Preface

Scientific disciplines are generally defined by reference to the methods that they use. Phonetics, by contrast, is rather defined by its object: the scientific study of speech. It calls on the methods of physiology, for speech is the product of mechanisms which are basically there to ensure survival of the human being; on the methods of physics, since the means by which speech is transmitted is acoustic in nature; on methods of psychology, as the acoustic speech-stream is received and processed by the auditory and neural systems; and on methods of linguistics, because the vocal message is made up of signs which belong to the codes of language.

Given this, phonetics finds itself at the intersection between human and social sciences, health sciences and the sciences of information technology and communication. Spoken communication has its roots in what we are accustomed to call the audio-phonatory loop. This arises in the speaker who intends to impart a message; it is followed by the selection and organization of linguistic signs, the construction of a motor plan, and the execution of motor commands resulting in a series of transformations of the geometry of the vocal tract and the transmission of an intelligible acoustic signal, from which the listener retrieves the meaning of the message by means of hearing, stimulation of the auditory and peripheral nerves, perception and linguistic analysis.

Speech constitutes a favored means of human communication by virtue of its "apparent" ease and because of the speed of information transmission that it enables. Thus, an average output of 20 phonemes per second allows not less than 150 words per minute that humans can produce for communication purposes. In addition to its semantic function, speech also conveys information about the speaker himself: his geographic origin, his social orientation, his emotions and his attitudes.

Speech is unique to humans. Nevertheless, from an anatomical point of view, there are no organs dedicated solely to this function. The organs employed in the act of speech are borrowed from the respiratory, laryngeal and digestive systems. They primarily serve other functions such as the exchange of gases for respiration, the protection of airways and lungs, mastication and swallowing. The articulatory processes consist of the manipulation of respiratory and laryngeal structures and of the vocal tract in order to create speech sounds, modulate, amplify and filter them.

Speech production involves the coordinated contraction of more than 200 muscles, including those of the lips, the jaw, the tongue, the velum, the pharynx and the larynx, as well as those concerned with respiration. The activity of the muscles involved in speech is initiated and controlled by more than 1,400 nervous impulses per second, originating in the motor areas of the cerebral cortex. These travel along the motor pathways, including those descending (upper motor neurons) from the central nervous system to the lower tract served by the peripheral nerves (including certain cranial and spinal nerves). The number of degrees of freedom to be controlled is very large.

Phonetic sciences are concerned with discovering what types of control are in place to ensure the production of intelligible meaningful speech. Particular attention is thus paid to the study of the biological bases of language. This preoccupation is not new and can be clearly discerned in the works of grammarians from the 5th century onwards. For example, in the 8 books of the *Astadhyahyi,* the Hindu grammarian Pānini proposed a phonetic and phonological classification of Sanskrit based on articulation. This treatise must encourage respect for the pronunciation of the language of the gods. In the *Edda*, Snorri Stuluson placed the principles of opposition and commutation on an articulatory basis that phonology would rediscover more than a millennium later. In the *Grammatica lingua anglicanae* (1652), J. Wallis described the production of isolated sounds for deaf-mutes.

Today, technological developments in medical imaging, progress in the observation of organs and muscles facilitated by new tools, and an interest in articulation stimulated by vocal technologies such as speech synthesis and automatic speech recognition have all provided a new impetus to phonetic research and produced significant advances in the understanding of the mechanisms involved in speech production.

The main question to be answered concerns the relationship between the physiological aspects of the vocal apparatus and their role in achieving phonetic goals. Humans make use of only some of the phonatory potential of the larynx and the configuration possibilities of the supraglottal cavities. Which principles inform

the selection of a finite ensemble of phonetic segments out of the whole extent of anthropophonic capabilities? How did phonological systems evolve over time? What were the influences that shaped the modifications?

In introducing this topic, we recall that the phonetic domain is vast and interdisciplinary in nature. In this work we deal principally with the aspects that connect physiology and speech production. We indicate the methods and techniques used to observe the activity of organs in speech production. We also present the current state of knowledge in linguistic usage based on the possibilities offered by articulation and the phonatory apparatus.

Speech is the result of a neuromotor activity. It is initiated by a current of air generated by the lungs and transformed at the level of the larynx by the action of the vocal folds, and directed towards the nasal or oral cavities by the velum or soft palate. Finally, the air current is very precisely shaped at different places in the mouth by the tongue until it emerges from the vocal tract through the double shutter known as the lips (see Figure 1).

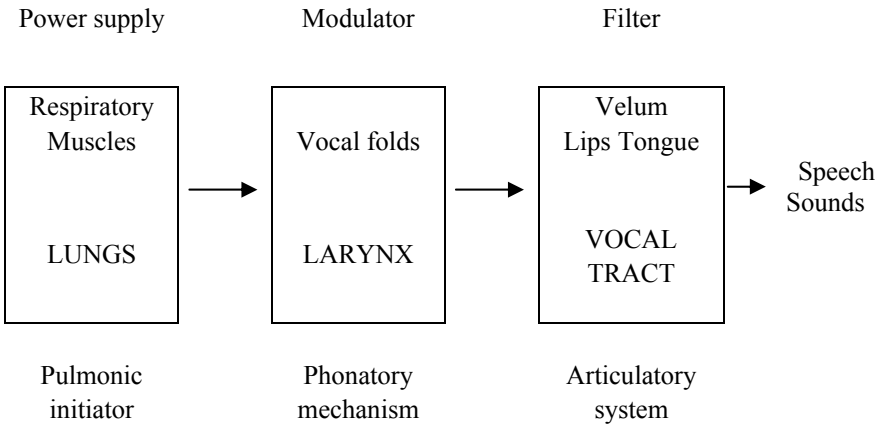

Figure 1. *Basic diagram of the speech production process*

A natural plan thus suggests itself for this book. We will follow the phonatory air-current from the lungs to the lips and address in turn the issues regarding respiration, phonation and articulation. We will indicate how the muscles and organs thus mobilized contribute to the distinction between phonemes and ensure the stability of phonological contrasts.

The temporal dimension of speech production is of vital importance. Given that the articulators move relatively slowly and that the speed of their movement varies greatly from one articulator to another, it follows that a rapid succession of segments can only occur if articulatory movements are synchronized.

It is therefore necessary to describe the role of motor coordination in realizing phonetic targets. Following the principles set by action theory, there are several theories, such as articulatory phonology and the optimality theory, which have tried to give a more adequate account of the dynamic aspects of linguistic systems by taking into account the articulatory and perceptual constraints that govern speech production. This volume adopts the same epistemological tradition and aims to provide a foundation for uniting phonetic and phonological descriptions on biological and articulatory bases.