Phonetics

'Phonetics' is the study of pronunciation. Other designations for this field of inquiry include 'speech science' or the 'phonetic sciences' (the plural is important) and 'phonology.' Some prefer to reserve the term 'phonology' for the study of the more abstract, the more functional, or the more psychological aspects of the underpinnings of speech and apply 'phonetics' only to the physical, including physiological, aspects of speech. In fact, the boundaries are blurred and some would insist that the assignment of labels to different domains of study is less important than seeking answers to questions.

Phonetics attempts to provide answers to such questions as: What is the physical nature and structure of speech? How is speech produced and perceived? How can one best learn to pronounce the sounds of another language? How do children first learn the sounds of their mother tongue? How can one find the cause and the therapy for defects of speech and hearing? How and why do speech sounds vary— in different styles of speaking, in different phonetic contexts, over time, over geographical regions? How can one design optimal mechanical systems to code, transmit, synthesize, and recognize speech? What is the character and the explanation for the universal constraints on the structure of speech sound inventories and speech sound sequences? Answers to these and related questions may be sought anywhere in the 'speech chain,' i.e., the path between the phonological encoding of the linguistic message by the speaker and its decoding by the listener. -

The speech chain is conceived to start with the phonological encoding of the targeted message, conceivably into a string of units like the phoneme although there need be no firm commitment on the nature of the units. These units are translated into an orchestrated set of motor commands which control the movements of the separate organs involved in speech. Movements of the speech

articulators produce slow pressure changes inside the airways of the vocal tract (lungs, pharynx, oral and nasal cavities) and when released these pressure differentials create audible sound. The sound resonates inside the continuously changing vocal tract and radiates to the outside air through the mouth and nostrils. At the receiving end of the speech chain, i.e., the acoustic speech signal is detected by the ears of the listener and transformed and encoded into a sensory signal that can be interpreted by the brain. Although often viewed as an encoding process that involves simple uni-directional translation or transduction of speech from one form into another (e.g., from movements of the vocal organs into sound, from sound into an auditory representation), it is well established that feedback loops exist at many stages. Thus what the speaker does may be continuously modulated by feedback obtained from tactile and kinesthetic sensation as well as from the acoustic signal via auditory decoding of his speech.

In addition to the speech chain itself, which is the domain where speech is implemented, some of the above questions in phonetics require an examination of the environment in which speech is produced, that is, the social situation and the functional or task constraints, e.g., that it may have evolved out of other forms of behavior, that it must be capable of conveying messages in the presence of noise, and that its information is often integrated with signals conveyed by other channels.

The endpoints of the speech chain in the brains of the speaker (transmitter) and the listener (receiver) are effectively hidden and very little is known about what goes on there. For practical reasons, then, most research is done on the more accessible links in the chain: neuromuscular, aerodynamic, articulatory, and acoustic. The articulatory phase of speech is perhaps most immediately accessible to examination by direct visual inspection and (to the speaker himself) via tactile and kinesthetic sensation. Thus it is at this level that speech was first studied—supplemented

by less precise auditory analysis—in several ancient scientific traditions. This history of phonetics—going back some 2.5 millennia—makes it perhaps the oldest of the behavioral sciences and, given the longevity and applicability of some of the early findings from these times, one of the most successful.

In the second half of the nineteenth century the instrumental study of speech both physiologically and acoustically was initiated and this has developed continuously until now some very advanced methods are available, especially as these involve on-line control and rapid analysis of signals by computers. One of the most useful tools in the development of phonetics has been phonetic transcription, especially the near-universally used International Phonetic Alphabet (IPA). Based on the principle of 'one sound, one symbol' it surpasses culturally-maintained spelling systems and permits work in comparative phonetics and in phonetic universals (Maddieson 1984).

In addition to classifying some of the subareas of phonetics according to the point in the speech chain on which they focus, research is often divided up according to the . particular problem attacked or to a functional division of aspects of the speech signal itself.

One of the overriding problems in phonetics is the extreme variability in the physical manifestation of functionally identical units, whether these be phonemes, syllables or words. Theories of coarticulation, i.e., the overlap or partially simultaneous production of two or more units, have been developed to account for some of this variation. Other proposed solutions to this problem emphasize that if properly analyzed there is less variation in speech than appears at first: more global, higher-order patterns in the acoustic speech signal may be less variably associated with given speech units than are the more detailed acoustic parameters. Other approaches lay emphasis on the cognitive capacity of speakers and hearers to anticipate each other's abilities and

limitations and to cooperate in the conveyance and reception of pronunciation norms. Another major problem is how the motor control of speech is accomplished by the brain when there are so many different structures and movements to be carefully coordinated and orchestrated, in biophysical terms, where there are an inordinate number of 'degrees of freedom.' A proposed solution is the positing coordinative structures which reduce the degrees of freedom to a manageable few (see *Action Theory and the Production of Speech).* Related to this issue is the meta-question: what is the immediate goal of the speaker? What is the strategy of the listener? Is the common currency of the speaker and hearer a sequence of articulatory shapes—made audible so they can be transmitted? Or are the articulatory shapes secondary, the common coin being acoustic-auditory images? It is in this context that atypical modes of speech, i.e., substitute articulations necessitated for purposes of amusement as in ventriloquism or because of organic defects in the normal articulatory apparatus.

One of the hallmarks of human speech, as opposed to other species' vocalizations, is its articulated character, i.e., that it is a linear concatenation of units such as consonants and vowels or perhaps of syllables. Most phonetic research has been done on this, the 'segmental,' aspect of speech In parallel with speech segments, however, there are other phonetic events loosely linked with them and which are less easily segmented. These are the so-called 'suprasegmentals, including intonation, stress, (lexical) accent, tone, and voice quality. They are receiving increased research attention because they are the next frontier in phonetics (after segmental research) and because of pressures from speech technology, especially text-to-speech synthesis, to produce a theory which fully accounts for the prosodic structure of speech.

In spite of the breadth of its scope and the diversity of its approaches, phonetics remains a remarkably unified discipline.

In its development as a discipline phonetics has drawn from a variety of fields and pursuits: medicine and physiology (including especially the area of communication disorders), physics, engineering, philology, anthropology, psychology, language teaching, voice (singing and oratory) instruction, stenography and spelling reform, and translation, among others.

It remains a multi-faceted discipline in the late twentieth century. As suggested above, phonetics and phonology are closely allied fields, whether one views them as largely autonomous with small areas of overlap or as one field with slightly different emphases. In the present article it is proposed that phonetics is a part of phonology: phonology's goal is to try to understand all aspects of speech sound patterning and phonetics is one domain where it must seek its answers; other domains include psychology as well as the study of society and culture. Additionally, phonetics is at the same time a scientific discipline that still maintains its ties to psychology, physics, and anthropology, trying to acquire new knowledge about the nature and functioning of speech. It is as well as a discipline which has made considerable progress in applying its existing knowledge in useful ways, e.g., in telephony, in diagnostics and therapy in communication disorders, in the development of writing systems, in teaching second languages, as well as a host of areas in speech technology, and in forensics. If product sales are a measure of the accomplishment of a discipline, phonetics must by this measure be one of the most successful areas within linguistics.

But in spite of the many seemingly diverse paths taken by phonetics, it has proven itself a remarkably unified field. Reports on work in all of these areas are welcome at such international meetings as the *International Congress of Phonetic Sciences* (a series begun in 1928, the last one being the 13th, held at Aix-en-Provence in 1991), *Eurospeech* (the most recent being the 5th, held in Berlin) and the *International Conference on Spoken Language Processing* (a series started in 1990, the most recent being the 2nd, held in Banff, Canada). Likewise in several journals a quite inter-

disciplinary approach to phonetics may be found: *Journal of the Acoustical Society of America, Journal of the Acoustical Society of Japan, Phonetica, Journal of Phonetics, Language and Speech, Speech Communication.*

What this author thinks keeps the field together is this: On the one hand we see speech as a powerful but uniquely human instrument for conveying and propagating information and yet because of its immediacy and ubiquity, it seems so simple and commonplace. But on the other hand, we realize how little we know about its structure and its workings. 'It is one of the grand scientific and intellectual puzzles of all ages. And we do not know where the answer is to be found. Therefore we cannot afford to neglect clues from any possibly relevant domain.' This is the spirit behind what may be called 'unifying theories' in phonetics: empirically based attempts to relate to and to link concerns in several of phonetics' domains: traditional phonology, clinical practice, as well as in the other applied areas. In an earlier era Zipf's 'principle of least effort' exemplified such a unifying theory: the claim that all human behavior, including that in speech, attempts to achieve its purposes in a way that minimizes the expenditure of energy. Zipf applied his theory to language change, phonetic universals, syntax, as well as other domains of behavior. In the late twentieth century there are unifying theories known by the labels 'motor theory of speech perception' (Liberman, et al. 1967; Liberman and Mattingly 1985), 'quantal theory,' 'action theory,' 'direct realist theory of speech perception,' 'biological basis of speech,' among others. They address questions in phonetic universals, motor control, perception, cognition, and language and speech evolution. Needless to say, one of the principal values of a theory—including the ones just mentioned—is not that they be 'true' (the history of science, if not our philosophy of science, tells us that what we regard as 'true' in the late twentieth century may be replaced by other theories in the future) but rather that they be interesting, ultimately useful, testable, and that they force us to constantly enlarge the domain of

inquiry—in other words that they present a challenge to conventional wisdom.

See also: Neuromuscular Aspects of Speech; Action Theory and the Production of Speech; Phonetics, Articulatory; Speech Development: Acoustic/Phonetic Studies; Phonetics, Descriptive Acoustic; Speech Processing: Auditory Models; Speech Perception: Direct Realist Theory; Speech Perception; Speech: Biological Basis; Speech Production: Atypical Aspects; Voice Quality; Quantal Theory of Speech; Phonetics: Precursors of Modern Approaches; Arab and Persian Phonetics; Phonetics, East Asian: History; Phonetics: Instrumental, Early Modern; Phonetic Transcription: History; Phonetic Pedagogy; Whistles and Whistled Speech.

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