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Speech Acoustics for the Mathematically Unsophisticated  
Elements of Acoustic Phonetics by Peter Ladefoged

Review by: Arthur S. Abramson

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1918 was the "critical year" when their children began giving up the parents' language; only those who, for religious reasons, have succeeded in remaining socially isolated from the English-speaking world are still making use of their language.

Beyond this there is much more we would like to know concerning the internal life of these communities, their cultural activities, and their share in the life of the state and nation. We would like to know not only what languages they spoke but how and to what effect. We trust this will come in the second volume. As it stands, this book is a model of its kind. State maps of foreign groups have been drawn elsewhere, for example, in Wisconsin and Minnesota, but nowhere has anything as ambitious as this been attempted. If this kind of material were gathered and published for every state in the Union before it is too late, we would have the basis for a real understanding of the part played by immigrants of non-English origin in the building of our country. The reviewer recommends it to the attention of every state historical society as an enterprise for imitation.

There must be some blemishes, which would appear on checking and scrutinizing the data. Your reviewer noted some disturbing misprints on the Scandinavian map (names like Östergötland, Dalsland, Uppsala, Uppland, Fredrikstad). But these are little more than minor flaws in a work which will stand as a contribution to the study of FL speakers (as this reviewer would have preferred it, for they are neither "linguists" nor "linguistics"). We look forward hopefully to the volume which will bring us the meat of this study to flesh out the bare bones of statistics.

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## SPEECH ACOUSTICS FOR THE MATHEMATICALLY UNSOPHISTICATED

Over the past fifteen years so much has happened in acoustic phonetic research that teachers of phonetics and speech science have felt the need for a new publication that would ease their students into the field. The desired book was to make allowances for the skimpy background in mathematics and physics that most of us in linguistics and speech have had. A textbook that fills this need to some extent is now available.<sup>1</sup> The author, Peter Ladefoged,

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1. *Elements of Acoustic Phonetics*. By Peter Ladefoged. Chicago: University of Chicago Press, 1962. vii, 118 pp.

is in the forefront of experimental phonetic research and is known for his work in both acoustic and physiological phonetics.

Unfortunately, the word *phonetics* in the title is a little misleading. While presenting clear, well-written statements of underlying acoustic principles, Ladefoged fails to give more than a disappointingly brief coverage of the acoustics of *speech*. Indeed, a better title might be *Preliminaries to Acoustic Phonetics* or even *An Easy Introduction to Acoustics with Some Applications to Speech*. The author makes no bones about this, saying in his preface, "it is intended to be a textbook explaining the preliminaries to a theory; it is not meant to be a comprehensive account of the physics of speech; indeed, it does not even attempt to survey the present state of investigations in acoustic phonetics." Instrumental techniques are to be discussed in his forthcoming *Speech in the Laboratory*. With these limitations in mind, the reader can profit greatly from careful study of this slim volume.

I find it hard to give the essence of most of the topics covered without simply paraphrasing Ladefoged's concise but simple explanations. Perhaps a brief mention of the contents of each chapter will be enough to whet the reader's appetite for the book.

Chapter 1, "Sound Waves," begins with a brief examination of the human ear, leading to the definition of sound as "any disturbance of the air that could cause a displacement of the eardrum which, after transmission by the bone chain, could affect the liquid in the inner ear in such a way that the auditory nerves are stimulated." This paves the way to a discussion of disturbances in the air. Ladefoged might have noted here that acoustics is also concerned with the passing of such disturbances through other media, although he wisely limits his treatment in this book to air-borne sounds. (For example, some speech scientists have investigated speech in helium-oxygen mixtures such as deep-sea divers must talk in.) With the help of diagrams showing the effects of a vibrating tuning fork on particles of air between the sound source and the eardrum, the author gives a lucid, nonmathematical description of wave motion. This lays the basis for reading wave shapes out of oscillograms.

In Chapter 2, "Loudness and Pitch," the reader is introduced painlessly to the acoustic features of amplitude and frequency along with their respective major psychological correlates of loudness and pitch. The lack of a one-to-one relation between amplitude and loudness is stated, but it is not so obvious in the text that this kind of nonequivalence also holds for fundamental frequency and pitch. It is true that the matter is treated more fully in Chapter 6, but the student reading the book chapter by chapter, as assigned, ought to be warned about pitch at this point too.

Chapter 3, "Quality," makes it quite clear that the auditory impression of quality that enables us to distinguish one kind of sound from another, for

example, middle C played on a piano and on a violin, is a major perceptual correlate of spectral composition. That is, sound may result not only from the simple variations in air pressure of pure tones (sine waves) considered up to this point but also from complex variations in pressure which are regarded in acoustics as sums of series of sine waves. To demonstrate the relevance of this to specifically phonetic quality, the author makes good use of oscillograms of three wave forms that have the same fundamental frequency but differ in other features of shape (thus in spectrum) such that they are heard as the vowels in *caught*, *who*, and *see*. Speech sounds are also used to illustrate the difference between repetitive and nonrepetitive wave forms, as in voiced vowels *vs.* voiceless fricatives.

The way has now been paved for the meaty content of Chapter 4, "Wave Analysis." The material will take some pondering, but Ladefoged's clear exposition makes a basic grasp of difficult points feasible without advanced mathematics. The superiority of the spectrum over the wave form in descriptions of acoustic correlates of phonetic quality is demonstrated. Having grasped these notions, the reader should find Chapter 5, "Resonance," rather easy to digest. It is too bad, however, that the author did not choose to use his explanation of the response of a resonator and the time constant of a filter as a basis for a brief description of the sound spectrograph with its wide-band and narrow-band displays, even though a more detailed discussion of the instrument and its uses is to appear in his next book.

Ladefoged's treatment of "Hearing" in Chapter 6 is the major topic of a review of this book by Newman Guttman.<sup>2</sup> Although the relevance to the perception of speech of the findings of the psychoacousticians in the perception of pure tones is not always clear and straightforward, it is helpful to the student to be aware of the problems. For example, it helps prevent naïve statements in auditory phonetic descriptions.

The twenty pages of the final chapter, "The Production of Speech," contain most of the material on acoustic *phonetics*. Elsewhere in the book there are just enough brief references to speech to help illustrate acoustic and perceptual concepts. In this chapter the author understandably emphasizes vowels, a good basis for further discussion of speech phenomena, but perhaps another ten pages would have made possible a quick over-all survey of speech sounds. The passing mention of nasals, laterals, fricatives, and stops on the last four pages is tantalizing. A virtue of this chapter is that the moderately attentive reader will come away from it with a good understanding of the independence of the excitation source and the vocal tract resonances. Indeed, it is not always easy, without a great expenditure of time and effort, to con-

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2. *Journal of the Acoustical Society of America*, XXXV (1963), 1069.

vince students of speech that the formant frequencies and the fundamental frequency of the speech wave can vary independently of each other. The oscillograms and spectra of Figure 7.5 reinforce the point.<sup>3</sup> Much is made in this chapter of the correlations between formant frequencies and the articulatorily determined configurations of the vocal tract. Some readers, however, have been confused by an ambiguity on page 104 in a discussion of the second formant of the vowels in *heed*, *hid*, *head*, and *had*. The statement that "as the constriction increases, so the frequency of the second formant decreases" is not to be taken to mean that there is more (i.e., narrower) constriction, but rather that there is an increase in the cross-sectional area of the constriction.

A glossary of technical terms used in the text is useful, although the term *formant* was left out. The book ends with a short annotated bibliography and an index.

*Elements of Acoustic Phonetics*, excellent as far as it goes, is a welcome addition to the literature, but at this stage of the game, someone ought to write a broad survey of what is known in acoustic phonetics, including, of course, the part played by techniques of speech synthesis in studies of the perception of speech. Such review articles as have recently appeared<sup>4</sup> are useful to the advanced student but can hardly serve as textbooks for the beginner. Let me conclude by saying that I have used Ladefoged as a textbook at two institutions with satisfactory results, and I expect to assign it to students during the present academic year as well; nevertheless, let the student be warned that this is not a textbook in acoustic phonetics. It is an introduction to acoustics for phoneticians. It is to be hoped that the sequel promised by Peter Ladefoged will appear soon.

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3. The student will also find it helpful to look at Fig. 5 in John M. Borst, "The Use of Spectrograms for Speech Analysis and Synthesis," *Journal of the Audio Engineering Society*, IV (1956), 14-23.

4. Two that come to mind are (1) Pierre C. Delattre, "Les indices acoustiques de la parole: premier rapport," *Phonetica*, II (1958), 108-18, 226-51, and (2) D. B. Fry and P. Denes, "The Role of Acoustics in Phonetic Studies" in *Technical Aspects of Sound*, Vol. III, edited by E. G. Richardson and E. Meyer (Amsterdam and New York: Elsevier Publishing Co., 1962), pp. 1-69.