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*Introduction : phonetics in phonology**

Carlos Gussenhoven
University of Nijmegen

René Kager
University of Utrecht

If there is such a person as the average phonologist, he might have a conception of the relation between phonetics and phonology that comes close to the relation between social perceptions of crimes and a Code of Criminal Law. The Code's definition of various types of crimes and the penalty each type carries ultimately reflect, to put it crudely, the feelings of the people. Also, the Code's development will reflect social change. Criminal codes will typically incorporate the changing perceptions of the general public, and will now begin to include articles devoted to the use of the Internet, for instance. But at the end of the day, what counts in a law suit is what is in the Criminal Code, not the feelings of the people. So it is with phonology. It is easy to show that lexical forms are frequently related to functional (ergonomic) considerations, and that the way the grammar processes them into surface representations will amount to a reasonable articulatory task for the speaker, while equally the acoustic result will enable the listener to recognise these forms with reasonable ease. However, ultimately we say things the way we do because our lexical representations are the way they are, and our phonological grammar is the way it is.

In addition to this historical relation between phonetics and phonology, our 'ideal' phonologist may also recognise that the way phonetic implementation turns representations into acoustic form is goal-oriented (perhaps comparable to a judge's consideration of what the press thinks of the case he is trying) and variable (perhaps comparable to the different ways in which jurisprudence and the opinions in the media are brought to bear on his verdict, to pursue the analogy still further). The speaker acts so as to aid the listener in the perception of the phonological feature concerned, and the articulation of the same feature will therefore vary across languages as a function of the phonological contrasts it is in-

* The papers in this thematic issue are the result of a workshop with the same title, which was organised by the guest editors in April 1999 at the GLOW conference in Potsdam.

volved in, as held by Kingston & Diehl's (1995) 'phonetic knowledge' hypothesis.

The strictest interpretation of our phonologist's research aims would leave both the historical phonetic connection and the functionally oriented aspects of the phonetic implementation unmentioned, and ask merely for an answer to the question of how the phonological grammar is organised, both in general and in the case of particular languages (plus related questions, such as how this organisation explains the details of the acquisition process and the differences between the grammars of successive generations). A possible problem with this definition of the phonological field of inquiry – let us refer to this conception of phonology as 'Type A' – is that it explains only part of the data. Among the effects it could in principle explain are, on the one hand, those that are due to the cognitive organisation, such as the hierarchical nature of phonological structure and dependence relations, and, on the other, those due to various kinds of cognitive economy, such as loss of exception markings, paradigm uniformity, other phonetically unmotivated extensions of phonological generalisations and avoidance of homophony. Of course, the point is not that this class of phenomena is uninteresting; on the contrary, they constitute crucial evidence for the organisation of our knowledge of linguistic sounds, and of the fact that this organisation is indeed cognitive and non-phonetic (Anderson 1981, Hyman, forthcoming). The point is rather that they may bear on a subset of the data, and that a broader perspective may enable us to understand better what we see.

There are many questions which a Type A phonologist would have to leave unanswered. One class of questions was summarised by Demolin (2000): why is the average number of segments 32? It is reasonable to assume that this number is given by phonetic considerations, not by cognitive limitations. Questions that fall more clearly within a phonological class of issues would similarly have to be put aside, such as why languages may neutralise contrasts in phonologically incoherent contexts. In most cases, neutralisation will involve a context which can be captured by the grammar with the help of a generalisation expressed in terms of phonological primitives. But when it cannot, the composition of the class of neutralising contexts does not thereby become incomprehensible. To illustrate, the Dutch dialect of Maastricht has a privative lexical tone contrast between what is known as Accent 1, which is toneless, and Accent 2, which is an H tone in the stressed syllable. (There are some 30 minimal pairs, and the distinction is pervasive in the lexicon, as is the comparable contrast between Accent 1 and Accent 2 in Norwegian and Swedish.) This tone contrast is neutralised in an apparently heterogeneous set of contexts. Neutralisation of the tone contrast occurs in syllable rhymes containing the segments in (1c) and (1e). However, other than this fact, there is nothing that distinguishes these rhymes from those containing the segments in (1a, b, d) (Gussenhoven & Aarts 1999).

(1) a. eː øː oː
b. ɛi œy ɔu
c. ɛː œː ɔː
d. aː
e. V + glide (ɑw, eːj, etc.)

Yet there is a generalisation to be made, and it can, moreover, be explained, but the answer does not lie in the phonological representation. One of the phonetic manifestations of Accent 2 is (gradient, phonetic) monophthongisation. For instance, the high mid series in (1a) is slightly diphthongal when co-occurring when Accent 1, and purely monophthongal when co-occurring with Accent 2. More crucially, the vowels in (1b) have maximal diphthongal movement when spoken with Accent 1, but have this movement severely curtailed when spoken with Accent 2, making them phonetically similar to, though not homophonous with, the low mid (1c). What combines (1c) and (1e) is that the implementation of the phonological tone contrast would jeopardise perceptibility. The series in (1c) cannot be monophthongised: it already is. Therefore, adding Accent 2 to this series would create a contrast with Accent 2 versions of (1b) which would be very hard to produce in a way that would satisfy a hearer. In the case of the CV combinations in (1e), monophthongisation cannot be applied either, as it would compromise the articulation of the glide phonemes, and bring the preceding vowels into the acoustic vicinity of various long vowels. In other words, the generalisation that explains the distributional gaps is essentially non-phonological (in a Type A interpretation). Yet, many would think it reasonable to turn to phonologists for an answer to the question why the Maastricht dialect neutralises the tone contrast in some segmental contexts. Strictly speaking, the fact that the implementation of Accent 2 involves more than just pitch differences – in addition to pitch and degree of diphthongisation, duration is also involved, with Accent 2 being longer than Accent 1 – is only marginally of interest to a Type A phonologist once he has established that the contrast is indeed tonal, as opposed to one of quantity or vowel quality, an analytical step which is fairly easy to take. The rest, after all, is a matter of phonetic detail; of how the contrast is implemented. Thus, in addition to being forced to merely record the neutralisation contexts, a Type A phonologist could not even begin to develop an understanding of the situation, as the crucial fact lies in the implementation.[1]

For someone who would like to go beyond the self-imposed, starkly cognitive Type A position, there are two ways to go. One is to actively respond to the fact that the explanatory principles shaping the sound structure of human language are manifold, ranging from the mental organisation of linguistic information via functional (perceptual and articulatory) boundary conditions to functionally arbitrary social pressures, but at the same time maintaining a modular conception of the

[1] The reason for the peculiar implementation can be understood in the light of the origin of the tone distinction, but is not relevant at this point.

grammar in which phonology is distinct from the ways in which it is phonetically processed in perception and articulation. This Type B phonologist could handle the Maastricht case, since he would be able to 'tell it like it is', with due regard to the relevant explanatory principles. But like his Type A colleague, he would feel strengthened by the rich array of evidence which shows that representations are not the same as acoustic records, epitomised by Morris Halle's question 'What did the word *piano* sound like when you first learnt it?', the typical answer being that we cannot say, which is explained by the fact that on that occasion we stored it in some skeletal form, without pitch and tempo information or articulatory detail (cf. Halle 1985).

The other way would be to stop thinking about how phonology is different from phonetic processing, and try to explain the facts within a single conception of grammar. Occam's Razor would come to the rescue of this Type C phonologist whenever a separation of the data into two sets, one phonological and one phonetic, would make things look more complex than without such separation. Our tacit knowledge of the chain of effects set up by our articulations (the articulations themselves, the acoustic patterns created by them and the perceptual effects of these patterns) is now no different from the tacit knowledge we have about which segment sequences are ill-formed in our language, at least not in principle. This position is epitomised by the title of John Ohala's article in the special issue of *Journal of Phonetics* on phonological representation, 'There is no interface between phonetics and phonology' (Ohala 1990). It has recently come to the fore due to work emanating from UCLA (and represented in this issue by Edward Flemming's article) and work by Paul Boersma (e.g. Boersma 1998). This development was perhaps spurred on by the emphasis Optimality Theory lays on the universal nature of phonological constraints. On the one hand, this may focus our attention on cognitive, 'UG-type' universality, but on the other hand it offers an opportunity for the design of a parallel architecture for phonetics and phonology. (For a textbook introduction to Optimality Theory, see Kager 1999.)

Ranging from Type B to Type C phonology, the articles in this special issue all appeal to phonetic considerations to increase our understanding of phonological patterns. **Darin Howe** and **Doug Pulleyblank** summarise patterns of glottalisation in a variety of North American languages and discuss their implications for the relationship between phonetic features and phonological systems. They argue that these patterns raise problems for cue-based optimality approaches, where phonetic and phonological phenomena are accounted for by the same sets of constraints, and which seek to integrate phonetics and phonology into a unified model. The glottalisation facts instead support the modularity hypothesis, under which interactions of largely independent submodules (e.g. grounded conditions, constraints on syllable structure and faithfulness) together provide an explanation.

Colin Wilson addresses the notorious problem of contextually determined consonant deletion ('In selecting a consonant to delete in a

sequence VCCV, why do languages always delete C_1, rather than C_2?'), and solves it by offering a novel set of assumptions about the substance and formal aspects of contextual markedness constraints. More specifically, a set of 'targeted constraints' is proposed, which prefer deletion of the weak/unlicensed member of a cluster (rather than a repair in the surrounding context). A substantive basis for the proposal is offered in the form of the weak element principle, which states that 'a representation *x* that contains a poorly cued (or 'weak') element α is marked relative to the representation *y* that is identical to *x* except that α has been removed'. This principle is based on the insight of licensing-by-cue, according to which the pressure for contextual neutralisation correlates with poor perceptual cues.

Observing that there are widespread similarities between contextual restrictions in the segmental phonology and coarticulatory adjustments in the phonetics, **Edward Flemming** argues that there is more to be said for an integration of phonetics and phonology in a single grammar than for the traditional position that they constitute separate components, with different properties. He develops an optimality-theoretic account with gradient phonetic constraints which can be used to describe different degrees of coarticulation, as encountered in different languages, as well as neutralising effects. The discrete effect of neutralisation is obtained by balancing gradient MINIMISEEFFORT (i.e. minimise articulatory effort) and gradient MINIMUMDISTANCE (i.e. maintain some acoustic difference between phonological elements), and checking the result off against system complexity: cost-benefit calculation of the minimisation of articulatory effort and the resulting degradation of the distinctiveness for some contrast could give a result that falls short of a pre-set level for maintaining the contrast. In such a model, it should in principle be possible to calculate which contrasts are maintained, given the number of contrasts required.

Hyunsoon Kim shows how articulatory factors may produce acoustic effects that listeners may interpret phonologically, thus arguing that the shape of phonological grammars can be explained by the conditions obtaining in the speech-production mechanism. Her detailed presentation of the varying degrees of turbulence created at the explosion of coronal stops in Korean is used to account for the prevalence of affrication and assibilation of coronals before, but not after vowels, and before high vowels but not before low vowels. She argues that phonological interpretation amounts to the insertion of a [+strident] feature, to give an affricate, and deletion of [−continuant], to give a fricative. She thus supports analyses of affricates as strident stops, and distances herself from accounts of contextual change in segment feature content that necessarily require feature spreading.

Astrid Kraehenmann presents a case of an underlying geminate–singleton contrast which occurs in word-initial, word-medial and word-final positions in the Thurgovian dialect of Swiss German, a contrast which she shows is realised purely with the help of duration differences. The

interest is in the explanation for the context in which word-final and word-initial geminates are degeminated in phrase-internal position: when adjacent to an obstruent in the other word. She argues that the explanation is phonological, and lies in the impossibility of syllabifying the geminate (the dialect syllabifies across words if legitimate syllables can be formed). Interestingly, phrase-final and phrase-initial geminates, which should both be unsyllabifiable, are degeminated categorically only in phrase-initial position; they are just hard to hear in phrase-final position. This difference is related to the phonetic difference between audible plosive release and inaudible plosive closure. A further interest lies in the origin of word-initial geminates.

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