor Jaeger provide any aerodynamic or articulatory data, so it is difficult to determine whether the differences they observed were also accompanied by variations in respiratory effort, or in what way the articulatory dynamics might differ, apart from the indication that the articulatory magnitude tends to be less for the lenis stops. We do not know whether any of these sounds should be regarded as fortis by our definition, but again, as when it co-varies with voicing, there does not seem to be independent use of articulatory strength as a contrastive parameter. Rather, it is an aspect of a contrast that also includes length.

The terms fortis/lenis may sometimes provide useful phonological labels for specifying a dichotomy when used language-spedfically, as noted by both Jaeger (1983) and Elugbe (1980). But we agree with Catford (1977a: 203) who says "the terms tense/lax, strong/weak, fortis/lenis, and so on, should never noted that there are no neat boundaries between one place of articulation and the next. This problem is even more acute in the case of some of the distinctions among stops. Those due to differences in phonation type cannot be neatly categorized, as is apparent when we try to draw up a matrix of contrasting states of the glottis, as shown in table 3.26. Contrasts that we do not know of are indicated by question marks. Those we think unlikely to exist are marked by solid lines. Pre-aspiration has been put at the bottom of the chart because it probably never forms the basis for contrasts among underlying forms. Glottal closure is also noted separately, as it is more appropriately considered to be in opposition to other places of articulation than to different phonation types. The table then shows languages illustrating the contrasting possibilities of the other states of the glottis.

There are no problems with the first three rows of the first three columns in table 3.26. Voiced, voiceless unaspirated and voiceless aspirated stops contrast with each other in many languages. The fourth column also lists reliable contrasts between creaky voice and the first two possibilities, voiced and voiceless stops, but it is a little more difficult to list clear cases of contrasts between creaky voiced and aspirated stops. We feel that this is likely to be an accidental gap, largely due to our lack of knowledge of phonetic details of languages with creaky voiced stops. Further problems come with the addition of the terms stiff voice and slack voice; some of these cases are unlikely to be accidental gaps. We doubt that creaky voice and stiff voice will contrast, and the same is true of breathy voice and slack voice. It would also be possible to re-arrange the contrasts that we have shown here, and suggest that Javanese contrasts modal and slack voice stops (instead of stiff voice and slack voice stops as we have indicated). But this would simply leave a gap at a different place in the table.

Given the evidence of table 3.26, we might be thought to have overspecified differences among phonation types. There are three comments that can be made on this observation. Firstly, it may be true - as far as stops are concerned. When we consider vowels we will be able to illustrate at least one of the contrasts that is noted here as missing or dubious. Secondly, the terms listed describe what Keating (1984a) has called "major phonetic categories." There is a continuum of phonation types, but phoneticians have no difficulty identifying archetypal sounds corresponding to each of these terms. Thirdly, although

(3) ASPIRATED	p^h b^{fi} Hindi	P^h b ?????	P^h b Thai	p^h b Shanghai
(4) BREATHY VOICED		?????	?????	—
(5) CREAKY VOICED			—	?????
(6) STIFF VOICE				b b Javanese

(8) PRE-ASPIRATION (9) GLOTTAL CLOSURE

there are missing or dubious entries, the matrix in table 3.26 illustrates a number of oppositions that would be difficult to describe using a smaller set of terms (but not impossible, with a bit of pushing and shoving). As our main aim in this book is to give good phonetic descriptions of the widest possible set of sounds occurring in the world's languages, we will tentatively suggest that all the phonation types listed here need to be distinguished within whatever feature set is proposed.

Table 3.27 summarizes most of the other contrasts among stops that we have been considering in this chapter. The four possibilities in this set, ejective, voiced implosive, voiceless implosive and affricate contrast with one another, and also contrast with plosives. In addition we have noted that a few languages have stops that contrast in length, and a smaller number still have contrasts in strength, either of the airstream mechanism or of the articulatory gestures.

The phonological representation of stops should take into account all the phonetic parameters listed in tables 3.26 and 3.27, plus the additional possibilities, length and strength. The theory should also make it apparent that stops are subject to continuous variation along a number of parameters, and that within these continua there are no hard boundaries. Thus it should be clear that there is a continuum between voiced stops and voiced implosives, so that it is natural for there to be allophonic variation within this range. There must

(2) VOICED IMPLOSIVE	6 6 Igbo	cf dz Avokaya
(3) VOICELESS IMPLOSIVE		d ts Igbo

be other continua linking voiced implosives with both creaky voiced stops and ejectives, and for many more such relations. The stops of the world's languages have to be specified not only in terms of their places of articulation as described in the previous chapter, but also in accordance with other distinctive properties as outlined in this chapter.

Nasalized Consonants

This chapter describes the types of nasal and nasalized consonants that occur in the languages of the world. It is also concerned with some general questions concerning the timing relationship between oral articulation and velic function. We will divide the discussion into three principal sections; 4.1 on purely nasal consonants, 4.2 on the analysis of consonant elements that are partly nasal (that is, for part of their duration they are nasal and for part of their duration they are oral), and 4.3 on nasalized consonants (where nasal airflow accompanies oral airflow). Nasalized vowels are discussed in chapter 9 and nasalization as an accompaniment to clicks in chapter 8.

4.1 Nasals

A nasal consonant is one in which the velum is lowered and there is a closure in the oral cavity somewhere in front of the velic opening. Hence, air from the lungs is directed out through the nasal passage alone. Note that what we call simply nasals are called nasal stops by some linguists. We avoid this phrase, preferring to reserve the term 'stop' for sounds in which there is a complete interruption of airflow. Ingressive nasals can be produced but they are not known to occur in human languages, although an ingressive nasal accompaniment to clicks occurs in !X6o, as described in chapter 8. In principle, nasal segviewed here.

Nasals have an articulatory similarity to stops by virtue of their oral closure, but in other respects they are similar to approximants. This is because there is an uninterrupted outward flow of air that does not pass through a constriction sufficiently narrow to produce local turbulence. There are no fricative nasals. It is quite possible to narrow the velic opening so that friction is produced by the constricted airflow through the velo-pharyngeal port (while maintaining an oral closure). Catford (1977a) mentions a fricative of this type as a potential speech sound, but, as far as we know, languages do not contrast nasal consonants which vary in the degree of velic opening in this way. We believe that distinctions of type of velic stricture are linguistically irrelevant for nasals. Pike (1943) also noted that 'frictionalized nasals' can be produced by making a forward oral closure and narrowing the pharynx sufficiently to create turbulence before the air enters the nasal passage. Again we do not know of any linguistic use of this possibility.

It has, however, been suggested that nasals can differ in degree of velic opening without involving friction in the contrast. In many Austronesian languages, nasals occur alone and in nasal + stop sequences (frequently analyzed as prenasalized units). Commonly, vowels are allophonically nasalized after nasals in these languages, but are oral after the nasal + stop elements. In a number of languages of Indonesia and dialects of Malay a special development has occurred which results in the loss of the stop component in the nasal + stop sequences while preserving the oral character of the following vowels. In at least some cases these newly developed nasals remain phonetically distinguishable from the original plain nasals, as well as having distinct phonological characteristics. Durie (1985) reports that in Acehnese they have a lesser rate of airflow through the nose than the plain nasals. (They also have a longer duration). If a distinction between the width of the velic opening in the new and the original nasals is inherent in these consonants, then open and close approximation of the velo-pharyngeal port distinguishes between types of nasals, i. e. there is a difference of manner of articulation. This is essentially the way that Catford (1977a: 139-40) interprets the Acehnese situation, as a distinction between 'lightly nasal' and 'heavily nasal' nasal consonants with controlled articulatory differences in the velic aperture.