Phonetics and Phonology then, and then, and now *

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Phonetics attempts to describe and understand how speech is produced and perceived; phonology attempts to understand the patterning — in general, the behavior — of speech sounds in particular languages and in all languages. Is phonetics part of phonology? This straightforward question has received various answers at different points in the history of linguistics. In this paper I attempt to document that for the two centuries starting approximately with the eighteenth century, phonetics was well integrated into linguistics but that around the start of the 20th century phonetics and phonology were estranged, at least in some cases. During the second half of the 20th century there began a trend, continuing today, to re-integrate phonetics and phonology.

The history I give is admittedly selective, interpretive, and possibly biased. Most if not all histories are like this. Whoever may disagree with this history is free to — indeed, obliged to — present and document their own interpretive history.

1 The two 'phonetics': taxonomic & scientific

I believe it is possible to distinguish two forms of phonetics, *taxonomic* and *scientific*, and historically their place in phonology has been different. Taxonomic phonetics provides two basic tools for the dealing with speech sounds: first, uniformity in naming and classifying speech sounds, and, second, transcribing them. Although the attempt to arrive at a uniform system to accomplish these essential functions dates back many centuries (Kemp, 1994), as far as the transcription is concerned, a widely adopted standardization was achieved in the late 19th century with the rise of the International Phonetic Association, founded in 1886 by Paul Passy and with the eventual codification of the International Phonetic Alphabet (IPA) (MacMahon, 1994). Although it has seen additions and modifications, it has remained in essence unchanged since then. Of course, if it is to remain useful in providing a lingua franca when describing and classifying speech sounds of the world's languages, it should not change in radical ways over time. In spite of some imperfections, the International Phonetic Alphabet (IPA) has been maintained in essentially the same form since its introduction and this has provided the basis for a vocabulary and a system with which to describe individual speech sounds as well as phonetic and phonological universals.

The other form of phonetics, which I call 'scientific phonetics' seeks to understand how speech works at all levels from the brain of the speaker to the brain of the hearer. This has a long history but unlike taxonomic phonetics, is continually in a state of flux, constantly taking in new data, new methods, new theories, and discarding older ones found to be less competitive. Although ideally there is a search for some convergence among theories, before that is achieved there is a healthy debate between adherents of competing theories (Fowler, 1996; Ohala, 1996). If the arguments against a particular theory are overwhelming, there is

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* This paper is an adaptation of Ohala (1991).

no hesitation in abandoning it completely [e.g., see Ladefoged (1967) arguing against Stetson's (1928) hypothesized "breath pulses"; van den Berg (1958) arguing against Husson's (1950) neurochronactic theory of vocal cord vibrations; on the latter controversy, see also Abramson (1972)].

In any case, it is in scientific phonetics where most of the work of phonetics lies. This is where theories are formulated, statistical analysis of results performed as well as controlled observations, calibrations and all the other characteristics of traditional scientific procedures. This is what one finds presented at phonetics conferences and congresses and in the phonetics journals; it is where most of the "action" is.

Besides these typical external differences between taxonomic and scientific phonetics there is a profound philosophical difference. The 'scientific' approach implies, as do all other sciences since the Renaissance that any given theory, including whatever one believes most fondly, may be erroneous but that by gathering data in a rigorous way such error may be minimized or avoided. In contrast, taxonomic phonetics thrives through conformity.

Phonology unquestionably embraces taxonomic phonetics — at the very least it provides the vocabulary for stating phonological generalizations. The question is to what extent it incorporates scientific phonetics. In the following sections I explore this question by briefly reviewing cases of what may be regarded as phonological studies over the centuries, and finally looking for long-range trends.

2 Scientific phonetics in the 17th, 18th and 19th centuries: phonetics integrated with phonology

I give examples where traditional phonological (linguistic) questions are offered phonetically-based answers *or* where the same individual is equally productive in scientific phonetics and phonology in general.

Johan Conrad Amman (1669-1724) was a Swiss physician practicing in the Netherlands. He wrote of his attempt to teach speech to a deaf person, *The talking deaf man: or, a method proposed whereby he who is born deaf may learn to speak* (Amman, 1694), and *Dissertatio de loquela* (Amman, 1700). He made some original observations about speech articulations including a characterization of how laterals are produced (namely, that the lateral channel may lie in the buccal sulcus, not necessarily in the space enclosed by the teeth). He noticed nasals assimilating to the place of following stops in connected speech and he proposed a "natural" hierarchical classification of the features of speech, e.g., in assimilation and in pathological speech, substitution of one sound for another involves features at the lowest strata of the hierarchy, e.g., place, not at the highest such as manner; thus substitutions of consonant for vowel, or nasal for fricative do not occur.

There were several others in the 17th c. who claimed to be able to teach the deaf to speak or who recommended procedures by which this might be done, e.g., van Helmont (1667), Holder (1669), and Wallis (1653). Wallis, in particular, exemplified an admirable union of a scientific approach to description of speech sounds with what would be regarded as phonological observations.

Wolfgang von Kempelen (1734-1804), was a lawyer, physicist, engineer, and student of language in the Austro-Hungarian empire. He conceived of and built what is regarded as the first mechanical speech synthesizer capable of producing connected speech (even though one of the 'components' of the system was the hand of the operator which helped to shape the resonating cavity that produced the different vowels). He published a detailed description of his device and his experience with it in 1791 (*Mechanismus der menschlichen Sprache*,

Vienna). His work was influential for more than a century following that and was an inspiration to, among others, Alexander Graham Bell.

The first few chapters are devoted to a review of the existing literature on speech production and to the phonology of various languages, esp. Hungarian. He showed how speech sound *behave* in languages, i.e., the *phonology* of Hungarian.

Erasmus Darwin (1731-1802), product of the Enlightenment, was a scientist, philosopher, promoter of liberal values (including the education of women). He constructed an elementary speech synthesizer (not unlike von Kempelen's, but much simpler) (Darwin, 1803). He proposed a system of 13 unary features by which to describe any and all speech sounds including, notably, the voiceless lateral [l̥] of Welsh. He also conducted what may be the first instrumental phonetic study on a live, intact speaker: he inserted cylinders of tin foil into his mouth to determine by the indentations made on them by the tongue where the different vowels were articulated.

Robert Willis (1800-1875), was a Cambridge professor of mechanics (engineering we would call it today). In his work "On the vowel sounds" (1830) he specified quantitatively the vocal tract resonances of vowels—a single resonant frequency for each vowel—and claimed that the major determinant of these resonances was vocal tract length. He demonstrated this with a uniform, cylindrical, tube whose resonating space was varied in length by putting the sound source (the excitation) on a piston-like structure that could move up and down within the cylindrical resonator. He suggested that with some refinement of his method, it should be possible to provide "philologists with a correct measure for that shade of differences in the pronunciation of the vowels by different nations."

Today we might fault his claims that there is a *single* characteristic resonance for each vowel sound (as opposed to being differentiated by *multiple* — at least 3 — different resonances (F1, F2, F3). But his single resonance may correspond to the F2' of Fant & Risberg (1963) and Chistovich & Lublinskaja (1979), or to the most characteristic resonance of the vowels by those concerned with the auditory transform of vowels.

But the philologists (at least one) paid heed to Willis! **T. Hewitt Key** (1799-1875), trained in medicine and mathematics, who became the first professor of Latin and then the professor of comparative philology at London University (now University College), published a paper in the Transactions of the Philological Society (of London) in 1852 entitled "On vowel assimilation, especially in relation to Professor Willis' experiment on vowel sounds." He tries to explain vowel harmony and umlaut by invoking Willis' notion that vocal tract length is the main determinant of vowels' characteristic resonance. This explanation might not be accepted today but it is the willingness to apply physical phonetics to philological questions that is admirable.

Hermann Grassmann (1809-1877) is one of the few linguists included in the *Dictionary of Scientific Biography,* but his inclusion is mainly due to his contributions to mathematics (namely his general calculus for vectors). However, within linguistics (or philology) he is primarily honored as the discoverer of "Grassmann's Law" (dissimilation of aspirated consonants in Greek and Sanskrit), thus accounting for a major set of exceptions to Grimm's Law. Less well known is that he also determined the resonant frequencies of spoken vowels using purely auditory analysis (1854; thus anticipating Helmholtz's results by 9 years).

Karl Verner (1846-1896) is famous for his resolution in 1875 of, until then, one of the thorniest exceptions to Grimm's Law, the variation in voicing of the medial obstruents in Gothic. He showed that the different reflexes were the effects of different accent on the adjacent vowels.

In his later years studied accent phonetically. He obtained an early Edison cylinder phonograph and devised on his own an elaborate system for magnifying the curves and projecting them onto a wall where they could be traced on paper. He did not obtain any results he thought worthy of publication. We know of this work only through the posthumous publication of his correspondence with the Finnish phonetician Hugo Pipping, to which Eli Fischer-Jørgensen has called attention (Fischer-Jørgensen, 1967).

Paul Passy (1859-1940) was founder of the International Phonetic Association (in 1886). This laid the foundation for today's taxonomic phonetics. Nevertheless his dissertation of 1890 offered phonetic explanations for sound change including, e.g., a cogent account of the aerodynamic factors favoring voiceless in obstruents.

Abbé J.-P. Rousselot (1846-1924) is widely regarded as the 'father of experimental phonetics'. With Rosapelly (1876) he pioneered and refined the use of the kymograph for study of speech articulations. His dissertation (1891) was a philological survey of the sound changes that gave rise to the contemporary pronunciation and an instrumental phonetic study of the factors that may have caused them.

Charles Rosapelly was an early recruit in the laboratory of E. J. Marey, who did pioneering research on time-varying physiological events: heart beat, walking, birds' flying, etc. Rosapelly (1876) described early work with the kymograph and commented that

> L'importance de ces études semble grande au point de vue des linguists, dont la science chaque jour pour precise tend à prendre pour point de depart une étude expérimentale. L'étude comparée des différentes langues et celle des transformations successive que chacune d'elles a subies dans sa formation ont permis, en effet, de saisir certaines lois qu'on pourrait appeler physiologiques et qui ont preside à l'évolution du langage.

3 Phonetics from ca. 1900 to ca. 1950: the estrangement of phonetics and phonology

Just when phonetics was starting to make significant advances in the understanding of the physical nature of speech, there is evidence that traditional phonology and linguistics started to distance itself from phonetics.

Henry Sweet (1845-1912) was the founder of the British School of Phonetics. He was the inspiration (in part) for G. B. Shaw's "Henry Higgins" in his play *Pygmalion*, from which the musical *My Fair Lady* was adapted. Sweet raised the standards of phonetic description. With Passy and Viëtor he helped to establish the taxonomic system (the descriptive and classificatory framework) used today in phonetics, as well as the IPA for transcription. But he had a harsh assessment of instrumental phonetics (Sweet, 1910):

> The claims of instrumental phonetics have been so prominently brought forth of late years that they can no longer be ignored, even by the most conservative of the older generation of phoneticians. But it is possible to go too far the other way. Some of the younger generation seem to think that the instrumental methods superseded the natural ones in the same way as the Arabic superseded the Roman numerals. This assumption has had disastrous results. It cannot be too often repeated that instrumental phonetics is, strictly speaking, not phonetics at all. It is only a help; it only supplies materials which are useless till they have been tested and accepted from the linguistic phonetician's point of view. The final arbiter in all phonetic questions is the trained ear of a practical phonetician: differences which cannot be perceived must—or at least may be—ignored; what contradicts the trained ear cannot be accepted.

Rousselot (1897:1) also noticed the "distance" between experimental phonetics and linguistics:

> … les procédés des sciences expérimentale sont assez étrangers aux linguists. Une sorte de terreur superstitieuse s'empare d'eux dès qu'il s'agit de toucher au méchanisme le plus simple. Il fallait donc leur montrer que la difficulté est moindre qu'ils ne se la figurant et leur faire entrevoir le champ immense que l'expérimentation ouvre devant eux.

In the translator's preface to Holger Pedersen's *Sprogvidenskaben i det nittende aarhundrede*, [*Linguistic science in the nineteenth century*], Spargo (1931:viii) writes:

> … one important feature of the work which should be mentioned is the striking role assigned to the study of phonetics in increasing our knowledge of linguistics. It is shown clearly that every important advance during the last century and a quarter was made by a scholar who attacked his problem from the phonetic side.[2] Surely this fact has its importance for the future of linguistic study, and suggests that the indifference to phonetics in many of the graduate schools in the United States is an evil presage for future progress.

One suspects this distance between instrumental phonetics and linguistics arose out of misunderstandings and misgivings that the linguistically- and philologically-trained researchers had towards a methodology that was unfamiliar to them.

Similarly, many traditionally-trained anthropologists had misgivings about modern work determining the hominid "family tree" structure using the techniques of microbiology, i.e., measuring the degree of similarity between DNA molecules and other biologically important molecules.

But remember: what defines a field are its questions, not its methods; one uses whatever methods get us the answers; there is no glory to researchers who get less-than-satisfactory answers to questions because they had a distaste for the methods that would yield the answers.

But perhaps the greatest wedge between experimental phonetics and linguistics was driven by structuralism: the focus not on the substance of speech but on the relations, the contrast between speech sounds. This was brought about by the Prague School which had great influence within phonology. In effect they banished experimental phonetics from linguistics.[3]

Trubetzkoy (1933) wrote,

> La phonétique actuelle se propose d'étudier les facteurs matériels des sons de la parole humaine: soit les vibrations de l'air qui leur correspondent, soit les positions et les mouvements des organes qui les produisant. … Le phonéticien est nécessairement atomiste our individualiste … Chaque son de la parole humaine ne peut être étudie qu'isolement, hors de tout rapport avec les autres sons de la même langue.

A similar stereotype applied to astronomy would characterize it as merely finding and cataloguing stars. But this would ignore cosmology, astrophysics and, in general, any attempt to generalize about the birth, development, and death of stars, the formation of galaxies, the origin of the universe. Trubetzkoy commits the fallacy of equating the immediate, visible, object of study as the ultimate object of study.

Phonetics, then and now, studied the physical (and psychological) aspects of speech sounds in order to understand how speech works, including the contrastive aspect that Trubetzkoy focused on.

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[2] He was probably referring of the phonetic decomposition of sounds as exemplified in the diachronic work of, among others, Rask, Grimm, von Raumer, Grassmann, Verner, Brugmann, and Saussure (on the IE "laryngeals").

[3] This is not to say that all members of the Prague school endorsed this view; see Laziczius (1966); nor that some phonetics research addressing traditional linguistic questions was prevented from being done; and it is also not claimed that other schools and individuals outside the Prague School didn't express similar views to them.

To give a more balanced history, it must be recognized that there were also phoneticians at this time whose approach might best be characterized as "positivist", for whom the physical aspect of the speech sounds tended to be the dominant focus of study, e.g., E. W. Scripture and Guilo Panconcelli-Calzia (Kohler, in press).

4 Phonetics since then: the present day: phonetics again becoming integrated with phonology

With a few exceptions, the distance between scientific phonetics and phonology continued up to approximately the mid-20th century. Pivotal developments contributing to reducing the distance were:

- The synthesis of speech from phonemic or other phonological input (Klatt, 1987; Maxey, 2002). This included the Haskins' claim that they had "found" the invariance of phonemes underlying their phonetic variants. (A claim subsequently qualified or even retracted.)
- The collaboration between Jakobson, Fant & Halle in proposing the acoustically-defined "distinctive features" (in 1952).

In spite of their short-lived popularity, the Jakobson-Fant features demonstrated that some of the linguistic functions of speech sounds, e.g., their contrastiveness and some certain phonological behavior (e.g., phonotactics), could be explained by invoking their acoustic-auditory nature — as discovered by experimental phonetics.

Since then, at least, courses in phonetics and phonetics laboratories have had a relatively secure home within departments of linguistics.[4]

Today "Linguistic Phonetics", "Experimental Phonology", "Laboratory Phonology" and similar movements are represented in the literature and have regular conferences. This success is based not on a fad but on 'existence proofs' — demonstrations of the relevance of physical and psychological aspects of speech for explaining sound patterns in language, the traditional concern of phonology.

5 Sieb Nooteboom's place in this history

Sieb Nooteboom has furthered the rapprochement between experimental phonetics and rest of linguistics. This has been done by providing *existence proofs* of the benefits of phonetic and psycholinguistic studies for answering linguistic questions.

In such diverse research areas as speech production and perception, speech technology, prosody, psycho-phonology, speech errors, addressing such fundamental problems as the nature of the units of speech, the role of feedback in speech production and many others. He has enlarged and enriched phonetics by demonstrating the utility of new methods and exploration of new research domains. He has a secure and honored place in the history of the integration of phonetics and phonology!

References

Abramson, A. S. (1972). Comments to: Lafon's "Essai sur la physiologie du son laryngé". In A. Rigault & R. Charbonneau (Eds.), *Proceedings 7th International Congress of Phonetic Sciences* (pp. 25-26). The Hague: Mouton.

[4] There are exceptions: certain leading universities in the U.S.A., famous for their linguistic work, do not require a course in phonetics for any of their academic degrees.

Amman, J. C. (1694). *The talking deaf man: or, a method proposed whereby he who is born deaf may learn to speak*. London: Tho. Hawkins.
Amman, J. C. (1700). *Dissertatio de loquela*. Amsterdam: J. Wolters.
van den Berg, J. W. (1958). Myoelastic-aerodynamic theory of voice production. *Journal of Speech and Hearing Research*, *1*, 227-244.
Chistovich, L.A., & Lublinskaja, V.V. (1979). The 'center of gravity' in vowel spectra and critical distance between the formants: Psychoacoustical study of the perception of vowel-like stimuli. *Hearing Research, 1*, 185-195.
Darwin, E. (1803). *The temple of nature*. London: J. Johnson.
Fant, G. & Risberg, A. (1963). Auditory matching of vowels with two formant synthetic sounds. *STL-QPSR, 4*, 7-11.
Fischer-Jørgensen, E. (1967). A sketch of the history of phonetics in Denmark until the beginning of the 20th century. *Annual Report Institute of Phonetics, University of Copenhagen, 13*, 135-169.
Fowler, C. A. (1996). Listeners do hear sounds not tongues. *Journal of the Acoustical Society of America, 99,* 1730-1741.
Grassmann, H. (1854). Leitfaden der Akustik. Programm des Stettiner Gymnasiums.
Helmont, F. M. van (1667). *Alphabeti verè Naturalis Hebraici brevissima delineatio*. Sulzbach: Lichtenthaler.
Holder, W. (1669). Elements of speech: An essay of inquiry into the natural production of letters. London: J. Martyn.
Husson, R. (1950). Étude des phénomènes physiologiques et acoustiques fondamentaux de la voix chantée. *Éditions de La revue scientifique, A, 2334* (3206), 1-93.
Kemp, J.A. (1994). Phonetic transcription: History. In R. E. Asher & J. M. Y. Simpson (Eds.), *The encyclopedia of language and linguistics* (pp. 3040-3051). Oxford: Pergamon Press.
Kempelen, W. von (1791). *Mechanismus der menschlichen Sprache*. Vienna: J. B. Degen.
Key, T. Hewitt. (1852). On vowel assimilation, especially in relation to Professor Willis' experiment on vowel sounds. *Transactions of the Philological Society* [London].
Klatt, D. H. (1987). Review of text-to-speech conversion for English. *Journal of the Acoustical Society of America, 82*, 737-793.
Kohler, K. (in press) Beyond Lab Phonology: The phonetics of speech communication.
Ladefoged, P. (1962). Subglottal activity during speech. In A. Sovijarvi and P. Aalto (Eds.), *Proceedings 4th International Congress of Phonetic Sciences, Helsinki, 1961* (pp. 73-91). The Hague: Mouton.
Ladefoged, P. (1967). *Three areas of experimental phonetics*. Oxford: Oxford University Press.
Laziczius, G. (1966). *Selected Writings of Gyula Laziczius* (edited by Thomas A. Sebeok). The Hague: Mouton.
MacMahon, M. K. C. (1994). International Phonetic Association. In R. E. Asher & J. M. Y. Simpson (Eds.), *The encyclopedia of language and linguistics* (pp. 1730-1731). Oxford: Pergamon Press.
Maxey, H. D. (2002). *Smithsonian Speech Synthesis History Project*. Available: http://www.mindspring.com/~ssshp/ssshp_cd/ss_home.htm
Ohala, J. J. (1991). The integration of phonetics and phonology. In *Proceedings of the XIIth International Congress of Phonetic Sciences, Aix-en-Provence, 19-24 Aug 1991* (Vol. 1, pp. 1-16).
Ohala, J. J. (1996). Speech perception is hearing sounds, not tongues. *Journal of the Acoustical Society of America, 99*, 1718-1725.
Passy, P. (1890). *Étude sur les changements phonétiques*. Paris: Firmin-Didot.
Pedersen, Holger. (1924). *Sprogvidenskaben i det nittende aarhundrede*. Copenhagen: Gyldendalske Boghandel Nordisk Forlag.
Rosapelly, C. L. (1876). Inscriptions des mouvements phonétiques. *Physiologie Expérimentale; Travaux du Laboratoire de M. Marey, 2*, 109-131. (Paris: G. Masson.).
Rousselot, P.-J. (1891). *Les modifications phonétiques du language étudiées dans le patois d'une famille de Cellefrouin (Charante)*. Paris: H. Welter. (Extrait de la Revue de Patois Gallo-Romans, 1891.)
Rousselot, P.-J. (1897). *Principes de phonétique expérimentale*. Paris.
Spargo, J. W. (1931). Preface to translation from Danish of Holger Pedersen's *Linguistic science in the nineteenth century*. Cambridge: Harvard University Press.
Stetson, R. H. (1928). *Motor phonetics. A study of speech movements in action*. Archives néerlandaises de phonétique expérimentale; 3.
Sweet, H. (1910). Phonetics. In *Encyclopædia Britannica* (11th ed.).
Trubetzkoy, N. (1933). La phonologie actuelle. *Journal de Psychologie, 1-4*, 227-246. [Theme issue on Psychologie du Langage, in French].
Wallis, J. (1653). *Grammatica lingua Anglicanae* [with an appendix: De loquela, sive sonorum formatione, tractus grammatico-physicus.] London: Leon Lichfield.

Willis, R. (1830). On the vowel sounds, and on the reed organ-pipes. *Transactions of the Cambridge Philosophical Society*, *3*, 229-268.