RESEARCH IN EXPERIMENTAL PHONETICS AND THE DEFEAT OF EMPIRICISM

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In this article I wish to describe how research in a restricted area of experimental phonetics finally came to call in question the very object of study, the methods used, and the place of experimental phonetics in the classification of sciences. In treating phonetic problems, I soon found myself going beyond strictly phonetic (or linguistic) domain to face general epistemological questions in which phonetic considerations merely exemplify the importance of epistemol1ogical issues.

What is the subject-matter of phonetics? Traditionally, from its beginnings in Europe at the turn of the century, it has been defined as the study of speech sounds. Classical phoneticians "recorded" and reproduced sounds using as equipment their ears and voices. In other words, the tools of investigation were human, and phonetics was almost a kind of art.

with the advent of "visible speech" (Potter et al. 1947) and the growing development of technology human equipment was replaced by increasingly sophisticated machinery (Fant, 1958) and the aim of phonetics became a quantitative description of the acoustic characteristics of speech sounds as well as a description of the physiological processes involved in the production and perception of utterances. As a consequence phonetics acquired the status of a natural

science whose object on the one hand was the human vocal tract, and, on the other, the acoustic characteristics of the sounds it produced. Experimental phonetics rapidly set itself the goal of constructing a theory of speech sounds (see Lindblom 1980 for review).

The study of the acoustic aspects of speech sounds involves an analysis of the phonic signal which in itself is complex and presents features reflecting the physiological state of the articulatory organs, the age, sex, attitudes and origins of the speaker, and of course the distinctive features of the phonemes that make up the utterance. An acoustic analysis of speech should allow the phonetician to sort out the parameters that are relevant to the phonological system of a given language. One of the ways of studying acoustic parameters is the spectrographic analysis of sounds. Such an analysis makes it possible to measure the changes in sound frequency and intensity, the composition of the spectrum (aperiodic, periodic sound), the areas of acoustic energy-concentration, and the speed of delivery.

In the mid-forties phoneticians were faced with a practical problem of designing a reading machine i.e. a device which was to convert print to sound thus enabling the blind to "read" (Cooper, 1950). The basic question that arose was: What features should an artificially produced sound have in order to be intelligible? Or, as Liberman and Cooper (1972) put it: “ (•••) the first task is (...) to find the cues - the physical stimuli - that control the perception."

It was assumed that a spectrographic analysis of the sounds should provide a description of the sounds such as the receiver perceives them.

The researchers expected:

a) that prominent parts of the acoustic signal (as captured by sonographs) would be information bearing elements i. e. linguistically relevant for perception;

b) that sonograms would show discrete units corresponding to phonemes and

c) that sounds representing a particular phoneme would exhibit the same acoustic features regardless of context

The search for an explanation of speech sound perception was thus based on the search of an "objective" description of sounds "such as they are". It was taken for granted that the subject perceived speech sounds in a mirror-like way which supposed a simple one to one correspondence between the acoustic invariants on the one hand and cognitive invariants on the other. It followed that linguistic segmentation into phonemes was supposed to be derived from material segmentation of the acoustic signal. The empiricist orientation inherent in this approach is obvious.

However, research showed that it is possible for two acoustically different sounds to be identified as the same phoneme and that the same acoustic stimulus can be identified as different phonemes (Delattre, 1958). It follows that perception eliminates differences and establishes identities.

As regards the segmentation of an utterance into successive linguistic units it was found that information about successive phonemic segments is transmitted in parallel.

That is, information about two or more successive phonemic segments is carried simultaneously by the same acoustic cue. This reduces by a significant factor the number of discrete acoustic segments that must be perceived per time unit and thus enables the listener to evade the severe limitations on rate set by the temporal resolving power of the ear.

The results of research in speech perception can be summarized as follows:

1) The relationship between acoustic signal and phoneme is highly complex.

2) The physical segmentation of the signal does not yield linguistic units corresponding to phonemes.

3) The acoustic indices of particular phonemes are not the same in different contexts.

4) The relevant acoustic features are often among the least prominent.

Experimentation then continued with speech synthesizers which revolutionized research, but left the following questions unanswered:

- What acoustic features underlie the perceptual invariants of speech sounds?

- What cues does the receiver use for the resolution of acoustic continuity into discrete linguistic units? According to the radical empiricist hypothesis percepts reflect material reality objectively and the results of phonetic experiments simply reveal "perceptual paradoxes". Within such an epistemological framework, experimental phonetics could not explain why the subject does not recognize certain features that are actually present in the

sounds i.e. why the mere presence of certain features does not entail their perception.

The empiricist illusion misled the phoneticians into endeavoring to grasp sounds as real objects already preconstructed and preexisting to their linguistic identification.

But experimental data attested the part played by the knowing subject. They indirectly confirmed the epistemological viewpoint whereby the object of cognition is constructed in the very process of cognition and that cognitive activity resolves material continuity according to forms of linguistic knowledge. The object of study of experimental phonetics, and its status as a natural science were thus called into question. At the Ninth International Congress of Phonetic sciences, Lindbom (1980) expressed his agreement with Bolinger in saying that "phonetics has become to linguistics what numismatics is to finance" i.e. the study of the irrelevant.

In this situation two distinct but at the same time related reactions (in linguists and phoneticians) made their appearance. They are related because both of them emphasize the role the subject plays in speech perception and they are distinct as one uses inneist explanations (Liberman, 1985); Stevens and House (1972) Cutting et al. (1975) and Cutting (1978) based on biological arguments, while the other Malmberg (1974), Lindbom (1980), Jakobson (1971) and Lang (1962) favors cognitive explanations supplemented by interdisciplinary considerations.

- The authors claiming a biological approach, emphasize the role of the subject who is guided by his innate capacities to produce and perceive the so called "phonetic objects". According to Liberman (1985) there are biological specifications for the linguistic treatment of speech sounds. He declares his point of view to be diametrically opposed to that of cognitive psychology, which, he avers, diverts the study of specifically linguistic processes towards general, functionally not specialized behaviors. Liberman in fact assigns the problem to the level he calls biological. According to him, a module specialized for phonetic perception takes charge of resolving acoustic continuity into distinct phonemes through its inborn links with neuromuscular, articulatory and coarticulatory processes, which are the biological basis that unites production and perception. The phonetic object then becomes an abstract representation of the speaker's articulatory movements. Liberman also believes in biological specification for syntax and phonological grammar. Stevens and House (1972) also recognize the role of the subject in what he calls the auditory treatment of the data. They admit the impossibility of isolation of elementary acoustic indices that would guide perception, and state that linguistic treatment by the ear covers general properties of sound spectra.

The authors use the catastrophy theory to describe this auditory treatment (where the relation between articulatory and auditory change is non-linear). They conclude that the fact that children learn a language from a relatively small number of examples is a proof "that the nervous system of

man is predisposed not only to encode sounds as segments and features, but also to decode sounds in the same ways ..... The predisposition of the auditory system toward the features and segments used in speech must, in part at least, be innate" (p. 14).

The authors stressing the role of cognitive strategies and of the human auditory system comment that "The empirical formula explains nothing. It captures certain regularities in the data in a compact and formalized way. It shows how the data come out but provides no clues as to why they come out that way ...” (Lindblom 1980).

Lindblom points out that "it is language structure and the human ear that determine what is linguistically relevant in the speech wave.(...) The facts of physical phonetics cannot do so no matter how fine-grained we make the analysis. (...) The acoustic-instrumental facts (....) must be accorded a secondary role in relation to the results of an auditory functional analysis of sound substance". (p. 11)

Lindblom also wonders whether phonetic research is inserted in a cultural context that would allow a unification of linguistic and psycholinguistic theories and adds "we are trapped by the choice of subject matter, by scientific method as well as by our obligation to produce knowledge to fields of applied phonetics".

In his message to the Ninth Congress of Phonetics Sciences Jakobson (1980) expresses the hope that "the idea of genuinely interdisciplinary research will be evermore realized in the field of speech sounds (...), as any constituent of speech sound requires a joint analysis both of its linguistic functions and of its physical means, and

hence a consistent cooperation of linguists with physicists, physiologists and of course psychologists (...)" (p. IX). Research in phonetics, as described, led to the defeat of empiricism in phonetics, to the uncovering or a rediscovery of the importance of the subject in cognition and to the realization that an interdisciplinary approach is needed. Experimental phonetics has thus raised general epistemological issues requiring a fundamental revision of the notion of "observational facts" and causing this discipline to undergo a second reclassification i. e. from a natural science to a science of man.

To conclude let me say that it is rather unfortunate that the epistemological issues raised already in the twenties by the Prague Linguistic Circle were for such a long time entirely ignored by many scholars involved in phonetic research.

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