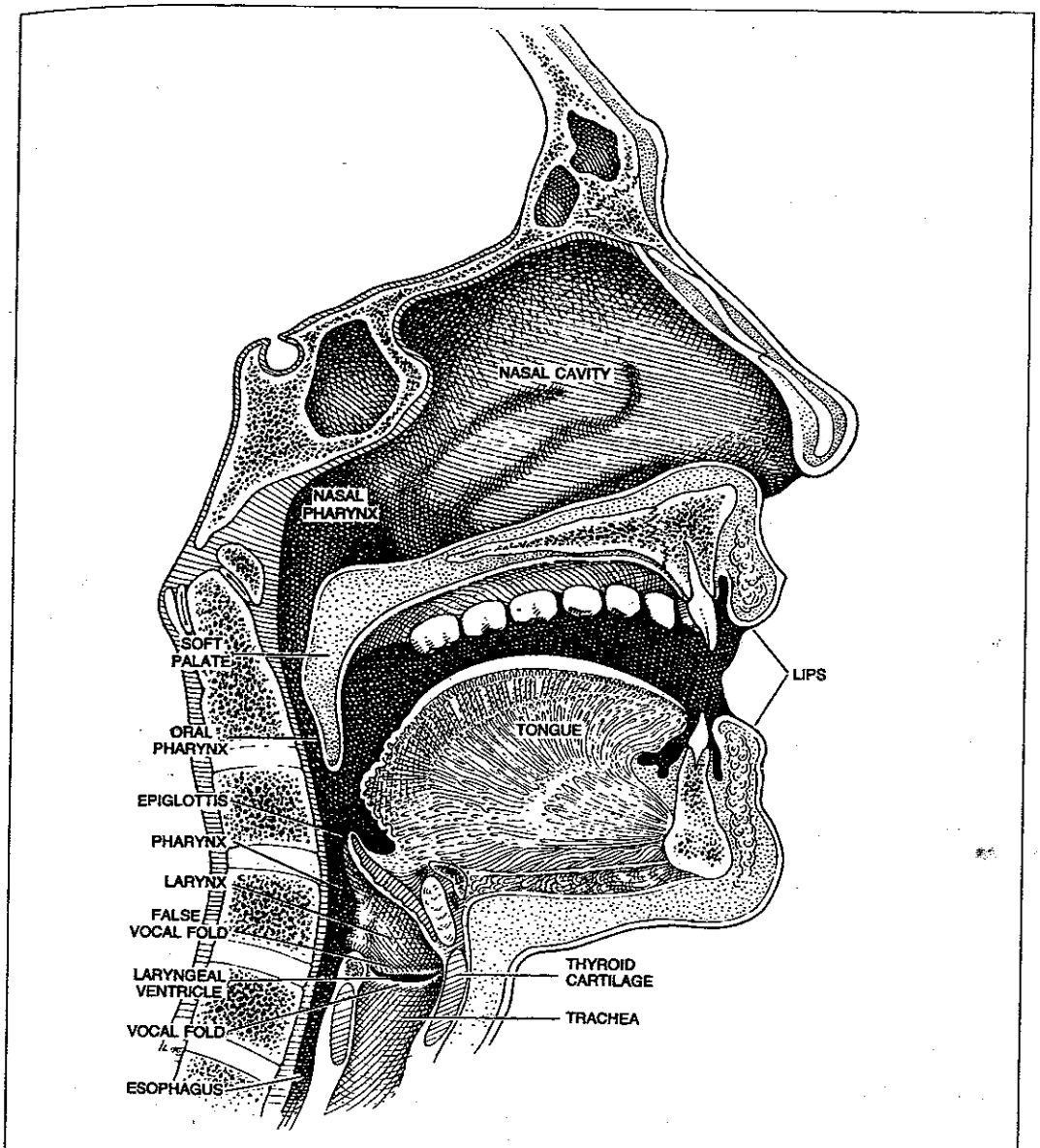

Figure 4.4 The vocal organs, shown in side view. Drawing by Laszlo Kubinyi from Sundberg (1977), ©Scientific American.

The area above the trachea is called the **vocal tract**, and consists of the **oral tract** and the **nasal tract**. After the air leaves the trachea, it can exit the body through the mouth or the nose. Most sounds are made by air passing through the mouth. Sounds made by air passing through the nose are called **nasal sounds**; nasal sounds use both the oral and nasal tracts as resonating cavities; English nasal sounds include *m*, and *n*, and *ng*.

NASAL SOUNDS

The technical use of these terms is much like the common usage; [p], [b], [t], [d], [k], [g], [f], [v], [s], [z], [r], [l], etc., are consonants; [aa], [ae], [aw], [ao], [ih], [aw], [ow], [uw], etc., are vowels. **Semivowels** (such as [y] and [w]) have some of the properties of both; they are voiced like vowels, but they are short and less syllabic like consonants.

Consonants: Place of Articulation

Because consonants are made by restricting the airflow in some way, consonants can be distinguished by where this restriction is made: the point of maximum restriction is called the **place of articulation** of a consonant. Places of articulation, shown in Figure 4.5, are often used in automatic speech recognition as a useful way of grouping phones together into equivalence classes:

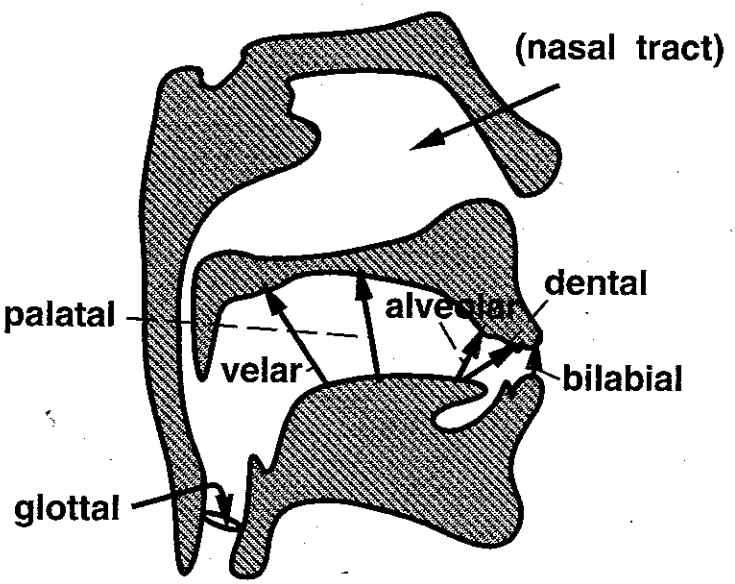

Figure 4.5 Major English places of articulation.

- **labial:** Consonants whose main restriction is formed by the two lips coming together have a **bilabial** place of articulation. In English these include [p] as in *possum*, [b] as in *bear*, and [m] as in *marmot*. The English **labiodental** consonants [v] and [f] are made by pressing the bottom lip against the upper row of teeth and letting the air flow through the space in the upper teeth.
- **dental:** Sounds that are made by placing the tongue against the teeth

what is called vowel **height**, which correlates roughly with the location of the highest part of the tongue, and the shape of the lips (rounded or not). Figure 4.6 shows the position of the tongue for different vowels.

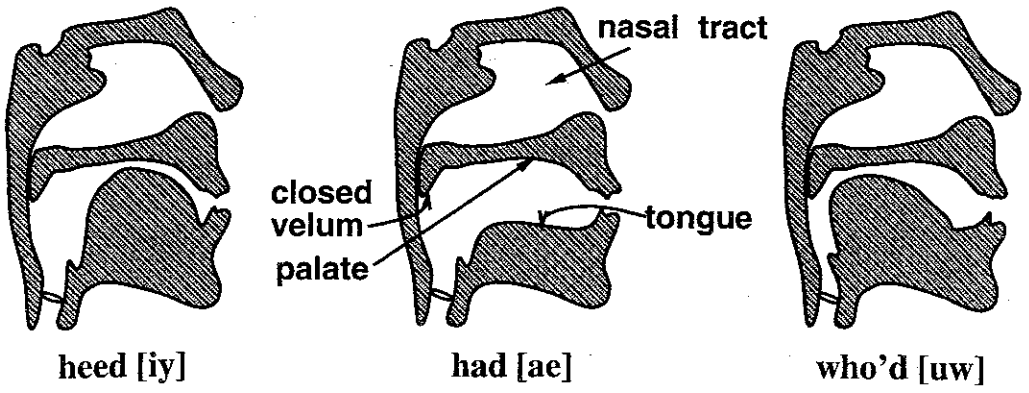

Figure 4.6 Positions of the tongue for three English vowels, high front [iy], low front [ae] and high back [uw]; tongue positions modeled after Ladefoged (1996).

In the vowel [i], for example, the highest point of the tongue is toward the front of the mouth. In the vowel [u], by contrast, the high-point of the tongue is located toward the back of the mouth. Vowels in which the tongue is raised toward the front are called **front vowels**; those in which the tongue is raised toward the back are called **back vowels**. Note that while both [ɪ] and [ɛ] are front vowels, the tongue is higher for [ɪ] than for [ɛ]. Vowels in which the highest point of the tongue is comparatively high are called **high vowels**; vowels with mid or low values of maximum tongue height are called **mid vowels** or **low vowels**, respectively.

FRONT
BACK
HIGH

Figure 4.7 shows a schematic characterization of the vowel height of different vowels. It is schematic because the abstract property **height** only correlates roughly with actual tongue positions; it is in fact a more accurate reflection of acoustic facts. Note that the chart has two kinds of vowels: those in which tongue height is represented as a point and those in which it is represented as a vector. A vowels in which the tongue position changes

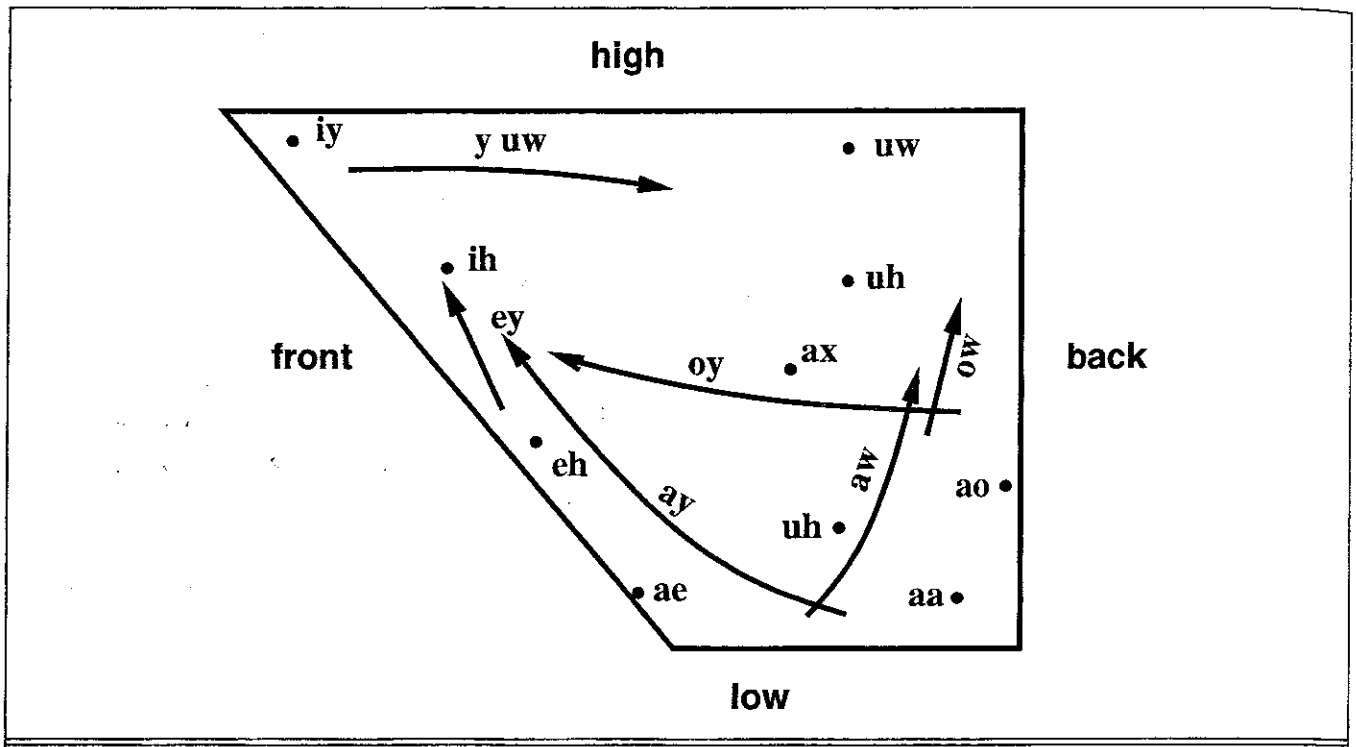

Figure 4.7 Qualities of English vowels (after Ladefoged (1993)).

Syllables

SYLLABLE

Consonants and vowels combine to make a **syllable**. There is no completely agreed-upon definition of a syllable; roughly speaking a syllable is a vowel-like sound together with some of the surrounding consonants that are most closely associated with it. The IPA period symbol [.] is used to separate syllables, so *parsley* and *catnip* have two syllables (['par.sli] and ['kæt.nɪp]