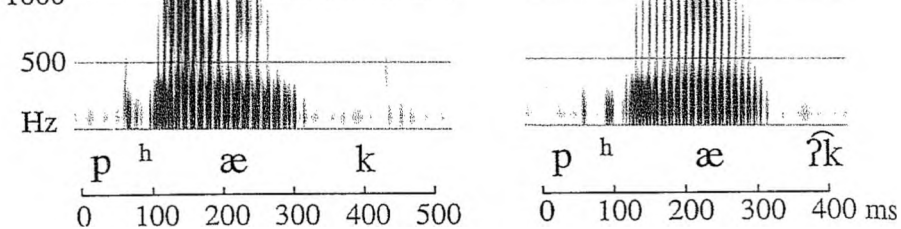

Figure 3.12 Spectrograms of the English word *pack* pronounced with final velar stop with (right) and without (left) accompanying glottal closure.

recordings of Siona, a Tucanoan language spoken on the Colombia-Ecuador border. This language is described by Wheeler and Wheeler (1962) as having a set of globalized stops which they transcribe p', *t'*, k', k^w', in contrast with "the simple stop series p, t, k, k^w." They note that "the feature of glottalization is very light, and the globalized series can best be distinguished by the laryngealization which occurs on the following vowels." Our impression is that there is a simultaneous glottal closure with the 'globalized' series. Both stop series have a brief delay of voice onset after the release of the oral closure, but whereas this is filled with an acoustically noisy interval in the simple stop series, there is essentially silence between the oral release of a 'globalized' stop and the beginning of voicing for a following vowel.

Glottal closures can, of course, occur without accompanying oral closure, in which case they form glottal stops. Different types of glottal stops have been observed in the world's languages. In several languages they are part of the regular stop series. This is the case in Hawaiian, in which there are only eight contrasting consonants, as shown in table 3.14. Elsewhere, glottal stops serve to demarcate the boundaries of phrases or other prosodic units. A frequent role of this type (for example, in German) is to indicate the beginning of a word when no other consonant is present. In other languages, however, glottal stops function more as a variation in phonation type. In Huatla Mazatec, as Pike and Pike (1947: 79) note, the glottal stop is sometimes realized as a complete stop, and sometimes as laryngealization of the following vowel. In Jalapa Mazatec

true stop, a very compressed form of creaky voice or some less extreme form of stiff phonation may be superimposed on the vocalic stream. True stops occur reliably only when it is a matter of gemination. A typical example of these phenomena from a speaker of Lebanese Colloquial Arabic is shown by the waveforms in figure 3.13. In this figure a long silent closure period is

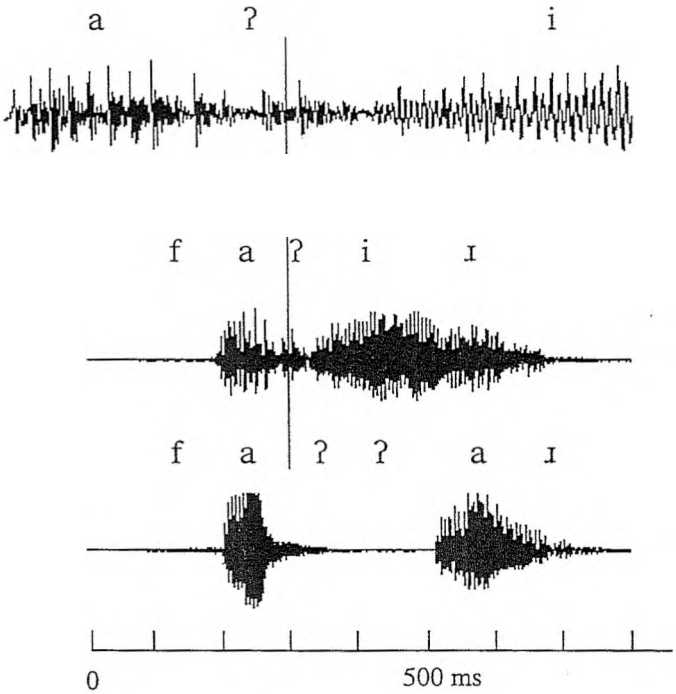

Figure 3.13 Waveforms of Lebanese Arabic geminate and single ? in the words 'make poor' (bottom line) and fa?u 'poof (middle line). An expanded waveform of the word on the middle line is shown on the top line. A vertical bar indicates the point at which the expanded portion is aligned with the main waveform.

that behave as if they had contrasting voiced and voiceless glottal stops, although, quite obviously, this could not literally be the case. One such language is Gimi, a Papuan language of the Eastern Highlands, Papua New Guinea. According to McBride (personal communication), Gimi has a stop system that includes contrasts between voiced and voiceless unaspirated stops at the bilabial and alveolar places of articulation. Where neighboring languages have cognate forms containing k and g, Gimi has a glottal stop corresponding to k and another segment, which we will symbolize using an asterisk, corresponding to g. From a phonological point of view this segment behaves like a glottal stop, in that it operates in rules which require a glottal stop in the context. For example, there is a rule whereby the nasals m, n become the corresponding stops b, d when they occur after a glottal consonant at the end of a preceding morpheme.

Our own recordings of Gimi show that * consists largely of a diminution of energy[7] between otherwise adjacent vowels. Waveforms of the words in table 3.15 are shown in figure 3.14. In each case an expanded version of the intervocalic portion is shown above the waveform of the whole word. A time scale applicable to the expanded waveforms is at the top of the figure; one for the unexpanded words is at the bottom. The waveform for the intervocalic h is that of breathy voice fi, and is similar to the intervocalic fi in English 'behold'. The waveform for ? shows some noise in the initial portion, but is otherwise indicative of a tightly closed glottis. The so-called voiced glottal stop is signaled by slight irregularities in the glottal pulses, and a considerable decrease in the amplitude of the pulses which is probably due to an increase in the glottal stiffness; but there is no indication of anything that would normally be called a stop, glottal or otherwise. There is, however, a clear distinction between * and a simple transition between adjacent vowels as shown in the lower part of the figure. The vowel-to-vowel transition reflects simply the waveform changes that can be associated with the changes in the formant frequencies. In summary, it seems that * in Gimi is voiced, and involves some glottal activity; but it might better be called a creaky voiced glottal approximant rather than a stop.

Thus Gimi uses in a distinctive way what are for most languages simply parts of the range of possible variation in the production of glottal stops.

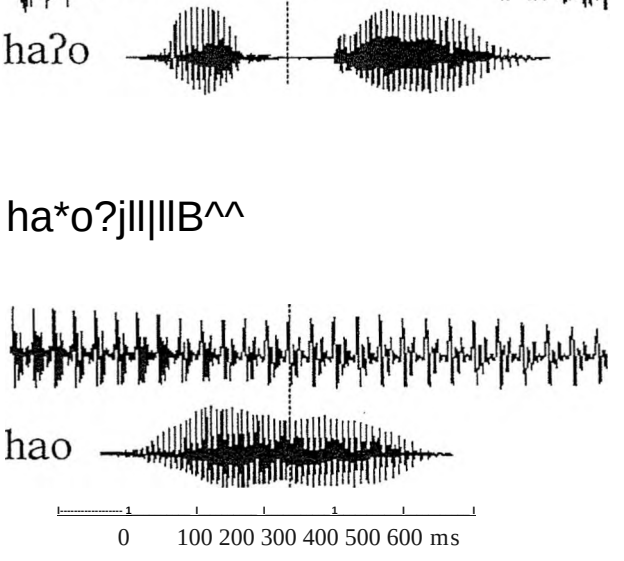

Figure 3.14 Waveforms of the Gimi words in Table 3.15. An expanded version of the intervocalic portion is shown above the waveform of the whole word, time-aligned as indicated by the dashed lines.

Another language which has been reported to have a voiced glottal stop is Jingpho (Maran 1971), but in this case it seems to us preferable to regard the contrasting forms as being distinguished by tonal differences.

3.2 Airstream Mechanisms

Nearly all the sounds of the world's languages are made with the pulmonic airstream mechanism, in which lung air is pushed through the vocal tract by the action of the respiratory system. We have been using the term plosive to

stops that we have already discussed in this chapter displaying certain features in common with canonical ejective and implosive stops. For example, stops that occur with an accompanying glottal stop, as in the London English pronunciation of 'rat' as jae?t may have small upward movements of the larynx making them weakly ejective. In addition, fully voiced stops in many diverse languages (e.g. Maidu, Thai and Zulu) are often accompanied by downward movements of the larynx that make them slightly implosive. Nonetheless, the familiar labels ejective and implosive provide a convenient organizational framework for the next sections. There is also a third airstream mechanism, in which movements of the tongue suck air into the mouth. Stops using this velaric airstream mechanism are referred to as clicks. Clicks are quite distinct from other types of stops, whereas plosives differ from implosives and ejective stops by small steps. This is one of the reasons why clicks are discussed in a separate chapter.

Ejectives

Ejectives are not at all unusual sounds, occurring in about 18 percent of the languages of the world (Maddieson 1984a), in language families as diverse as Mayan, Chadic and Caucasian. As we noted, they are produced by the action of the closed glottis, while there is an occlusion in the oral cavity. The larynx is raised rapidly upwards, so that air in the vocal tract above the glottal closure is compressed. The pressure behind the closure in the oral cavity is often increased to about double the normal pulmonic pressure (i.e. from about 8 to about 16 cm H2O). The oral closure is then released, and, owing to the greater supraglottal pressure, there is a greater amplitude in the stop burst.

Among the places of articulation, velar articulations are the most favored for ejective stops (Haudricourt 1950, Greenberg 1970, Javkin 1977, Maddieson 1984a). Uvular ejectives are also quite common, and are reported in many North American languages such as Haida, Wintu, South-Eastern Porno and most of the Salishan languages, as well as in Caucasian languages such as Georgian and Kabardian. The ejectives in Montana Salish are illustrated in table 3.16. Palatal ejectives on the other hand sire comparatively rare, but not

q^{w}atsqan	'hat'	q"'ajalqs	'priest'

disproportionately so when compared with the palatal plosives. They are reported in Kwakw'ala, Acoma, Bella Coola and Jaqaru. The bilabial place of articulation is relatively disfavored, as it is for plosives. Typically, languages will have ejective stops at the same places at which pulmonic stops occur. This mirroring of behaviors for the two airstreams adds further underpinning to the notion that glottalic and pulmonic systems share more than do pulmonic and velaric.

There are considerable phonetic differences among the ejectives that occur in different languages, some of which have been well documented by Lindau (1984), who compared velar ejectives in Hausa and Navajo, and found significant cross-linguistic variation, as well as some notable inter-speaker differences. Waveforms illustrating some of the differences are shown in figure 3.15. The two languages differ in the relative durations of the different parts of the ejectives: the duration of the glottal closure is longer in the Navajo stop than in the one for Hausa. The Hausa glottal closure is probably released very soon after the oral closure, at the point shown on the figure by an arrow, and it is followed by a period of voiceless airflow. The Navajo glottal closure is released into creaky voice which continues for several periods into the beginning of the vowel. Lindau (1984) found that the long glottal closure in Navajo is a highly significant difference between the Navajo and Hausa speakers, and could not be attributed to the overall speech rate, which was similar in both cases. We do not know of any data that addresses the question of the relative timing of the formation of the oral and glottal closures.

This leads us to consider whether it is in any way possible to make ejectives with modal voice during the oral closure, that is, sounds in which although the larynx is being raised and the volume of the supraiaryngeal cavity is thereby being reduced, the vocal folds are nonetheless in a position for modal voice and sufficient air is flowing between them to induce vibration. It seems most unlikely that the requisite pressure differential could be produced so as

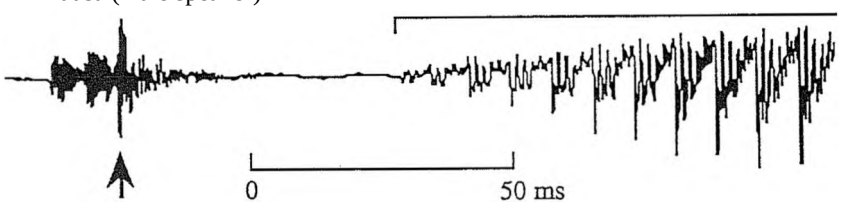

Figure 3.15 Waveforms illustrating differences between Navajo and Hausa velar ejective stops. The arrows indicate the releases of the glottal closures.

to cause sufficient airflow from the lungs to ensure vibration of the upward moving glottis. We do not know of any linguistic use of voiced ejectives.

Sounds that have been described in the literature as voiced ejectives are, in our opinion, misnamed. Voiced ejectives have been reported as contrastive in Zhu|'hoasi (Snyman 1970, 1975). But as Snyman makes clear, and as Maddieson (1984a: 216) is careful to point out, these 'voiced ejectives' are pre-voiced; the release is voiceless and from a phonetic point of view they are clusters of the form dt'. Clusters involving obstruents with mixed voicing in the same syllable are very rare in the world's languages, but they occur in !Xu languages and in Kelabit (Blust 1974,1993). We have already noted Zhu|'hbasi stops with mixed voicing in table 3.7. Further examples illustrating mixed voicing in ejectives and affricates are given in table 3.17. As is evident in the waveforms shown in figure 3.16 (which also illustrates one of the plain stops listed in the earlier table), the initial voiced stops are unexploded. These are not sequences of the form d't, but are simply homorganic pairs of stops, with the first member being voiced and unreleased, and the second being voiceless and, on some occasions, also ejective or affricated.

The ejective mechanism can also be used in conjunction with other articulations, including those that do not involve an oral closure. Ejective fricatives are discussed in chapter 5, and ejective accompaniments of clicks in chapter 8. Ejective affricates will be illustrated in a later section of this chapter.

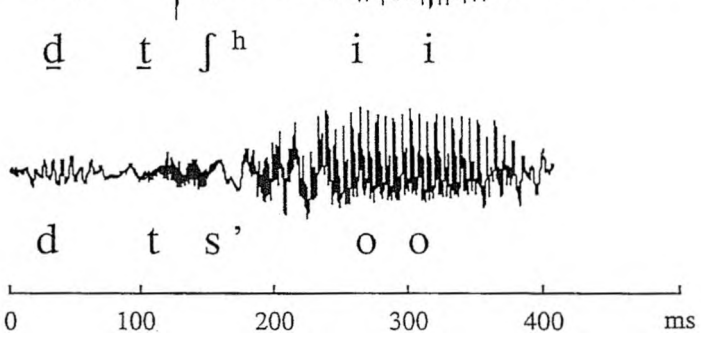

Figure 3.16 Waveforms of clusters with mixed voicing in Zhu|’h6asi.

Table 3.17 Words illustrating voiceless affricates and clusters with mixed voicing in Zhul’hoasi

	ALVEOLAR	POST-ALVEOLAR
VOICELESS UNASPIRATED	tsam 'to stalk'	tja 'to fetch'
ASPIRATED	tsʰe 'week'	tpatfa 'to sprinkle'
VOICED PLUS ASPIRATED	dtsʰau 'woman'	dtjʰii 'to carry straddled on shoulder'
VOICELESS EJECTIVE	ts’a 'sleep'	tj”am 'bird [coracias garrulus]'
VOICED PLUS EJECTIVE	dts’oo 'hartebeest'	dtj”i 'to be wet'

the vocal folds are vibrating. If the larynx is lowered rapidly enough, there may be a negative pressure in the oral cavity, so that on the release of the oral closure air flows into the mouth. However, it is often the case that the airflow through the glottis producing the vocal fold vibrations is sufficiently great to prevent the pressure of the air in the oral cavity from becoming negative; consequently there is no digressive airflow on the release of the stop closure. In fact, there is a gradient between one form of voiced plosive and what may be called a true implosive, rather than two clearly defined classes. Even when there has been a considerable glottal movement, the pressure in the oral cavity is often not very different from the pressure outside the mouth so that the stop burst is less evident.

About 10 percent of the world's languages contain implosives, many of them occurring in West African languages (Maddieson 1984a). Voiced implosives are found at most of the different places of articulation, but there is a tendency for anterior closures to be favored. Bilabial implosives are by far the most common, and voiced uvular implosives are very rare; they are reported to occur in the Ugandan language Ik (Heine 1975). It was once said (Jakobson, Fant and Halle 1952) that languages do not contrast implosives and ejective stops at the same place of articulation, but such contrasts have been reported in a number of languages, including Uduk, a Nilo-Saharan language, as shown in table 3.18.

Sindhi is a good example of a language with an extensive stop system including implosives, as shown in table 3.19. Nihalani (1974,1991) has provided good aerodynamic data on this language, some of which has been used in figure 3.17. This being a citation form, the utterance begins with an increase in the

Table 3.18 Words illustrating stop contrasts in Uduk, including ejective and implosive stops at the same place of articulation (suggested by Robin Thelwall)

	BILABIAL		ALVEOLAR	
VOICED	ba?	'to be something'	ded	'to shiver'
VOICELESS	pal	'to try'	ter	'to collect'
ASPIRATED	p^{h}alal	'centipede'	t^{h}er	'to pour off'
EJECTIVE	p'ac^{h}ad	'fermented'	fed	'to lick'
IMPLOSIVE	6a?	"back of neck'	dek'	'to lift'

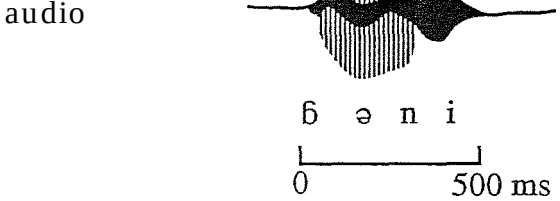

Figure 3.17 Aerodynamic data (based on Nihalani 1974) for the Sindhi implosive ɓ in the word Bank

Table 3.19 Words illustrating contrasting stops in Sindhi. j and c are affricates, and might be transcribed dz and tq. The palatal implosivef is often a slightly creaky voiced palatal approximant

	BILABIAL	DENTAL	RETROFLEX	PALATAL	VELAR
VOICED	banu 'forest'	daru 'door'	doru 'you run'	jatu 'illiterate'	guqu 'quality'
VOICELESS	panu 'leaf'	taru 'bottom'	tanu 'ton'	catu 'to destroy'	kanu 'ear'
VOICELESS ASPIRATED	pʰan.u 'snake hood'	tʰaru (district name)	tʰacfu 'thug'	cʰatu 'crown'	kʰanu 'you lift'
BREATHY VOICED	bᴮanariu 'lamentation'	dᴮaru 'trunk of body'	dᴮa^o 'bull'	patu 'grab'	gᴮani 'excess'
IMPLOSIVE	ɓani 'field'		digu 'festival'	fatu 'illiterate' [var.]	cfanu 'handle'

subglottal pressure, during which the lips are closed (there is no airflow), and the oral pressure first rises slightly and then decreases while the vocal folds are vibrating. At the moment of the opening of the lips the air can flow into the mouth because of the negative oral pressure. For this speaker, in these citation forms, the implosives at each place of articulation always have a negative oral pressure and a very small ingressive airflow.