Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

Key Aspects of Declarative Phonology

James M. Scobbie
Queen Margaret College, Edinburgh
John S. Coleman
University of Oxford
Steven Bird
University of Edinburgh

1 Introduction

1.1 Constraints in phonological theory

Constraints are a major component in many phonological theories, past and present. They are exploited to their full in Declarative Phonology. It is worthwhile to briefly state some general considerations about the circumstances which have led to their ubiquitous use.

Constraints are compelling in many individual cases, because in cases of alternation a limited set of phonological primitives are being constantly reused in a limited set of general configurations. Moreover, these entities are needed for the analysis of non-alternating forms. We therefore impose constraints on the set of well-formed representations permitted in the analysis of the language in question to force alternating and underived/non-alternating forms alike to use, by definition, a set of well-formed representations. While it was once hoped to use constraints on underlying representations alone to capture generalisations about the limits on non-alternating forms, it was seen that constraints must also apply to what is usually called the 'output' of rules in order to give formal expression to rule conspiracies. In fact, constraints on the output of a grammar are now the norm, and constraints on underlying forms the exception (e.g. Paradis & Prunet 1993, Clayton 1976, Hooper 1976).

Where constraint-rich phonological theories differ is in their approach to the interaction of lexical entries, rules governing alteration, and constraints on surface forms. In different theories, constraints can block rules, trigger repair strategies, conflict with each other, over-ride lexical entries and be over-ridden by them (e.g. see the papers in Paradis & LaCharité 1993).

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

Whatever stance is taken, the solution to this *Interaction Problem* (Scobbie 1991ab) is an essential part of all theories. Some theories, such as the Theory of Constraints and Repair Strategies (e.g. Paradis 1988, this vol.), Optimality Theory (Prince and Smolensky 1993; McCarthy and Prince 1993) and Declarative Phonology address this issue as a central concern, and the particular solution offered is taken as a defining characteristic of that theoretical framework, over all other representational considerations.

Declarative Phonology provides a radical solution to the Interaction Problem. First, all elements of the phonology are constraints, so we only have to characterise constraint interaction, but not the interaction of constraints with any other type of element, such as the lexicon or rule-set. Second, the theory of constraint interaction within Declarative Phonology is maximally simple: all constraints must be compatible, all apply equally, all must be satisfied.

1.2 Overview

In this paper we give a brief and broad characterisation of Declarative Phonology in terms of certain key aspects, both theoretical and methodological. In Section 2 we present our identification of constraints on well-formedness with partial descriptions of phonological representations. In Section 3 we discuss the declarative model of constraint interaction and consider the consequences of the surface-oriented character of the framework. In Section 4 the relationship between universal grammar and language particular grammars is explored. Finally, in section 5 we discuss the intellectual context of Declarative Phonology and argue for greater empiricism in phonological research.

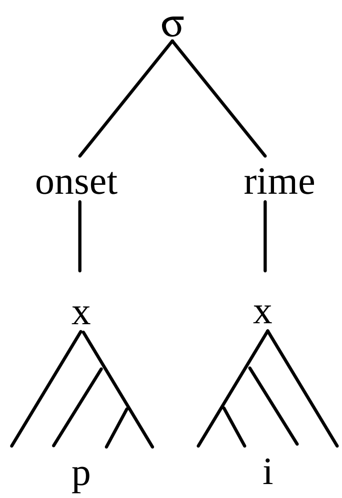
2 Constraints as partial descriptions

It is surely uncontroversial that phonology attempts to scientifically model aspects of a cognitive system and the physical system which signals it. Declarative Phonology adopts the distinction proposed by Johnson (1988) and Kaplan and Bresnan (1982) between linguistic *objects* and the formal theoretical *descriptions* of these objects. A formal description usually consists of the rules of a generative grammar (1) or particular representations generated by the rules (2).

(1) a. $\sigma \rightarrow$ (onset) rime b. rime $\rightarrow$ nucleus (coda)

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

(2)



In addition to the universal and language-wide aspects of a representation of a word or phrase are, of course, the demands of whatever morphemes happen to be involved. Their lexical entries tell us in fact a great deal about the representation. Consequently a graphical diagram like (2) will indicate all the relationships and entities necessary to model a particular phonological object, the word *pea*. Using such diagrams tends to impose a strong distinction between rules and the representations which the rules generate. It is as though lexical entries provide building bricks, which are piled up to make a tower that satisfies various rules. A three brick tower added to a two brick tower makes a five brick tower (modulo any destructive rules).

Since Declarative Phonology makes a clear distinction between the linguistic object and the formal description of that object, it adopts a *description language* suitable for all formal purposes. It is used to express rules, lexical entries and representations of all kinds: *every* element of the phonology is a description of the intended phonological object. Each statement is a *partial* description, since it only refers to a tiny characteristic of the object concerned. A partial description of the five brick tower stating ‘there are three bricks’ added to a partial description of it ‘there are two other bricks’ makes a description ‘there are five bricks’.

Independent partial descriptions can refer to the same object, so combining ‘there are (at least) three bricks’ and ‘there are (at least) two bricks, which are red’ would give ‘there are (at least) three bricks, and two of them are red’. This means there is no distinction between structure checking and structure building. A rule like ‘/a/ must be nuclear’ is often thought either to ‘build’ syllabic structure onto an underlying /a/ which lacks it, or to ‘check’ that the underlying /a/ has the structure ‘already’ — and these are supposed to be quite different conceptions. From the

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

perspective of partial descriptions the phonology is oblivious to whether or not an individual morpheme /pa/ has, as part of its lexical description, the information that there is a link from /a/ to a nucleus. The linguistic object being described is nuclear /a/: the rule ‘if /a/ then nuclear /a/’ is a partial description of it; and the lexical entry for /pa/ could include either ‘there is an /a/’ or the partial description ‘there is a nuclear /a/’. Either is a suitable partial description of the object in combination with the rule. Each is true. Obviously, a declarative lexicon cannot allow ‘there is a non-nuclear /a/’, since this partial description is not true.

It is equally valid to call these partial descriptions ‘*constraints*’. To describe a vowel as being nuclear, or round, is to constrain it to be nuclear, or round. Consequently we use both terms interchangeably.

We can define a phonological *representation* (a partial description) as the combination of these relevant constraints (partial descriptions):

- all the universal constraints,
- all the language-particular constraints,
- all the morpheme-specific constraints of the morphemes concerned.

The particular formalism chosen for the description language is not a concern of this paper, but assume it will satisfy these basic requirements: that it is internally consistent; that every statement in a language’s phonology describes a phonological object; and that every object can be so described.[1] Indeed, much research in Declarative Phonology is into suitable description languages for nonlinear phonology (e.g. Bird 1995, Bird & Klein 1994, Coleman forthcoming). The language will make use of the logical connectives (‘and’, ‘or’, ‘implies’, ‘exclusive-or’, ‘not’) to combine primitive predicate-argument structures.[2] Predicates express phonological properties such as ‘syllable(x)’ (‘x is a syllable’) or ‘$\partial(x,y)$’ (‘x dominates y’). Examples are given in (3), with possible glosses in (4).

(3)
a. $\exists x\ \text{onset}(x)$
b. $\exists xy\ \text{onset}(x) \wedge \text{rime}(y) \wedge \partial(x,\text{‘p’}) \wedge \partial(y,\text{‘i’})$
c. $\forall x\ \neg(\text{rime}(x) \wedge \partial(x,\text{‘t’}))$
d. $\forall x\ \text{onset}(x) \rightarrow \exists y\ \text{syllable}(y) \wedge \partial(y,x)$
e. $\forall vx\ \text{back}(x) \wedge \text{vowel}(v) \wedge \partial(v,x) \rightarrow \exists y\ \text{round}(y) \wedge \partial(v,y)$
f. $\exists xy\ (\partial(x,\text{‘p’}) \vee \partial(y, \text{‘p’})) \wedge (\text{onset}(x) \vee \text{coda}(y))$
g. $\forall c \exists xy\ (\text{onset}(x) \vee \text{coda}(y)) \wedge \text{cons}\ (c) \wedge (\partial(x,c) \ovee \partial(y, c))$
h. $\forall x\ \neg(\text{onset}(x) \wedge \text{coda}(x))$
i. $\exists cxyz\ \text{cons}(c) \wedge \neg\text{voiced}(x) \wedge \text{cont}(y) \wedge \text{coronal}\ (z) \wedge \partial(c,x) \wedge \partial(c,y) \wedge \partial(c,z)$

(4) a. *x* is an onset
b. /p/ is (dominated by) an onset and /i/ is (dominated by) a rime
c. no /t/ is a rime
d. every onset requires a syllable to dominate it
e. all back vowels are also round
f. /p/ is an onset, a coda, or both (i.e. a geminate)
g. all consonants are either an onset or a coda, but not both
h. onsets are not codas
i. /s/ (underspecified)

This dichotomy between rule and representation mentioned above was evident in the SPE framework, which dealt with symbols and operations on those symbols. It is also found in phonological theories using constraints. Constraints and lexical entries are seen as ontologically different. Morphemes supply parts of the representation. Parts are then removed, or other bits of representation added in order to satisfy the constraint grammar.

In Declarative Phonology, as has been indicated, lexical entries contain partial descriptions. Morphemes are constraints.[3] This is because all representations containing lexical items are licensed in part by those lexical items. A phrase using the morpheme for *pea* contains in English a partial description of a /p/, of an /i/, and of the relative sequential order of their root nodes. Typically the information in a lexical entry is existentially quantified, but not necessarily so.

All the familiar components of a phonological theory which must somehow interact are, in Declarative Phonology, the same type of partial description, stated in the description language and pooled together to constitute a ‘representation’:

- phrase structure rules
- features
- feature geometries
- lexical entries
- defaults
- linear precedence statements
- filters
- redundancy rules
- Boolean combinations of these

Different theories of phonological structure can be investigated from the declarative perspective: research has been carried out along the general

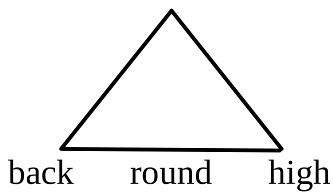
Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

theoretical lines of Articulatory Phonology (Bird 1995), Autosegmental Phonology (Scobbie 1991a; Bird and Ellison 1994), Government Phonology (Russell 1993), Lexical Phonology (Coleman 1991a, 1995), Underspecification Theory (Broe 1993), Feature Geometry (Bird 1995, Broe 1993, Scobbie 1991a), Firthian Prosodic Analysis (Coleman 1991a; Broe 1993) and Metrical Phonology (Coleman 1991ab, 1993; Walther 1992, 1993) amongst others. Declarative Phonology is a *framework* for theory construction: we do not *a priori* demand or eschew relations such as licensing or phonological government as primitives. The general approach is compatible with many variations, and it thus to be seen on a par with the breadth of a term like ‘transformational grammar’.

For example, we can bring the declarative point of view to bear on the underspecification of phonological representations (see Broe 1993 for an extensive and rather different analysis). In Declarative Phonology, partial descriptions are fundamental, and we can see ‘underspecification’ as a case simply of relatively smaller quanitites of firm information being supplied by lexical entries. A partial description of a high back vowel which may be round or unround is informally (5a).[4] A constraint might force high back vowels in certain circumstances to be /+round/ (5b). Considered *together* these constraints comprise a partial description of an object indicated in (6). Considered *independently* they are still both partial descriptions of (6).

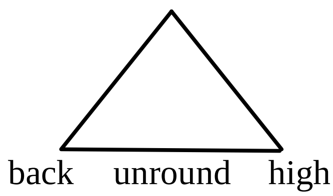
(5) a. Lexicon: $\exists\ldots$ back(x) $\wedge$ high(x) $\ldots$
b. Rule: $\forall\ldots$ back(x) $\wedge$ high(x)$\ldots \rightarrow$ round(x)$\ldots$

(6)



Considering (5a) alone, it is also a partial description of (7). Since it is a partially specified lexical entry, (5a) is able alternate between (6) and (7). (The implication (5b) is not a partial description of (7).)

(7)



Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

We need to specify somewhere in our grammar that a vowel is the sort of entity which can be /round/ or /unround/, but not /nominative/ or /animate/. The description language takes care of these ‘feature geometrical’ issues. Once we have defined a vowel to be the sort of entity that expresses rounding, we give the information in (8a) that /rounding/ means /round/ or /unround/. In other words, a vowel is ‘unspecified’ for rounding in a different way than a noun: rounding is an appropriate sort of information for a vowel, but is inappropriate for a noun. We can say that while a noun may not be specified, the vowel described in (5a)/(8b) is underspecified. The underspecification is in fact an exclusive disjunction which is part of universal grammar (8a). In effect, the vowel is *hyperspecified* as (8b) or the equivalent (8c).

(8) a. $\forall x$ rounding(x) $\leftrightarrow$ round(x) $\ovee$ unround(x)
b. $\exists\ldots$ back(x) $\wedge$ high(x) $\wedge$ rounding (x) …
c. $\exists\ldots$ back(x) $\wedge$ high(x) $\wedge$ (round(x) $\ovee$ unround(x)) …

Disjunctions like (8a) define feature geometry, and are part of UG. They can be said to define underspecification classes. Other cases of disjunction which are not part of Universal Grammar are simply suppletive. Thus a disjunctive lexical entry is not in itself an encoding of free variation or suppletion — it depends on the universal status of the disjunction.

Declarative Phonology therefore has an automatic and deeply ingrained commitment to something akin to underspecification. If it is necessary to stress the independence of this notion of underspecification from the issues raised in the debate between Radical Underspecification, Contrastive Underspecification and other models of underspecification, we can call it ‘*hyperspecification*’.

3 Constraint Interaction

The Interaction Problem is simplified in Declarative Phonology because only *constraint* interaction need be considered. Lexical entries and rules are mutually constraining. This is not a framework in which lexical entries are supplied to structure-building and evaluation modules: the phonological representation is constrained by the relevant lexical entries and the grammar-wide (and universal) constraints alike. There is no difference of kind, and so the only interaction is a mutual and symmetric one.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

The actual model of constraint interaction adopted is maximally simple: the declarative model. In such a model, all constraints must be satisfied. The procedural order in which constraints are checked (or equivalently, in which they apply) is not part of the grammar, but part of an implementation of the grammar (as a parser, say) which cannot affect grammaticality. Under this declarative interpretation, constraints must be mutually compatible. A grammar in which the order in which constraints or rules apply affects the outcome is a procedural grammar.

Absolute faithfulness to lexical entries is automatic in the partial description model. Productive phonological alternations are analysed using the partiality of the descriptions in the lexicon. The framework makes a commitment to monotonicity in that no aspect of the partial description, *once certain*, can be revoked. In consequence, destructive or transformational operations such as feature changing and deletion rules are prohibited. This guarantees a straightforward link between underlying and surface structures, as we will see.

Constraint combination (conjunction) is associative, symmetric and commutative. Consequently, extrinsic ordering is impossible in a declarative framework. This has the meta-theoretical benefit of making the statements of grammaticality neutral with respect to generation or recognition. There is no requirement that the constraint satisfaction process start with lexical entries. On the contrary, partial descriptions of the phonological object can be contributed by a phonetic perception module, and enter the constraint pool that way. There is no ordered derivation which requires to be reversed. Constraints are combined using the Boolean connectives: independent constraints are conjoined. (9a) and (9b) are therefore equivalent, as are (9c) and (9d). (From here onwards, we are leaving out variables unless they are necessary for clarity.)

(9)	a.	back $\wedge$ round	b.	round $\wedge$ back
	c.	back $\wedge$ (back $\rightarrow$ round)	d.	(back $\rightarrow$ round) $\wedge$ back

We must at this point bring up the distinction between natural language phenomena and the theoretical devices used to analyse them. The phenomena studied by the phonologists are not deletion rules, counterfeeding rule interactions, universal quantifiers, feature changing rules etc. These are aspects of our various theoretical descriptions of the objects we study. But such metaphors are strong and can be difficult to see past, particularly when there is a relatively transparent link between one of these procedural notions and the data it has been used to analyse. For example, one can become so accustomed to analyses of alternations between something and nothing being analysed as the deletion of the something, that a declarative analysis can seem remarkably novel. In fact a declarative analysis reflects a different set of intuitions: deletion phenomena are analysed formally as an alternation with zero. Phenomena for which destructive rules seem particularly attractive seem common, but in fact, many are phonetic, or are morphologised, or are, we claim, better analysed non-destructively in the phonology. See Hooper (1976), Dinnsen (1985), Bird (1995:ch. 3), Russell (1993:§3.5.5), Scobbie (1995), Coleman (1991a, this vol.) amongst many others.

The formalism underpinning Declarative Phonology is non-procedural, so in addition to extrinsic rule ordering being impossible, intrinsic 'ordering' is not an appropriate metaphor for the relationships between different constraints. It is worthwhile to see how some of the concepts of extrinsic *and* intrinsic ordering can be compared to aspects of Declarative Phonology.

3.1 Feeding

Feeding relations between rules, for example, is automatic in Declarative Phonology, not because rules apply iteratively to their own output, but because partial descriptions are conjoined, and conjunction is transitive (and symmetric). We saw that (9c) and (9d) are equivalent, and a similar equivalence holds between two implications (10a) and (10b). In either case, there is a transitivity/feeding relationship giving (10c) as true.

(10)
- a. (velar → fricative) ∧ (fricative → voiceless)
- b. (fricative → voiceless) ∧ (velar → fricative)
- c. velar → voiceless
- d. (fricative → voiceless) ∧ (velar → fricative) ∧ velar
- e. velar ∧ voiceless ∧ fricative

If the constraint pool also includes a positive specification of /velar/ (10d), this specification also 'feeds' one implication which 'feeds' the other (10e). Instead of procedural terminology like 'feed', we can say that (10d) (or equivalently (10e)) licenses or is satisfied by a representation of a voiceless velar fricative, but not a voiced velar fricative or a velar stop.

3.2 Counterfeeding

Counterfeeding, in which a feeding chain fails to materialise, is strictly impossible because of the symmetry and transitivity of conjunction. The

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

type of data which motivates counterfeeding is analysed instead in Declarative Phonology using partial specification. Underspecification theories share this solution of the counterfeeding problem. If voiceless stops weaken to voiced stops, and voiced stops weaken to fricative in the same environment, a traditional approach was to posit two phonemes /t/ and /d/, say, and two rules (11ab). A counterfeeding order (11c) was required in the SPE framework (and other frameworks not permitting simultaneous rule application) to prevent underlying voiceless stops like /t/ merging with /d/ as surface category /z/ as a result of /t/ feeding both rules.

(11)	a.	[-voice, -cont]→[+voice]	(i.e. t→d/X__Y)
	b.	[+voice, -cont]→[+cont]	(i.e. d→z/X__Y)
	c.	b << a	

In Declarative Phonology, the lexical representation of a segment would be the alternants it conditions: /t/ alternates on the surface, so its representation is the partial description of both alternants, informally (12a). Similarly, /d/ is given in (12b). Clearly, /t/ can never weaken to /z/.

(12)	a.	$t \vee d$
	b.	$d \vee z$

This isn't a weak suppletive disjunction, however. The analysis is motivated because there is a simple underspecification (hyperspecification) here. The alternating /t~d/ is partially specified for /voicing/, and /d~z/ is partially specified for /continuancy/.

3.3 Bleeding (and counter-bleeding)

Bleeding relationships between rules are interesting in a framework which employs destructive rules. If all rules were feature-filling, bleeding has less importance, because one rule cannot literally remove the context for the application of another.

Bleeding is mirrored by some aspects of disjunction. For example, an inclusive-or disjunction (such as 'feet are quantity sensitive to the rime, or to the nucleus') is satisfied by superheavy feet which have heavy rimes and heavy nuclei, but an exclusive-or disjunction (such as 'in multifooted words, strong feet are found at the left or at the right of the word') has the consequence that the satisfaction of one disjunct bleeds the other requirement.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

3.4 Intrinsic ordering and the Elsewhere Condition

Finally, in addition to the possibilities offered by the logical connectives and partial specification, we can make use of the *relative* specificity of two constraints: we can use the Elsewhere Condition. While this is often seen as a convention governing the intrinsic order of application of rules, it can be characterised as governing the omission of information from the specification of a rule. The condition usually says that only the most specific rule is applicable when either it or a more general one would apply (with incompatible results). Alternatively, the structural description of the general rule is interpreted as if it were a conjunction formed from the structural descriptions of the general rule and the negation of the structural description of the specific rule. In logical terms, the antecedent of the 'explicit' general rule is the conjunction of the antecedent of the 'implicit' general rule (the elsewhere rule) and the negation of the antecedent of the specific rule. For example, consider (13). That (13a) and (13b) fall into an elsewhere relationship can be detected by inspection solely of their informational content: the antecedent of (13a) is a more partial version of the antecedent of (13b), and their consequents are incompatible. (Thus their mutual ordering or ranking is predictable from their content.) (13a) is an elsewhere case, so we can treat it as a conventional notation for an 'explicit' general rule (13a').

(13) a. $\text{back} \rightarrow \text{round}$
b. $\text{back} \wedge \text{low} \rightarrow \neg\text{round}$
a'. $\text{back} \wedge \neg\text{low} \rightarrow \text{round}$

We derive (13a') as indicated in (14). Chains of elsewhere relations are similarly resolved.

(14) $\text{back} \wedge \neg(\text{back} \wedge \text{low}) \rightarrow \text{round}$
$\text{back} \wedge (\neg\text{back} \vee \neg\text{low}) \rightarrow \text{round}$ (De Morgan's Law)
$\text{back} \wedge \neg\text{low} \rightarrow \text{round}$ (Absorption)

One of its great theoretical benefits of (13a) over (13a') is that (13a) states the general relationship between backness and roundness. There is a countercase in (13b) to (13a), but since (13b) is more specific, the generalisation (13a) can still be made. In other words, the declarative grammar which uses (13a) and (13b) doesn't step beyond the bounds of 'intrinsic ordering'. Although these constraints are apparently ordered/contradictory, in fact they can be interpreted declaratively

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

precisely because of the non-arbitrary relationship between the formal content of each.

3.5 Deletion and epenthesis

A deletion constraint is not possible in Declarative Phonology. Deletion is usually posited in an analysis when an object with a general distribution alternates with zero in a specific environment. This impressionistic description of deletion as ‘alternation with zero’ is very similar to the declarative analysis. When a morpheme is realised as some object *d* which alternates with zero, then the lexical entry for the morpheme must have a disjunction of (d $\vee$ Ø). Following normal practice, we indicate this with parentheses: (d). Schematically then, the lexeme expresses the partial ordering of its obligatory and optional elements (15a). These constraints are equivalent to the disjunction in (15b). Another constraint (15c), more specific, bans some of the cases which (15b) describes. In other words, in (15c), B' must be more specific than B. Thus the second disjunct in (15b) is prohibited just in case B is further specified (by some independent constraint) as B'. In such a context we have the ‘deletion’ (i.e. non-appearance) of *d*. Elsewhere, the more specific disjunct in (15b), AdB, correctly decribes the appearance of *d*.

(15)	a.	A(d)B
	b.	AB $\vee$ AdB
	c.	$\neg$dB'

Of course, epenthesis is also an alternation between some object *e* and zero. In this case it is the epenthetic element which is conditioned by the more specific environment. The partial ordering of the descriptions A and B of an alternating morpheme (16a) provides the framework for epenthesis, i.e. the ‘gap’, and if the epenthetic constraint itself (16b) is fed by constraints demanding the more specific B', the appearance of *e* is correctly described by AeB'. Immediate precedence is notated as <<, and < indicates precedence.

(16)	a.	AB	(i.e. A<B)
	b.	AB' $\rightarrow$ AeB'	(i.e.A<<e<<B)

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

4 Phonology as a surface

So far we have assumed a phonological object described by a level of representation which is defined by constraints on its well-formedness. We have also referred to underlying representations and surface representations, and so now we turn to another key aspect of Declarative Phonology: it is *surface-oriented*.

Consider for a moment a phonological theory in which the underlying representation (the content of a lexical entry) is subject to well-formedness constraints. A lexical entry /ppp/ might be ruled out, whereas /bar/ would be passed. The valid underlying representations are concatenated or otherwise combined by morphology, and serve as input to the phonological rule base. There follows a derivation the output of which is a surface representation. This surface representation ought itself to be subjected to constraints on well-formedness in order that the apparently teleological behaviour of alternations be captured. Three questions arise. Are both levels necessary? What are their functions? How are they related?

The surface representation is essential: it is interpreted phonetically.

Apart from providing distinct categories for phonetic interpretation, phonology must capture the unity of morphemes rendered distinct by alternation and delimit the range of phonotactic variability. A level (i.e. a set of active constraints) is needed to reveal this underlying system.

The relationship between these two functions may be so transparent that a single representation can encompass them (surely the null hypothesis) or at the other extreme it may be entirely opaque.

The general consensus has been that underlying and surface representations are both necessary — that they *are* distinct. At the same time, the general consensus has been that they are *minimally* distinct. This imposition is made in order to reduce the remoteness of the underlying level. The more remote underlyers are, the more difficult they are to deduce from surface patterns. Moreover, rules deriving each level from the other must be given (although normally there is a skew favouring the generation of surface forms from underlying ones, but not the reverse). Minimising remoteness then is a metatheoretical imposition: a tensing of a spring that holds these levels in some kind of transparent relationship.

In Declarative Phonology, there is a very simple relation between underlying and surface aspects of phonology, due to the monotonic character of the theory: underlying forms are partial descriptions of the phonological surface. In terms of levels of representation, an underlying representation would be a set of distinct surface representations. In

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

consequence, we do not speak of underlying forms as constituting a grammatical level. Such representations are simply less constrained (more disjunctive) descriptions of the surface.

Although we do not use two levels of representation, it is uncontentious that a language's lexicon in general must be divided into arbitrary (sub)domains and that part of the structural description of many phonological rules will be a reference to the domain(s) to which it applies. In the surface-oriented Declarative Phonology, the range of categories exhibited in surface structure is basic (Figure 1). Sub-levels, or domains, of the lexicon impose 'extra' constraints only in the sense that the structural description of some constraints includes information about the lexical domain to which they apply, e.g. (17). Sub-domain A does not have a contrast between voiced and voiceless fricatives, say.

(17) $\forall f \quad \text{fricative}(f) \wedge \text{sub-domain-A}(f) \rightarrow \text{voiceless}(f)$

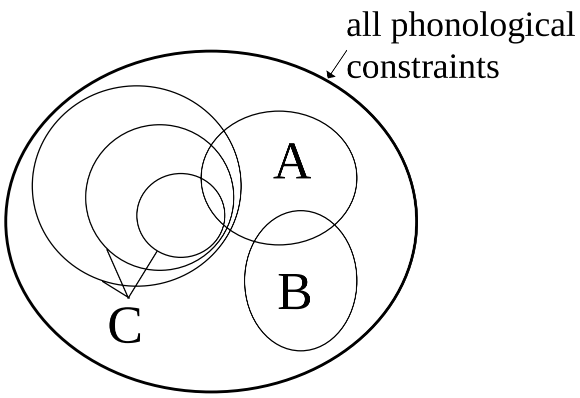


Figure 1
Non-hierarchical lexical domains

Morphemes which are defined as belonging to such a sub-domain are more *limited* in the categories used than morphemes which do not belong to it. This is a surface-oriented reinterpretation of the derivational metaphor, which loosens constraints as the derivation proceeds from a single well-defined underlying level of representation towards a rather vaguely constrained surface. We think it more likely that the limits of subdivision of the lexicon be ill-defined ones, varying from speaker to speaker (depending at least on the size, complexity, learnedness and breadth of vocabulary known to that speaker) rather than that the surface is ill-defined. An unproductive, lexicalised alternation can be learned in late adulthood and be added deep within the lexicon without any ramifications for the surface.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

In a monostratal framework, we cannot countenance the licensing of a phonological representation which would not be an acceptable underlying form. Declarative Phonology's strict structure preservation cannot be switched off within the phonology. Any geometrically complex nonlinear structure which is deemed necessary for the representation of some surface configuration would be equally at home deep in the lexicon.

For example, one configuration which is ripe for critical examination is the contour segment. Used in the analysis of affricates, prenasalised stops, contour tones and light diphthongs, this class of structure (in which a root node dominates two opposite-values features) has at best a limited contrastive utility. It may be that underlying representations would be the better for eschewing this formal class. But there is apparently less to be gained from contour segments being abandoned in surface representations, given the structure of underlying representation-oriented theories. Yet permitting contour segments (say) at the surface while not using them underlyingly again increases the remoteness of the underlying structures. In Lexical Phonology, structure preservation is switched off at the surface and 'anything goes'. This cannot be a tenable position. In Declarative Phonology, if a configuration is ruled out, it is ruled out. If contour segments are banned from the lexicon, then the data which motivates contour segments in surface representations would be predicted to be nonphonological. In fact, the type of data adduced usually comes from phonetic coarticulation (Scobbie 1995) so in fact there may be good reasons (in addition to limiting the remoteness of underlyers) for avoiding overly concrete surface representations employing contour segments.

Monostratality means that underlying representations ought not to become too abstract. In a complementary manner, surface structure is so tied to the theoretical requirements for expressing contrast that the surface cannot become overly *concrete*.

This issue is not to be confused with the interpretation of phonology: it seems obvious now that one cannot reach phonetics by adding more and more phonological detail — phonetics is akin to the semantics of the phonological description language rather than being an extension of its syntax (see for example Pierrehumbert 1990, Coleman 1992). Declarative Phonology, in common with many other theories, adopts this stance. Where we differ is in our commitment to avoiding overly concrete representations. This in turn makes declarative phonology a predictive theory. Gradient coarticulation must be phonetic. It does not admit to two alternatives, a phonetic coarticulation analysis and a phonological contour segment analysis.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

5 Universal grammar

In Declarative Phonology, Universal Grammar consists of just those constraints which are true for all languages (including ‘truth in the elsewhere case’). This includes rather obviously the substantive universals like the list of distinctive features or elements and the configurations they can occur in. In addition are basic definitions of the syntax and semantics of the description language, including primitives such as dominance, association, precedence and the like. Traditionally universals have been stated as conditionals or as schematic templates and this approach is adopted here. Rather than treating universals as being violated by particular languages, they are stated as implications or disjunctions (i.e., universals may be explicitly parameterised).

Examples of universal constraints are given in (18). (18a) is a statement of onset licensing, part of prosodic licensing generally, which states that all onsets must be dominated by a syllable. (18b) is also part of prosodic licensing, but makes the stronger constraint that syllables must have rimes in addition to rimes necessarily being dominated by syllables. (18c) states that given a tautosyllabic onset and rime, the onset must immediately precede the rime. (18d) is a parametrised metrical universal, an exclusive disjunction between heavy-initial and heavy-final disyllabic feet.

(18) a. $\forall y\ \mathrm{onset}(y) \rightarrow \exists x\ \mathrm{syllable}(x) \wedge \partial(x,y)$

b. $\forall x\ \mathrm{syllable}(x) \leftrightarrow \mathrm{rime}(y) \wedge \partial(x,y)$

c. $\forall xyz\ \mathrm{onset}(x) \wedge \mathrm{rime}(y) \wedge \mathrm{syllable}(z) \wedge \partial(z,x) \wedge \partial(z,y) \rightarrow x < y$

d. $\forall z \exists xy\ \mathrm{foot}(z) \wedge \partial(z,x) \wedge \partial(z,y) \wedge (\mathrm{heavy}_\sigma(x) < \mathrm{light}_\sigma(y) \oslash$
$\mathrm{light}_\sigma(x) < \mathrm{heavy}_\sigma(y))$

In (19) are language particular constraints which are conjoined with the universal constraints in the languages which make use of them. In addition to universal aspects of syllable onsets (18a), individual languages make their own demands. (19a) states that all syllables have an onset, and the weaker alternative (19b) that any element immediately preceding a rime must be an onset. (19b) permits onsetless syllables initially in whichever prosodic phrase is the domain of syllabification. (19c) is a shorthand for a featural redundancy rule, and (19d) is the setting of the universal parameter in (18d), forcing disyllabic feet to be right-stressed.

(19) a. $\forall x\ \mathrm{syll}(x) \rightarrow \exists y\ \mathrm{onset}(y) \wedge \partial(x,y)$

b. $\forall xy\ \mathrm{rime}(y) \wedge x<y \rightarrow \mathrm{onset}(x)$

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

c. $\ldots\ \mathrm{velar}(x) \rightarrow \neg\mathrm{sonorant}(x)$

d. $\forall z \exists xy\ \ldots\ \mathrm{light}_\sigma(x) < \mathrm{heavy}_\sigma(y)$

Finally, the lexical entries contribute their constraints. As well as simple positive specifications of existence — which may be underspecified for featural content or linear order (20a) — prosodic information can be included. (20b) says that a particular word's first syllable is onsetless, as might be required in an analysis of French h-aspiré. (The first vowel is ultimately dominated by a syllable node which may not dominate an onset.) One other type of partial specification that needs to be included in some lexical entries pertains to alternations between a segment and zero. As discussed, such an alternation may not be expressed as a deletion, and we explicitly express such an alternation as a disjunction. In the case of (20c), the optional phantom consonant must be dominated by an onset.

(20) a. $\exists\ldots\ \mathrm{cons}(x) \wedge \mathrm{vowel}(y) \wedge x \ll y\ \ldots$

b. $\exists\ldots\ \mathrm{vowel}(v) \wedge \mathrm{leftmost}(v) \wedge \partial^*(x,v) \wedge \mathrm{syllable}(x) \wedge \partial(x,y) \wedge \neg\mathrm{onset}(y)$

c. $\exists\ldots\ ((\mathrm{cons}(t) \wedge \partial(x,t) \wedge \mathrm{onset}(x))\ \ovee\ \varnothing)$

6 Antecedents to Declarative Phonology and the role of phonology as a part of the wider analysis of sound systems

To get an accurate picture of Declarative Phonology, it is important to look at the research traditions that have led to it, and the research methodology its practitioners follow. The theoretical linguistic influences are twofold: non-linear phonology and non-transformational grammar.

On the first topic we see Declarative Phonology as following firmly in the tradition of representation-oriented research that exploded in the mid 1970s (e.g. Scobbie 1991b). Non-segmentalism is one crucial aspect of Declarative Phonology research, both because the move away from an alphabetic phonology to a richly tiered and constituentised one has had amazing empirical benefits, but also because of the need to resolve the novel formal demands stemming from such representations. And of course, there is the ever-present and increasing interest in constraints on representations, which in the earlier nonlinear tradition were expressed as various *ad-hoc* formal proposals, such as syllable templates, association conventions, conditions on locality, filters, licensing statements, feature

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes). European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

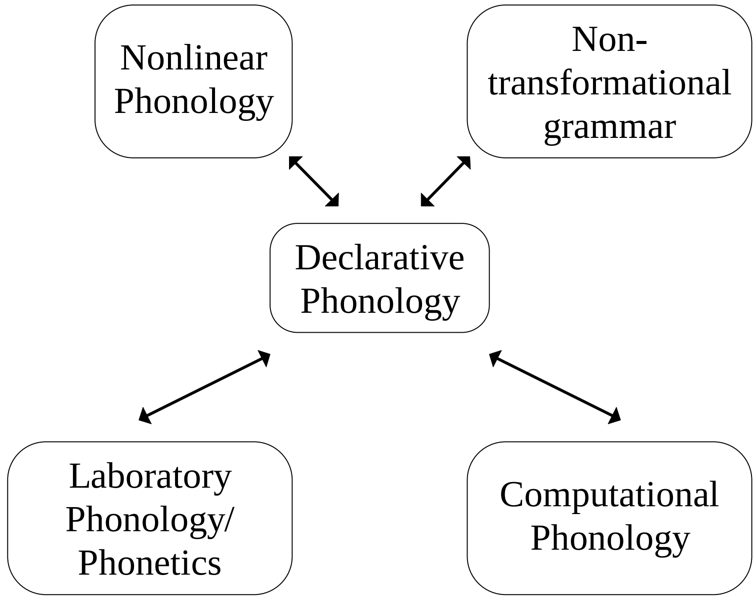


Figure 2
Declarative Phonology in context

co-occurence conditions, etc. Non-linear representations also enabled morphemes which appeared to condition processes of mutation, umlaut, etc. to be presented as simple content morphemes (albeit morphemes which are highly underspecified and/or floating) rather than as process morphemes. By using partial descriptions, this dichotomy between item-and-arrangement and item-and-process is rendered null (in favour of item-and-arrangement). Since a rule is viewed as a universally quantified and highly partial representation, it is not surprising then that much declarative research can draw explicitly on the insights and methods of Firthian Prosodic Analysis (see Broe 1993; Coleman 1991a).

On the second topic, Declarative Phonology is very strongly influenced by the insights of non-transformational grammar. On one hand, this encompasses work in phonology which generally predated the interest in nonlinear representations, and was concerned with the meta-theoretical undesirability of extrinsic rule ordering or the use of well-formedness constraints within a segmental framework. Here we might cite Shibatani (1973), Koutsoudas et al. (1974) and Hooper (1976). On the other hand, non-transformational research in syntax had much greater and lasting effect. The development of unification-based theories such as GPSG (Gazdar et al. 1985) was very important in the development of Declarative Phonology because they demonstrated in an empirically and theoretically satisfying manner the possibility of eschewing destructive operations and extrinsic ordering. They also provided a great deal of ground work in the development of formal devices and techniques which were then available

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

for the analysis of phonological phenomena. Important too are previous systheses of such concerns, such as Wheeler (1981; 1988).

So we adopt and incorporate many aspects of such formal theoretical work as part of our view of theoretical phonology. In consequence the theoretical work is often concerned with logical treatments of nonlinear phonological structures.

There are two other spheres of influence which are highly significant to research in this area, and though they lie outside the strict core of theoretical phonology, both interface with it, and are essential parts, we would argue, of any research paradigm into sound systems: phonetics and computational linguistics. Specifically we are concerned with the interfaces, so more accurately we address here Laboratory Phonology and Computational Phonology.

In pursuing a research programme which adopts a limiting (i.e. predictive) formal phonology, data sometimes appears to offer counterexemplification of the theory. Such data, though only a tiny part of the content of any language's phonological patterns, occupies the majority of the theoretical literature, with good reason. The testing data is the important data. If a theoretical development can handle this data, it ought to be adopted. We should not lose sight of two important assumptions here, however. The phonologist is allowed to ignore the bulk of the data on the grounds that it is non-problematic on the proviso that this common or garden material can in fact still be analysed. In fact, this assumption is rarely confirmed. More on this topic follows below. Meantime, consider the second assumption, that the interesting, problematic data is valid phonological data in the first place.

It is unarguable that among the sound system alternations that languages evince are suppletive alternations and phonetic alternations — the problem for phonological theory is to predict that a given alternation is not phonological, but belongs instead to one of these other domains.[5] A powerful theory can analyse more data, but this is not necessarily a benefit. Laboratory Phonology (see for example Pierrehumbert et al this vol.) as a paradigm of research can be interpreted as attempting to uncover experimentally whether critical phonological data is indeed phonological, or phonetic. Given explicit implementations of phonetic parameters, it may be that particular cases of neutralisation, deletion, metathesis, epenthesis, umlaut, harmony, assimilation, etc., are more satisfyingly analysed using these parameters. Part of the methodology of Declarative Phonology is to undertake such research (e.g. Coleman 1991a, 1992, 1995, this vol., Scobbie et al. 1995, Bird & Stegen 1993). In particular, by arguing that

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

would-be phonological transformations are in fact suppletive or phonetic, the one-level view of phonology is made tenable.

It is also crucial that phonological theories can be demonstrated to actually account for the data that they are designed to illuminate and explain. Such a minimal requirement is rarely adhered to in practice, but more worryingly, the level of formalisation and commitment to testing of conventional grammars against corpora is so weak that it is unlikely that any such test would be a trivial task. Given the increased computerisation of language resources and the development of on-line corpora of reasonable size, in the future we can expect much more testable phonological theories. To be tested computationally, a grammar must be implementable, and in Declarative Phonology not a little thought is given to the implementation of the grammars whether for corpus testing against alphabetic corpora, as an implementation of a nonlinear theory, as input to a synthesiser, or for the machine learning of phonological generalisations (e.g. Bird 1995; Bird & Ellison 1994; Coleman 1991b, 1995, this vol.; Ellison forthcoming). This is not to say that there is any confusion between grammar and implementation. On the contrary, it is likely that a solid separation and parallelism of research is more likely to keep questions of grammaticality away from implementational issues.

7 Conclusion

In this paper we have given a brief and broad picture of Declarative Phonology, characterising the key aspects of the framework and the way in which they form a coherent whole. Obviously it is impossible to offer full comparisons with other phonological theories (though see Scobbie 1993 for some discussion). Our approach, therefore, has been to concentrate on characterising one perspective. In brief, we support (21).

(21) **The Declarative Hypothesis**: the unordered declarative interaction of partial descriptions delimits the class of truly phonological structures and rules.

Such a phonology cannot typically handle all the known sound system generalisations contained in the grammar of a language in the same way. There will be a properly phonological core, of course. Peripheral phenomena will require morphological conditions or be phonetic. We think it is a great empirical advantage of the theory that it can make predictions in this way.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

Declarative Phonology aims to be the core of an empirical theory of sound systems. Phonetic interpretation plays a crucial part of the analysis of some familiar phenomena. Morphophonemic phenomena are predicted to use mechanisms other than conjunction and underspecification. Getting the balance right between these areas is crucial, and in many ways is the core problem of the field. Central to any phonological research programme are: the computational implementation of grammars; the testing of grammars computationally against data from large corpora; the testing of data empirically with phonetic studies and informant work; and the phonetic implementation of the phonological representations proposed. Phonological theories need to be restrictive enough to make predictions about data.

NOTES

* Our thanks are due to Jacques Durand and Bernard Laks for organising the excellent meeting at Royaumont and to the other participants at that conference. This paper has benefitted from comments by Jacques Durand and Carole Paradis, and any errors remaining are our own responsibility. In this short review paper we have not attempted to cite representatively from the Declarative Phonology literature. See Bird (1995) and other references mentioned in the text for a more representative survey.

[1] This may include the abstract null object.

[2] The relationship between partial description and linguistic object must make full use of the logical connectives: a description like '¬p' refers to all those objects which are not '*p*' but to no object which is '*p*'; a description like 'p→q' refers to all those objects which are '*q*' or are not '*p*', but to no object which is '*p*' without also being '*q*', etc. In this way rules can be stated. For example, the constraint '¬p' prevents there being any other constraint demanding 'p' (which is a little like a filter), and the constraint 'p→q' is equivalent to all cases of 'p' being 'p∧q' instead (which is a little like a structure-building or structure-checking rule).

[3] This is a fundamental characteristic of the approach, with far-ranging effects. The similarities with the proposals in Kiparsky (1982ab) permitting lexical entries to enter into 'elsewhere' relationships with rules remain to be fully explored.

[4] We omit irrelevant aspects of the constraints. In particular, note that statements of the kind 'back(x) $\wedge$ high(x)' or 'back $\wedge$ high' are short for the more explicit '$\exists vxy$ vowel(v) $\wedge$ $\partial(v,x)$ $\wedge$ $\partial(v,y)$ $\wedge$ back(x) $\wedge$ high(y)'.

[5] The same is true of phonotactic patterns.

REFERENCES

Beckman, Mary E. (ed.) (1990). *Phonetic representation.* Theme issue of *Journal of Phonetics* **18**. 297-480.

Bird, Steven (ed.) (1991). *Declarative perspectives on phonology*. Edinburgh Working Papers in Cognitive Science, Vol. 7. Centre for Cognitive Science, University of Edinburgh.

Bird, Steven (1995). *Computational phonology: a constraint-based approach.* Cambridge: Cambridge University Press.

Bird, Steven, John S. Coleman, Janet B. Pierrehumbert & James M. Scobbie (1992). Declarative phonology. In A. Crochetière, J.-C. Boulanger & C. Ouellon (eds.) *Proceedings of the Fifteenth International Conference of Linguists*. Québec: Presses de l'Université Laval.

Bird, Steven & T. Mark Ellison (1994). One level phonology: autosegmental representations and rules as finite-state automata. *Computational Linguistics* **20**. 55–90.

Bird, Steven & Ewan E. Klein (1994). Phonological analysis in typed feature systems. *Computational Linguistics* **20**. 455–491.

Bird, Steven & Oliver Stegen (1993). Tone in the Bamileke Dschang associative construction: an electrolaryngraphic study and comparison with Hyman (1985). Research Paper EUCCS RP-57, University of Edinburgh, Centre for Cognitive Science.

Bresnan, Joan (ed.) (1982). *The mental representation of grammatical relations.* Cambridge, Mass.: The MIT Press.

Broe, Michael (1993). *Specification theory: the treatment of redundancy in generative grammar.* PhD dissertation, University of Edinburgh.

Clayton, Mary L. (1976). The redundancy of underlying morpheme structure conditions. *Language* **52**. 295–313.

Coleman, John S. (1991a). *Phonological representations*. PhD dissertation, University of York.

Coleman, John S. (1991b). Prosodic structure, parameter-setting and ID/LP grammar. In Steven Bird (1991). 65–78.

Coleman, John S. (1992). The phonetic interpretation of headed phonological structures containing overlapping constituents. *Phonology* **9**. 1–44.

Coleman, John S. (1993). English word-stress in unification-based grammar. In T. Mark Ellison and James M. Scobbie (1993). 97–106.

Coleman, John S. (1995). Declarative lexical phonology. In Jacques Durand & Francis Katamba (1995). 333–383.

Coleman, John S. (this vol.). Declarative syllabification in Tashlhit Berber.

Coleman, John S. (forthcoming). *Phonological representations.* Cambridge: Cambridge University Press.

Connell, Bruce & Amalia Arvaniti (eds.) (1995). *Phonology and phonetic evidence. Papers in Laboratory Phonology IV*. Cambridge: Cambridge University Press.

Dinnsen, Daniel A. (1985). A re-examination of phonological neutralisation. *Journal of Linguistics* **21**. 265–279.

Durand, Jacques & Francis Katamba (eds.) (1995). *Frontiers of phonology: atoms, structures, derivations.* London: Longman.

Ellison, T. Mark (forthcoming). *The machine learning of phonological structure*. Cambridge: Cambridge University Press.

Ellison, T. Mark & James M. Scobbie (eds.) (1993). *Computational phonology*. Edinburgh Working Papers in Cognitive Science, Vol. 8. Centre for Cognitive Science, University of Edinburgh.

Gazdar, Gerald, Ewan Klein, Geoff Pullum & Ivan Sag (1985). *Generalised Phrase Structure Grammar.* Oxford: Blackwell.

Hooper, Joan (1976). *An introduction to natural generative phonology.* New York: Academic Press.

Hulst, Harry G. van der & Norval S.H. Smith (eds.) (1982). *The structure of phonological representations.* 2 parts. Dordrecht: Foris.

Johnson, Mark (1988). *Attribute-value logic and the theory of grammar*. Stanford: CSLI, Stanford University.

Kaplan, R.M. & Joan Bresnan (1982). Lexical-Functional Grammar. In Joan Bresnan (1982). 173–281.

Kiparsky, Paul (1982a) From cyclic phonology to lexical phonology. In Harry G. van der Hulst & Norval S.H. Smith (1982: part 1.). 131–175.

Kiparsky, Paul (1982b) Some consequences of Lexical Phonology. In I.-S. Yang (ed.) *Linguistics in the morning calm.* Seoul: Hanshin. 3–91.

Koutsoudas, A., G. Sanders & C. Noll (1974). The application of phonological rules. *Language* **50**. 1–28.

McCarthy, John J. & Alan S. Prince (1993). Prosodic morphology I. Constraint interaction and satisfaction. Ms, University of Massachusetts at Amherst and Rutgers University.

Oehrle, Richard T., Eamon Bach & Deirdre W. Wheeler (eds.) (1988). *Categorial grammars and natural language structures.* Dordrecht: Reidel.

Paradis, Carole (1988) On constraints and repair strategies. *The Linguistic Review* **6**. 71–97.

Paradis, Carole (this vol.). The inadequacy of filters and faithfulness in loanword adaption.

Paradis, Carole & Darlene LaCharité (eds.) (1993). *Constraint-based theories in multilinear phonology*. Special issue of *Revue canadienne de linguistique/Canadian Journal of Linguistics* **38**. 127–303.

Paradis, Carole & Jean François Prunet (1993). On the validity of morpheme structure constraints. In Carole Paradis & Darlene LaCharité (1993). 235–256.

Pierrehumbert, Janet (1990). Phonological and phonetic representation. In Mary E. Beckman (1990). 375–394.

Prince, Alan S. & Paul Smolensky (1993). Optimality Theory: constraint interaction in Generative Grammar. Technical Report RuCCS TR-2 Rutgers Center for Cognitive Science, Rutgers University.

Russell, Kevin (1993). *A constraint-based approach to phonology and morphology.* Revised version of PhD dissertation, University of Southern California.

Scobbie, James M. (1991a). *Attribute Value Phonology*. PhD dissertation, University of Edinburgh. Distributed by the Centre for Cognitive Science, University of Edinburgh.

Scobbie, James M. (1991b). Towards Declarative Phonology. In Steven Bird (1991). 1–26.

Scobbie, James M. (1993). Constraint violation and conflict from the perspective of Declarative Phonology. In Carole Paradis & Darlene LaCharité (1993). 154–168.

Scobbie, James M., William J. Hardcastle, Paul Fletcher & Fiona Gibbon (1995). Consonant clusters in disordered L1 acquisition: a longitudinal acoustic study. *Proceedings of the X11th International Congress of Phonetic Sciences.* Stockholm, Sweden. Vol. 2, 706–709.

Scobbie, James M. (1995). What do we do when phonology is powerful enough to imitate phonetics? Comments on Zsiga. In Bruce Connell & Amalia Arvaniti (1995). 303–315.

Shibatani, Masayoshi (1973). The role of surface phonetic constraints in Generative Phonology. *Language* **49**. 87–106.

Walther, Markus (1992). *Deklarative silbifizierung in einem constraintbasierten grammatikformalismus.* Master’s dissertation, University of Stuttgart.

Walther, Markus (1993). Declarative syllabification with applications to German. In T. Mark Ellison and James M. Scobbie (1993). 55–79.

Current Trends in Phonology: Models and Methods. (1996) Jacques Durand and Bernard Laks (eds.) (2 volumes).
European Studies Research Institute (ESRI), University of Salford: Manchester UK. Volume 2: 685-709.

Wheeler, Deirdre W. (1981). *Aspects of a categorial theory of phonology*. PhD thesis, University of Massachusetts at Amherst.

Wheeler, Deirdre W. (1988). Consequences of some categorially motivated phonological assumptions. In Richard T. Oehrle, Eamon Bach & Deirdre W. Wheeler (1988). 467–488.