

REVIEWS

Steven Bird, *Computational phonology: a constraint-based approach*. (Studies in Natural Language Processing.) Cambridge: Cambridge University Press, 1995. Pp. xv + 203.

Reviewed by JOHN COLEMAN, Phonetics Laboratory, University of Oxford

This small book is big on important new ideas and arguments. Phonology is given more space than computation, and apart from Chapter 5, it will be of greatest value to phonologists, whose attention it deserves. Computational linguists may also find it useful as a review of the rapid explosion of work in this area of the field. This is not a 'how to' manual on the practicalities of computational implementations of phonological theories, such as might compare with the many excellent recent textbooks on computational linguistics, but primarily a monograph on a declarative, constraint-based approach to phonology, expressed in first-order logic. That makes it in many ways a contemporary successor to formal studies of phonology such as Batóg (1967). But it has none of the dryness and concentration on symbolic nitty-gritty that made such works inaccessible, unpopular and uninfluential.

Phonology has been taking a turn towards constraint-based approaches for several years: witness such publications as the papers in Goldsmith (1993) and Paradis & LaCharité (1993), and the astonishing influence of Prince & Smolensky (to appear), in advance of its formal publication. Bird's book is unquestionably timely.

Chapter 1, 'Introduction', begins with two pointed criticisms of contemporary phonology. First, a reminder of a statement of Chomsky's that linguistic notations should be 'perfectly explicit' and ought not to 'rely on the intelligence of the understanding reader'. 'It is not clear', says Bird, 'that modern non-linear phonology, to any great extent, meets these fundamental requirements of generative grammar.' (1) Second, 'despite claims to the contrary, many current phonological theories remain performance models. They enumerate the steps which must be taken in moving from a lexical form to a surface form, borrowing heavily on the now dated flowchart model of computation. Crucially, there is no guarantee that such rule systems work in reverse.' (2) We have seen these criticisms before, in the early days of non-transformational syntactic theories, but they deserve re-stating, because they are correct, and because mainstream phonology has so far largely failed to take notice of them.

The theoretical orientation which Bird offers as a remedy is the monostratal, constraint-based and declarative approach to grammar

employed in approaches such as HPSG. His primary motivation is the integration of phonology with other components of grammar.

Central to Bird's approach lies the description/object distinction, familiar from semantics as intension vs. extension. Consider a feature such as [place], with three possible values, labial, coronal and dorsal. Phonological formulae such as [place: labial] are seen as partial descriptions of a set of grammatical representations – those which conform to the description. Adoption of the distinction enables Bird to work with descriptions involving disjunction and negation, for example. In mainstream phonological theory, in which constraints and representations are different kinds of formal objects, a negation statement such as *[place: labial] is not a representation, but a constraint on representations – a kind of rule. For Bird, however, *[place: labial] is a description – a predicate which is true of the set of representations which do not contain the feature [place: labial]. The distinction between constraints or rules and representations maintained in mainstream phonology is overturned. The description *[place: labial] is useful because it generalizes over unspecified place, coronal place and dorsal place. The only way in which mainstream phonology can employ prohibition is with a filter: prohibitions cannot occur in lexical entries, under the mainstream view, which also lacks representations such as '[place: coronal OR dorsal]'. As we shall see, the ability to employ disjunction in phonological representations is a key mechanism for describing alternations without using destructive operations. Since lexical entries, structure-building rules, feature constraints etc. are ALL descriptions, the classical distinction between rules and representations does not obtain in declarative phonology.

The body of Chapter 1 surveys the contemporary orthodoxy in generative phonology, computational phonology, and constraint-based phonology. The survey of computational phonology focuses on finite-state methods (mainly two-level phonology, an approach which is close to both classical phonemics and SPE phonology) and connectionist methods (for example, the work of Goldsmith and Larson).

The constraint-based approach is introduced via a history of constraints in phonology, from classical phonemics, Firthian phonology, and Natural Generative Phonology (all of which are declarative approaches), leading to the more recent explosion of interest in declarative generative phonology.

In Chapter 2, 'A logical foundation for phonology', Bird sets out an axiomatic approach to phonology in which constraints are expressed using a decidable subset of first-order logic. 'Decidability' means that it is possible to determine algorithmically whether or not a representation conforms to the set of constraints constituting the grammar. In this approach, licensing replaces derivation as the method of rule-operation: a representation is well-formed if its various parts are consistent with the constraints. We can say that each of the constraints licenses a part of a representation. Section by section, Bird provides a logical treatment of (i) sorts, used for enforcing

appropriate layering in prosodic structure, and the subsegmental grouping of features (using lattice theory rather than feature-geometry); (ii) predicates for describing hierarchical organization, including dominance, branching degree, autosegmental licensing (or prohibition) of features at specific places in structure and prosodic licensing; (iii) temporal organization, including linearization, the precedence and overlap relations, points and intervals; and (iv) the interaction of hierarchical and temporal structure. Much of this material has been reworked without substantial change from earlier publications, such as Bird & Klein (1990). Then Bird examines the relationship between phonological rules and logic. Structure-building redundancy rules such as (1a) are expressed as implications such as (1b).

- (1) (a) $[-\text{voice}] \rightarrow [-\text{nasal}]$
 (b) $\forall x, -\text{voice}(x) \rightarrow -\text{nasal}(x)$

Under the logical interpretation of rules, ordered rule application, even feeding order, is replaced by conjunction. For example, from the implications $[+\text{nas}] \rightarrow [+\text{son}]$ and $[+\text{son}] \rightarrow [+\text{voi}]$ it can be inferred that $[+\text{nas}] \rightarrow [+\text{voi}]$, whether the implications are 'chained' in the conventional 'feeding order' or in the reverse order ($[+\text{son}] \rightarrow [+\text{voi}]$ and $[+\text{nas}] \rightarrow [+\text{son}]$), as conjunction is commutative: 'A and B' is true under exactly the same conditions as 'B and A'. The chapter concludes with a discussion of default rules, crucial to declarative analyses of epenthesis ('default presence') and some instances of apparent deletion ('default absence'). Bird discusses a non-monotonic, modal approach to defaults and Karttunen's 'elsewhere' interpretation of defaults.

Bird's logical methods would be easier for many phonologists to follow if he had deconstructed the logic of standard phonological notation more explicitly. SPE notation (Chomsky & Halle 1968) includes silent conjunction (for example, co-occurrence of features and/or parts of structures in a single representation or rule), disjunction (the curly bracket notation), and now negation (the * notation). Alternation with zero (i.e. optionality) is conventionally written using parentheses. Rule ordering in SPE is in most cases partial, and many rules could be evaluated in parallel. Once feeding order is recognized as amenable to simultaneous rule application, the empirical basis of extrinsic ordering is significantly weakened. By not addressing these matters head-on, Bird misses an opportunity to open some of his readers' eyes to the power of the logic already available in mainstream phonological theory. This is an unfortunate omission, as many phonologists would welcome an exposition of phonological logic in familiar terms, I believe.

In Chapter 3, 'A critique of destructive processes', Bird attempts to forestall the inevitable response from mainstream phonologists regarding his sanction against deletion, feature-changing and structure-changing rules, by showing how a number of classic cases of such analyses can be tackled

monotonically. Since there are numerous examples but no extended phonological analyses in this book, the material in this chapter provides the best basis on which to assess Bird's approach as applied to practical cases.

Deletion is eliminated in two ways. First, Bird argues that many apparent instances of phonological deletion ought to be recognized as phonetic hiding. Since deletion and feature-changing can give rise to absolute neutralization, Bird follows Dinnsen and co-workers in arguing that destructive phonological rules are refuted by phonetic facts showing that the putative neutralization is not absolute. For the remaining cases which must be recognized as a phonological alternation with zero, Bird employs disjunction in representations to encode 'deletable' segments. He examines consonant deletion in Samoan and /r/-insertion/deletion (i.e. 'linking /r/' and 'intrusive /r/') in Australian English in this way. His /r/-insertion/deletion data is similar to McCarthy's (1991) description of Eastern Massachusetts English. As McCarthy pointed out, analyses involving the insertion of /r/ intervocally are inadequate since vowel-final words do not manifest the alternation. Bird posits an /r/ ~ \emptyset alternation in all 'vowel-final' major category words and function words ending in an orthographic 'r'. For example, the lexical representation of 'her' could be /hə(r)/, in which the disjunction between r and \emptyset written here as /(r)/ is explicitly encoded in the lexical representation. Bird extends this account of linking /r/ to embrace intrusive /r/ too. For instance, 'tuna' could be lexically represented as /tjunə(r)/, by virtue of the fact that it participates in an /r/ ~ \emptyset alternation. To complete the analysis, it is necessary to state the constraints which determine whether the well-formed surface form manifests or lacks the /r/. Bird gives two constraints which determine the correct surface forms:

- (2) (a) onset licenses r
- (b) not-shared(r)

Two analyses of feature-changing harmony are then discussed and overturned in a similar manner. An analysis of Montañes Spanish vowel harmony is presented which uses morphologically conditioned or lexically determined defaults. The lexicalist basis of Bird's analysis is bolstered by the existence of exceptions in the data to general vowel-raising and lowering rules. His treatment of Chumash consonant harmony again takes the form of a challenge to its empirical basis: Bird argues that the assimilation is incomplete (i.e. does not involve feature-switching) and is therefore a gradient phonetic process.

As a paradigm example of structure-changing, Bird looks at resyllabification. His example is taken from Turkish, in which /p/ is syllable-final in 'şarap', but syllable initial in 'şarap aldı'. The placement of a segment in different syllable positions in different contexts is straightforward in constraint-based phonology. Since the position of the /p/ alternates, the

lexical representation cannot give it a specific syllable position: Turkish lexical representations are unsyllabified. Instead of syllabifying 'şarap' (with /p/ a coda), adding 'aldı', and then resyllabifying 'şarap' so that the /p/ becomes an onset to the following vowel, Bird takes the forms 'şarap' and 'şarap aldı' as disjoint cases, to be parsed independently.

This rejection of re-parsing is completely standard in other areas of grammar. For example, few syntacticians would argue that in a 'raising' sentence like *John believes Bill to be a criminal*, a syntactic parser should first provide an analysis of the substring *Bill to be a criminal* (in which *Bill* is parsed as a subject NP), following which re-analysis of the larger string revises this analysis by placing *Bill* in object NP position as the complement of *believes*. Resyllabification analyses require little response from declarative phonology, as they rest on a computationally naïve view of parsing.

Chapter 4, 'A theory of segmental structure', gives a more detailed review of feature geometry, followed by a reworking of Browman and Goldstein's articulatory feature structures.

Chapter 5, 'Implementation', will be opaque to phonologists unfamiliar with the literature on computational mechanisms of theorem-proving, but the details given here could be readily extended to the implementation of other areas of constraint-based grammar, and may interest a wider readership. The most important aspects of Bird's work in this chapter are the use of Belnap's 4-valued logic (true, false, unknown and inconsistent) to compute *and*, *or*, *not*, *precedes* and *overlaps*, and his ingenious approach to constraint solving. In his implementation, phonological constraints expressed in first-order logic are translated into statements in the Prolog programming language. Since Prolog is based upon logic, these are also statements of a decidable subset of first-order logic. Executing a program in Prolog amounts to proving a theorem, such as "'şarap aldı" is a well-formed string', according to the set of constraints that constitute the grammar. The Prolog interpreter has a built-in theorem-proving mechanism to do this, and naturally Bird makes use of this. However, Bird does not make Prolog do all the work: in fact (ordinary) Prolog is not suitable for general constraint logic programming. (Bird also tried using a constraint logic extension of Prolog called CLP(\mathcal{R}), but found a number of inelegancies with that implementation.)

Bird uses Prolog mainly to enforce the flow-of-control régime. Checking that the constraints are all satisfied as the proof proceeds is performed by a constraint engine that Bird has written in C. The way in which the work of the constraint engine is linked to the flow of control in the Prolog theorem-prover involves an ingenious use of chaining variables, an idea which Bird credits to Chris Mellish. Bird's description of the technique is brief but sufficient, as he provides a step-by-step illustration of constraint solving.

Chapter 6, 'Conclusion', is followed by an Appendix, which examines a number of logical extensions: feature matrices (actually HPSG-style feature-

structures, rather than SPE-style matrices), another shot at prosodic structures, and a modal tense logic for reasoning about temporal intervals. The extensive bibliography is followed by a language index, including for each entry details of the language family, geographical location and, where relevant, date of extinction; a name index and the usual subject index. Sticklers for adequate indexing will not be disappointed.

Bird writes in an intelligent yet accessible style. His arguments are often expressed briefly, with minimal exemplification, yet he has a knack of homing in on the heart of the matter. He might have made more concessions to a readership of phonologists, as they stand to gain most from this book, in my opinion. The typography and layout of the book is excellent, and in all the logical formulae, phonological statements, diagrams and text I found no errors. I am sure that it could be an important contribution to theoretical phonology, if phonologists would study it carefully and take note once again of what REAL generative grammar offers.

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- Author's address: Oxford University Phonetics Laboratory,
41 Wellington Square,
Oxford OX1 2JF,
U.K.
E-mail: John.Coleman@Phonetics.Oxford.ac.uk*

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Barry J. Blake, *Case*. (Cambridge Textbooks in Linguistics.) Cambridge: Cambridge University Press, 1994. Pp. xviii + 229.

Reviewed by HENRY SMITH, Yale Law School

This book fills a long-neglected niche in the world of linguistics textbooks. Writing a textbook on an aspect of language as thoroughly studied as case is an ambitious undertaking, and, with some exceptions, this book rises to the task. It is well organized and full of interesting and useful data. Although it