

**Bruce Hayes, Robert Kirchner, and Donca Steriade (eds.)** (2004). *Phonetically-based phonology*. Cambridge: Cambridge University Press. Pp. viii + 375.

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*Phonetically-Based Phonology* is a collection of eleven papers examining the role of phonetic factors in shaping phonological patterns. The contributions cover a range of topics, examining the phonetics and phonology of place assimilation and dissimilation, consonant lenition, metathesis, vowel harmony, vowel reduction, syllable weight, distribution of contour tones, as well as dispersion and neutralization of phonological contrasts. The empirical focus of the volume is on cross-linguistic similarities and differences – ‘universal’ phonological patterns, although some individual languages also receive a detailed treatment (e.g., Florentine Italian in Kirchner). Theoretically, most of the papers are couched in the framework of functionalist or ‘phonetically-driven’ Optimality Theory (OT), usefully summarized in Hayes & Steriade’s introduction. In this sense, the volume is also a tribute to this influential framework developed at UCLA, as seven out of the eleven papers are originally based on UCLA phonology dissertations: Jun (1995), Kaun (1995), Flemming (1995), Kirchner (1998), Crosswhite (1999), Gordon (1999), and Zhang (2001). At the same time, the volume includes papers that represent distinctly different approaches to phonetics-phonology interactions (Blevins & Garrett and Frisch), or can be described as articles providing more in-depth phonetic background (Wright). Below I will briefly review the contributions individually, grouping them roughly on theoretical/thematic grounds: I will start with the papers representing the phonetically-driven OT and will then discuss the papers dealing mainly with phonetic cues, processing, and sound change.

## **1 Phonetically-driven Optimality Theory**

Bruce Hayes and Donca Steriade begin the introductory chapter (‘Introduction: the phonetic bases of phonological markedness’) by raising a number of questions about sources of phonological markedness: “Where do markedness laws come from? Why are sound systems governed by these laws and not by some conceivable others? What is the source of individual’s knowledge of markedness-based constraints?” (p. 1). The answer to these questions, Hayes & Steriade argue, lies in understanding the facts of phonetic difficulty – articulatory effort and perceptual confusability (cf. Lindblom 1990). Facts of phonetic difficulty are internalized by speakers as ‘phonetic knowledge’; the speakers use this knowledge to make grammatical generalizations – constraints and their rankings; sound patterns observed across languages reflect the activity of constraint rankings in language-particular grammars. The goal of the outlined research program, therefore, is to identify grammatical markedness generalizations by deducing them from facts of phonetic difficulty (observed through experimentation) and cross-linguistically common sound patterns (observed through typological surveys). Hayes & Steriade illustrate this deductive approach by examining the phonetics and phonology of voiced obstruent geminates. Phonetic studies show that it is difficult to sustain vocal fold vibration when producing long obstruents, more so for some places than others. This knowledge of phonetic

difficultly, a markedness scale for [+voice] referring to gemination and place, serves as a basis for hierarchies of OT markedness constraints. Different rankings of these constraints with IDENT[voice], as the authors show, correspond to cross-linguistically attested patterns of voicing gemination. They note that although the phonetically-based analysis of the phenomenon is more complex than a traditional modular analysis, it is arguably more empirically adequate than the former. Hayes & Steriade conclude by highlighting the differences between their framework and the approach presented further by Blevins & Garrett.

All other contributions in this category apply the general program of research outlined in Hayes & Steriade to various phonological phenomena. These works are relatively similar structurally, combining theoretical analysis with typological surveys, reviews of phonetic literature, and in some cases, with phonetic experimentation or computational modeling.

Robert Kirchner, in 'Consonant lenition', argues that the key factor behind lenition is minimization of articulatory effort; moreover, patterns of lenition are directly derived through an interaction of effort-based markedness constraints (LAZY) and perceptually-based faithfulness constraints. Articulatory effort is assumed to depend on a number of phonetic parameters and factors, including constriction degree, adjacent segments, speech rate and style, among others, and these are directly incorporated into constraint hierarchies. The approach is further tested in great detail on data from Florentine Italian, a language representative of the typology of consonant lenition. The language exhibits both obligatory/categorical and optional/gradient lenition, which applies depending on context, consonant, speech rate, and style. The latter effect is modeled in the paper using register-specific LAZY constraints, thus capturing the optionality of the process. Gradient phonetic effects are expected to be achieved in the framework through an introduction of features that are relatively more fine-grained than traditional phonological features (see, e.g., p. 338 on the use of the feature [ $\pm$ more strident]). As Kirchner notes, the presented analysis is tentative and based on certain assumptions about articulatory effort cost that await future confirmation.

Edward Flemming, in 'Contrast and perceptual distinctiveness', argues that the functional imperative to avoid perceptual confusion plays a key role in phonological grammar. Unlike articulatory difficulty, perceptual difficulty has to refer to contrasts rather than to individual segments, since perception is based on categorization of sounds, often involving discrimination of pairs of sounds. Thus, the relatively uncommon, marked, vowels /y/ and /u/ are not difficult per se; rather, the contrast between these vowels is less perceptually distinct than the contrast between the relatively common vowels /i/ and /u/ that have more extreme second formant values. Building on the insights of Lindblom's (1986) Theory of Adaptive Dispersion, Flemming develops a grammatical theory of phonological contrasts – Dispersion Theory (Flemming 1995). The key component of this theory is a set of scalar OT constraints requiring maximization of the distinctiveness of contrasts referring to auditory features (e.g., MINIMALDISTANCE = F2: 2: two sounds have to differ at least by 2 pre-defined units of distance along the second formant dimension). Flemming shows that interactions of these constraints with those requiring maximization of the number of contrasts and minimization of articulatory effort produce various attested patterns of dispersion and neutralization. The processes discussed in more detail include enhancement of vowel 'color' and consonant laryngeal contrasts in inventories, vowel reduction in unstressed syllables, as well as the role of contrast in allophonic vowel variation and patterns of nasal harmony. A particularly interesting case illustrating the role of perceptual contrasts is pre- and post-stopping of nasals in Kaingang, an articulatory strategy presumably aimed at maintaining the contrast between nasalized and non-nasalized vowels.

Jongho Jun, in 'Place assimilation', notes that standard OT and previous phonological theories provide a satisfactory formal descriptive account of place assimilation, but fail to adequately explain a number of asymmetries observed in its cross-linguistic patterns. The patterns of place assimilation in clusters, identified in a language survey, include the regressive direction of assimilation and greater likelihood of certain segments as targets (e.g., nasals > stops > fricatives; coronals > labials > dorsals) and triggers of assimilation (e.g., noncoronals > coronals). An explanatory account of these patterns, Jun argues, has to incorporate articulatory and perceptual teleologies. His analysis of place assimilation crucially involves a set of faithfulness constraints requiring preservation of perceptual cues to consonant place in various contexts, ranked against the articulatory effort-based WEAKENING constraint. Thus, for example, the factors underlying the susceptibility of nasals to assimilation are the relatively poor cues to nasal place, compared to the cues to stop place (grammaticalized as a constraint hierarchy PRES(PL([stop]\_\_C)) » (PRES(PL([nas]\_\_C))). Jun also addresses the issue of optionality and gradiency in assimilation, proposing to derive these effects using a set of gradient, speech rate/style-sensitive PRESERVE and WEAKENING constraints.

Abigail Kaun, in 'The typology of rounding harmony', presents results of a cross-linguistic survey of rounding harmony systems, showing that there are systematic preferences in terms of targets and triggers of harmony. Particularly, she finds that the nonhigh front vowel (/ø/) is the most likely trigger of rounding harmony, while the high back vowel (/i/) is the most likely target. In addition, harmony is more likely if triggers and targets agree in height (e.g., high /y/ - /i/ or nonhigh /ø/ - /a/). Kaun attributes these asymmetries to a number of articulatory and perceptual factors, based on a survey of phonetic studies of lip rounding. First, high vowels tend to be produced with greater lip rounding than nonhigh counterparts, and so do back vowels compared to their nonback counterparts. These differences have perceptual consequences, so that high and back vowels are perceived as relatively more rounded than nonhigh and front vowels. Second, implementation of two consecutive lip rounding gestures is apparently facilitated when the corresponding lingual gestures have the same height targets (i.e. vowels agree in height). Kaun argues that rounding harmony is an optimization strategy, as it improves recoverability of less salient vowels by extending the span of rounding to more salient vowels. An OT account of the phenomenon uses alignment and markedness constraints grounded in these phonetic factors. The author further presents results of an experimental study of rounding harmony in Turkish loanwords. The patterns exhibited by speakers in the experiment are notably different from Turkish rounding harmony in suffixes, yet apparently consistent with the cross-linguistic patterns. Additional support for the perceptual account of target/trigger asymmetries, Kaun notes, comes from the finding of short/long vowel asymmetry: in some languages, the less salient short vowels trigger rounding harmony, while the more salient long vowels do not.

Katherine Crosswhite, in 'Vowel reduction', argues that there are two different types of reduction, each involving distinct phonetic mechanisms. Reduction that eliminates noncorner vowels (as in Belorussian and Luiseño) is 'contrast-enhancing', presumably resulting from licensing perceptually demanding noncorner vowels to stressed syllables. Phonetic evidence for noncoronal corner vowels as sub-optimal is based primarily on Lindblom's (1986) Dispersion Theory and Steven's (1989) Quantal Theory. The second type of vowel reduction – 'prominence reduction' – is driven by the imperative to avoid phonetically long or salient vowel qualities in unstressed position (as in Bulgarian and Sri Lankan Portuguese Creole). The ultimate outcome of such reduction is a schwa (as in English). Formally, this process is implemented as a hierarchy of

constraints referring to the scales of accentual and vocalic prominence, which is assumed to be grounded in differences in vowel intensity and amplitude, among other possible factors. Crosswhite notes that prominence reduction should not be equated with vowel target undershoot (as suggested by Flemming in this volume), and considers the two phenomena phonological and phonetic respectively. Cases of languages having more than one type or degree of reduction (e.g., Brazilian Portuguese) are particularly revealing; however, the author does not elaborate on whether these cases are consistent with the proposed analysis. Another interesting observation made by Crosswhite is that all cases of prominence reduction in the survey are limited to stress-timed languages, thus suggesting a link between reduction types and stress- or syllable-timing.

Jie Zhang, in 'The role of contrast-specific and language-specific phonetics in contour tone distribution' notes that contour tones in many languages are restricted to either phonemically long vowels or stressed syllables. His review of the literature on production and perception of tone suggests that unlike level tones, contour tones require longer sonorant rhyme duration, the property shared by both long vowels and stressed syllables. He takes a 'direct approach' arguing that licensing of contour tones is implemented with direct reference to phonetic categories of duration and sonorancy, and not with reference to abstract structural categories (such as syllable position). A grammar of tone licensing, he proposes, refers to phonetic scales of contour-bearing ability and tone complexity. Moreover, the grammar is argued to be sensitive to gradient language-particular phonetic differences in duration. Zhang further presents experimental results that appear to support his analysis: an acoustic examination of sonorant rhyme duration in three languages showed a close correlation between duration measurements and licensing of contour tones. Another interesting typological finding of the study is that word-final syllables and monosyllabic words are also among the preferred licensing sites of contour tones. Sonorant rhyme duration is a factor here as well, Zhang argues, as utterance-final syllables and shorter words tend to undergo phonetic lengthening.

Matthew Gordon, in 'Syllable weight', challenges the traditional assumption of 'weight uniformity' – that light/heavy syllable weight criteria are uniform for various processes in a given language, while possibly being different across languages. His survey of over 400 languages exhibiting six weight-sensitive phenomena – stress, tone, poetic metrics, minimal word requirements, and syllable template restrictions – reveals that weight is not always uniform within a language, being strongly process-specific. In other words, a given language may have different weight criteria for different weight-sensitive phenomena; across languages, however, weight-sensitive phenomena are largely uniform in choosing some weight criteria over others. For example, tone is often sensitive to CVV and CV[+son] heavy syllables, while stress is sensitive to CVV and CVC heavy syllables (regardless of coda sonorancy). Gordon proposes that these phonological differences are rooted in phonetic factors specific to particular weight-sensitive phenomena. He further explores the phonetics of weight-sensitive stress in more detail, showing that the syllable-weight hierarchy relevant to stress correlates closely with the phonetic 'effectiveness' (measured as energy of the sonorant portion of the rhyme) of the corresponding syllable types. While phonetic effectiveness is clearly a factor, Gordon argues that the principle of phonological simplicity is equally important in selecting language-particular syllable weight criteria. He further presents results of an acoustic study of different syllable types in six languages with weight-sensitive stress. The findings show that in all of the examined languages phonological weight distinctions are both structurally simple and phonetically effective, being tuned to language-specific phonetic properties. He interprets the findings as evidence for an 'integrated model' of phonology and phonetics where "one aspect of phonological structure

influences phonetic properties which in turn influence another phonological phenomenon” (p. 300). Further evidence for this view comes from an intriguing finding of a close correlation between coda inventories (ratios of sonorants to obstruents and voiceless to voiced consonants) and the choice of weight criteria in a given language.

It is interesting to note that while these papers share many theoretical assumptions, there are some clear differences in the details of how phonetic influence on phonology is formalized. In many papers phonological constraint hierarchies refer directly to scales of phonetic difficulty (Jun, Flemming, Kirchner, and Zhang; cf. Steriade 2001); other papers take a more traditional view, assuming that phonological constraints are ‘grounded’ in phonetics (Crosswhite and Kaun); yet others espouse an ‘integrated’ phonology-phonetics approach (Gordon). Interestingly, these different assumptions in some cases result in conflicting accounts of what appears to be the same phenomenon (e.g., vowel reduction in Crosswhite and Flemming and distribution of contour tones in Zhang and Gordon). Given the considerable proliferation of OT constraints in many phonetically-driven accounts, a question that often comes up is whether markedness constraints of this type can or need to be innate, specified in the traditionally assumed Universal Grammar (UG). This question, although not raised in most contributions, is taken up by Hayes and Steriade, who view UG as “a set of abstract analytical predispositions that allow learners to induce grammars from the raw facts of speech, and not as a – dauntingly large – collection of a priori constraints” (p. 6). This represents an intriguing departure from the standard generative view of UG adhered to since Chomsky & Halle (1968) (see also Mielke’s 2004 work on emergent features).

While all papers are concerned with cross-linguistic typology of phonological patterns, they differ considerably in their descriptive typological coverage. Typological generalizations presented in some of the contributions are based on impressive surveys of about 200 to 400 languages (Gordon, Zhang, and Kirchner). Generalizations presented in some others papers are based on less extensive surveys, likely convenience samples of languages (e.g., 23 languages in Kaun and 17 languages in Jun). Understandably, the sample size of a survey is often constrained by the frequency of a phonological phenomenon examined and by the availability of descriptive data. Still, generalizations based on smaller and genetically biased samples may not always reflect true universal patterns, being possibly skewed by genetic or areal linguistic developments. One case in point is Kaun’s typology of rounding harmony, where 8 out of 13 types of rounding harmony are represented exclusively by Turkic languages. Further, the main typological generalization that the nonhigh front rounded /ø/ is the best trigger and the high back unrounded /i/ is the best target (although may indeed be phonetically motivated) is based largely, if not exclusively, on Turkic languages, since no other languages in the sample have both vowels in their inventories (with the exception of Shuluh Höh, a Mongolian language; based on Kaun 1995). This highlights another issue that seems to be underplayed in this and some other contributions: phonemic contrast is highly important, since language-particular inventories crucially delimit the set of triggers and targets of many phonological processes (cf. Flemming and Gordon). Further, Kaun’s typology does not include some relatively well-known cases of rounding harmony, for example, Hungarian and Cheremis (Mari) (e.g., Ringen & Vago 1998; Odden 1994), whose patterns do not seem to fit into Kaun’s factorial typology. In these languages, the triggers of rounding harmony are high and nonhigh front rounded vowels and targets are nonhigh back unrounded vowels.

Another apparent limitation of some of the papers is that universal scales of perceptual difficulty are mainly deduced from acoustic studies, rather than established in perceptual

experiments. As Wright (discussed further below) notes, “not all acoustic features that can be discerned in a spectrogram or waveform will necessarily have an even impact on the listener” (p. 42). Jun’s paper is particularly relevant in this respect. He attributes the lack of susceptibility of unreleased velars in assimilation (compared to labials and coronals) to the characteristic conversion of F2 and F3 prior to the closure. A number of recent perceptual studies of place, however, showed that unreleased velars are identified more poorly than unreleased labials, and as bad as or even more poorly than unreleased coronals (Kochetov & So 2006, among others). Similarly, other studies found that place in nasals is identified as good as, if not better than, place in stops (Winters 2003, among others), thus contradicting Jun’s manner scale of perceptibility intended to explain susceptibility of nasals to assimilation. All this underscores the need for careful experimental testing of the claims about the scales of phonetic difficulty.

## **2 Perceptual cues, language processing, and sound change**

Richard Wright’s paper ‘A review of perceptual cues and cue robustness’ complements the above reviewed contributions by providing a detailed survey of phonetic studies, examining auditorily/perceptually important acoustic properties of consonants and vowels. The survey includes a discussion of various cues to place contrasts (formant transitions, fricative noise, release bursts, nasal cues), cues to manner and voicing contrasts, and cues to vowel quality. He further discusses the concept of ‘cue robustness’ – the ability of linguistically important acoustic information to ‘survive’ in external noise and to overcome inherent distortions during auditory processing. One apparent limitation of Wright’s survey is that it lacks the cross-linguistic focus found in other papers, being concentrated mostly on English sounds (which is, however, hardly avoidable given that most of the research on the topic has been done on English). As Wright notes in the introduction, the survey is intended to provide background for a revision of the Sonority Sequencing Constraint, which is envisioned as “scalar constraint in which an optimal ordering of segments is one that maximizes robustness of encoding of perceptual cues to the segmental makeup of the utterance” (p. 35). While this proposal is promising, the section dealing with it is rather brief (slightly over two pages), leaving questions about the exact formal implementation of the constraint and its use in phonological grammar.

Stefan Frisch, in ‘Language processing and segmental OCP effects’, explores the role of higher-level phonological processing in phonotactic patterns of similarity avoidance (OCP). He shows that earlier documented gradient OCP effects in Arabic and English roots (Frisch, Pierrehumbert, & Broe 2004; Frisch 1996) reflect “the functional pressure to make language processing as easy as possible”, particularly by avoiding difficult-to-process sequences of similar sounds. Frisch develops this argument by presenting an extensive and highly informative overview of current theories of language processing – spoken word recognition, lexical neighborhood effects, and phonological encoding in speech production. He highlights the ‘problem of serial encoding’ – as psycholinguistic research shows, sequences with repeated or similar items present problems for speech production and perception, leading to errors and confusion. While arguing for the relation between the phonetic/phonological processing and OCP effects in the lexicon (which may be part of speakers phonological knowledge), Frisch views it as essentially diachronic: “Over time, functional pressures on the language have shaped the lexicon by influencing borrowings, the creation of nonce forms, and the loss of lexical items”. He further notes that patterns of reduplication and harmony present an apparent problem for the

serial encoding-based processing account, and suggests that these phenomena have to involve more specialized cognitive processes or result from other functional pressures. Particularly, with respect to harmony he adds that “it may merely be the case that some languages place functional value of repetition avoidance above the value of harmony, while others do the reverse” (p. 361). This line of reasoning, however, seems problematic, as similarity avoidance and harmony patterns may co-exist in a given language (e.g., the OCP place effects in Ngbaka, mentioned by Frisch, are accompanied by consonant harmony involving laryngeal features and nasality: Hansson 2001).

In stark contrast to most of the above mentioned contributions, Juliette Blevins and Andrew Garrett in ‘The evolution of metathesis’ explicitly argue for an indirect, diachronic influence of phonetics on phonological patterns: “Certain sound patterns are cross-linguistically frequent as a consequence of convergent evolution: the intrinsic properties of speech perception and production result in certain frequent sound changes; these in turn yield common sound patterns” (p. 118). The goal of this approach, also known as Evolutionary Phonology (Blevins 2004), is to develop “phonetically plausible diachronic explanations for phonological patterns”, thus simplifying synchronic models of grammar. Instrumental to this goal is understanding the mechanism of sound change and sources of its regularity. Building on Ohala’s work (e.g., 1981), Blevins & Garrett view sound change as resulting mainly from listener-based misperception and re-interpretation of phonological input. The source of regularity in sound change, according to them, is rooted in categorical perception and phonological acquisition. In this paper, the authors concentrate on various kinds of consonant and vowel metathesis, a phenomenon that has been traditionally problematic for phonological theories. The typology of metathesis they present (illustrated by a wealth of examples) distinguishes four main types, for expository reasons referred to as ‘perceptual’, ‘compensatory’, ‘coarticulatory’, and ‘auditory’ metathesis. To provide a background for the analysis of these types, Blevins & Garrett review relevant articulatory and perceptual factors. First, ‘elongated phonetic cues’ to some features such as pharyngealization, rhoticity, and laterality tend to span multiple segments, thus creating a considerable segmentation problem and ultimately resulting in cases of perceptual metathesis (e.g.,  $C^sVC \rightarrow CVC^s$ ). Second, V-to-V coarticulation under certain prosodic conditions can give rise to an ‘extreme’ anticipatory coarticulation, resulting in a C-V shift, a case of compensatory metathesis ( ${}^hV_1CV_2 \rightarrow {}^hV_1V_2C$ ). Interestingly, this type of metathesis is almost exclusively attested in two language families (Austronesian and Pama-Nyungan), whose languages are known for their small and highly variable vowel inventories (and thus presumably greater degree of coarticulation). Third, extreme cases of C-to-C coarticulation can obscure consonant place cues (more for some places than others), producing patterns of coarticulatory metathesis (e.g.,  $pk \rightarrow kp$ ). And finally, sibilant noise in sequences of sibilants and stops tends to be ‘decoupled’ from the auditory stream, leading to confusions in segment sequencing – cases of auditory metathesis (e.g.,  $sk \rightarrow ks$ ). Blevins & Garrett conclude the paper by making specific predictions about the types of metathesis that are impossible under the outlined approach (while being predicted by the functionalist approach), as well as predicted, but not yet unattested types.

In the context of this volume, Blevins & Garrett’s paper raises intriguing questions about possible alternative accounts of the phenomena examined in many of the papers reviewed above. For example, place assimilation in clusters can be alternatively analyzed as resulting from C-to-C coarticulation and subsequent listener-based misperception/phonologization (Blevins 2004, 2007; but see Steriade 2001). To what extent such re-analysis of this and other cross-linguistic patterns is possible is an issue of particular importance for the field of theoretical phonology, as

it has implications for the synchronic architecture of phonological grammar and models of phonology-phonetics interface. It is expected that future progress in this direction will be achieved through rigorous experimentation and modeling, combined with extensive typological studies.

In conclusion, the papers showcased in *Phonetically-Based Phonology* truly represent some of the highlights of the recent research on the role of phonetics in phonology (together with work by Paul Boersma, Daniel Silverman, Elizabeth Hume, and Jaye Padgett, among others). Given the overall diversity of the topics, fascinating typological findings, ground-breaking theoretical analyses, the current volume is likely to appeal to a wide range of scholars working in the areas of theoretical phonology, phonetics, phonetics-phonology interface, linguistic typology, and sound change.

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