

Outstanding issues and future prospects in Rule-Based Phonology

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Abstract

This chapter surveys some of the main predictive differences between rule- and constraint-based formalisms that have taken center stage in work on Rule-Based Phonology (RBP) since 1993. In addition to the familiar cases of conspiracies (argued to favor Optimality Theory (OT)) and opacity (argued to favor RBP), we review unnatural processes, morpheme structure constraints, and local (as opposed to global) process interactions. We then turn to the larger question of the extent to which naturalness and markedness should be encoded in the phonological component of Universal Grammar, which is in principle orthogonal to the rules vs constraints debate but in practice divides proponents of RBP (many of which support some form of Substance-Free Phonology (Hale and Reiss 2008) and/or Evolutionary Phonology (Blevins 2004)) from supporters of Classic OT (in which substance-based markedness plays a central role in UG). Finally, the chapter identifies prospects for future exploration of language in non-auditory modalities and acquisition as a window into more abstract properties of phonological and general computation, and outlines a possible cross-over between rationalist and empiricist phonological perspectives involving models using information theory and/or Bayesian probability.

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Key Words

Austronesian, Indonesian, Malay, Toba Batak, Kaingang, Mandar, Quechua, Umbundu, Si-Luyana, Konjo, Yokuts, Spanish, Hebrew, English, Lithuanian, Armenian, Japanese, Greek, Mongolian, Ganda, Shona, Abkhaz opacity, crazy rules, morpheme structure constraints, locality, globality, Optimality Theory, OT-CC, Rule-Based Phonology, Lexical Phonology, Natural Phonology, blocking, cross-derivational feeding, markedness, language acquisition

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1. Introduction

The term “Rule-Based Phonology” (RBP) has been employed since at least Kaye 1988 as a cover term for phonological theories that derive surface representations from underlying representations via a set of (typically

ordered) rules, including not only what McMahon 1992 and others term “Standard Generative Phonology” (Chomsky 1951; Chomsky, Halle, and Lukoff 1956; Halle 1959, 1962; Chomsky and Halle 1968; Kenstowicz 1994) but also offshoots including Natural Phonology (Stampe 1969, 1972) and Lexical Phonology (Kiparsky 1982, 1985). Since 1993 the term “Rule-Based Phonology” has primarily been employed to represent the standard generative alternative to Optimality Theory, and this is what we concentrate on in this chapter.

RBP shares with Government Phonology (Kaye, Lowenstamm, and Vergnaud 1985, Kaye 2000, Scheer 2004, 2012; see also this volume, chapters 9-11) a rationalist perspective emphasizing formal parsimony and the role of reason in grammar. This perspective sets these theories in opposition to the more empiricist and functionalist orientations of much work in Optimality Theory (OT), Connectionism, Usage-Based Phonology, Probabilistic Phonology, Laboratory Phonology, and Articulatory Phonology.

Work in RBP in the 1960s/70s and the 1980s tended to revolve around the nature of rules and of representations respectively, but beginning in 1993 the focus of work in RBP shifted away from these to issues raised by OT: Do we need constraints on underlying representations? Is more than one stratum of phonological computation required? Does the phonological component of the grammar employ just rules (Reiss 2008), just constraints (Prince and Smolensky 2003), or both (Calabrese 2005)? Are phonological configurations evaluated locally, or globally (Embick 2010)? More generally, as Anderson (2010) observes, “theoretical discussion in phonology since [the] introduction [of descriptions in constraint-based terms] has been largely dominated by comparisons of the two frameworks.”

For reasons of space, we lay aside many issues that are of relevance to both RBP and OT but crosscut the two, such as features vs. gestures, feature geometry, alpha notation, the construction and content of underlying representations, the cycle, the Phase Impenetrability Condition, interlanguage effects, and underspecification. In section 2, we concentrate on *predictive differences* between rule- and constraint-based formalisms, following David Pesetsky’s aspirational (2013) comment that “most of what [linguists] *do* for a living is discover puzzling linguistic phenomena [...] and try to explain them by evaluating competing proposals that make distinguishable

predictions about the phenomena in question”. In Section 3, we address a debate relevant to both RBP and OT; namely, the question of the content of Universal Grammar. In Section 4 we discuss future prospects, including a possible cross-over between the rationalist and empiricist perspectives is models using information theory and/or Bayesian probability. Section 5 is a brief conclusion.

2. Predictive differences between rule- and constraint-based formalisms

When setting out to identify predictive differences between RBP and OT, one encounters at least two potential hurdles. First, some phonologists have suggested that rules and constraints are logically intertranslatable, and more generally that RBP and OT boil down to notational variants of a single generative framework (for variants of this position see Karttunen 1998, Mohanan 2000, and Nevins 2007; see also section 5 of Odden 2008 for discussion of the philosophical and computational issues involved, and McCarthy 1998 for the claim that rules can be thought of as equivalent to a pairing of a markedness constraint with a faithfulness constraint). If rule- and constraint-based formalisms are logically intertranslatable, one might expect there to be no predictive differences between the two. Arguably, though, comparison of *specific instantiations* of RBP or OT (such as the SPE model (Chomsky and Halle 1968) or Classic OT (Kager 1999) respectively) does turn up predictive differences, as we shall see later in this section.

The second hurdle when searching for predictive differences between RBP and OT involves an argument sometimes made by proponents of OT in response to the identification of problematic predictions in specific instantiations of the theory. This argument tends to take something like the following form: “Scholar X suggests that OT, by virtue of property Y of the theory, incorrectly predicts the impossibility of attested linguistic phenomenon Z. This is not in fact a problem for OT per se, which consists of nothing more than the proposal that grammars are rankings of a universal,

violable set of constraints CON¹. Property Y may be a component of *Scholar A's implementation of OT*, but is not a property of OT.”

A stripped-down version of OT of the sort just described makes no testable predictions, though, and hence is not a scientific theory. As Moreton (1999:5) puts it, “the claim that every natural-language grammar can be computed by some constraint-hierarchy grammar is [...] an empty one. We already know it to be true, since it rules nothing out. [The d]efinition [of a grammar as a ranked set of constraints acting on candidate outputs generated from an input by GEN] provides a framework or notational device, rather than a theory of language. If we want falsifiable predictions, we will have to constrain G[EN] and C[ON].”

Practitioners of OT typically augment GEN and CON with entities such as EVAL, Richness of the Base, parallelism, strict domination, Lexicon Optimization, and the rest of what is normally called “Classic OT”, as set out in Kager 1999, and it is this more fleshed-out form of OT whose predictions we will be discussing in this chapter.² The form of RBP to which it is compared is the one described by Kenstowicz (1994), which assumes that the surface representation of the morphemes in a sequence is derived from their underlying representations by the application of a series of ordered rules. These rules may be subject to the cycle, Structure Preservation, the Derived Environment Condition, and inviolable constraints on underlying and surface representations such as the Obligatory Contour Principle.

¹ Cf. McCarthy 2000:149, “the central thesis of OT is that a grammar is a language-particular ranking of violable, universal faithfulness and markedness constraints”.

² The generalized form of OT evaluated here, following Vaux (2008:30-31, fn 11), represents our best attempt “to capture what [is] essential to the [theory], eliminating the inconsistencies and the debilitating unclarity of the various approaches that are developed in the literature. As an interpretation, it might be incorrect; but to reject attempts at such interpretation is pointless, since the only alternative is to reject what exists as inconsistent and vague, overlooking the important insights embedded in it.” (Chomsky 1967:110).

Comparison of RBP and OT has thus far been socio-politically inconclusive, in the sense that neither camp has conceded the intellectual high ground to the other. Supporters of OT generally consider conspiracies and the Duplication Problem to pose fatal problems for RBP, while supporters of RBP find these arguments unpersuasive and see insuperable flaws in the OT framework. Some even maintain that the rise of OT has precipitated a decline in the field; as Wauquier, Scheer, and van Oostendorp (2015) put it, “the theory that dominated the field since the early 90s, Optimality Theory, rapidly loses velocity and is progressively dissolving. The vacuum that this movement has already created and continues to produce is typically engaged by approaches which have little theoretical substance”. Nevertheless, one can say that the rise of OT as an alternative to RBP has at least had the positive effect of raising issues that were not previously on phonologists’ radars, such as overapplication in reduplication (McCarthy and Prince 1999:290) and Counterfeeding from the Past (Wilson 2006, Wolf 2010).

In this section we examine predictive differences adduced in the literature as arguments in favor of OT (2.1) or RBP (2.2), focusing for reasons of space on the most-discussed cases, conspiracies and opacity. We try moreover to advance the debate by considering ways in which these arguments have been or might be responded to, and problems that they raise.

2.1. Predictive differences suggested to favor OT

Though practitioners of OT do not generally consider RBP as something that needs to be argued with in any depth (Scheer 2010:195, 2013/to appear), when discussing the paradigm shift from RBP to OT they often refer to two predictive differences believed to favor OT over RBP, involving conspiracies and the Duplication Problem respectively. The latter has been addressed in detail by Paster (2013), who argues that the diachronic origins of alternations and lexical patterns explain the frequent cooccurrence of productive alternations and seemingly related static generalizations about underlying forms, such that the relation between the two does not necessarily have to be formally captured in the synchronic grammar. We therefore focus here on conspiracies.

2.1.1. Conspiracies

It is commonly argued that OT improves upon RBP by providing an explanatorily superior account of conspiracies. As McCarthy (1999) states, “compelling examples of homogeneity of target/ heterogeneity of process tend to support constraint-based over rule-based theories” (cf. Kager 1999:56, Pater 2001:161, Hayes 2004:165). The alleged problem raised by conspiracies for RBP is usually formulated as follows. Kisseberth (1970) noted that in many languages one could observe different rules whose action systematically ensured that a certain output configuration never surfaces. Because rules are independent grammatical processes formulated by the linguist (and, by hypothesis, the Language Acquirer) in accordance with the data, there is no way in RBP (by which he meant SPE, which contained no constraints of the relevant sort) to express the apparent “functional unity” of such rules in the synchronic grammar. In Lombardi’s words (2001:13), “in a theory where phonological rules specify both context and change, as in SPE and much work following it, it is not possible to account for this asymmetry of patterns except by stipulation.”

Optimality Theory is often argued by its proponents to offer a solution to this problem (see for example McCarthy 2002; Kager 1999). Because grammatical processes in OT result from the interplay of ranked constraints rather than having any independent existence, OT allows for the “functional unity” of conspiratorial processes to be “factored out” (in Kisseberth’s 1970 terms) from the processes themselves. This separation of target from repairs is effected as follows:

- The “functional unity” of a set of rules and/or constraints is captured by the fact that the avoided configuration is punished by a single markedness constraint—what McCarthy (2002:93) terms “homogeneity of target”.
- The nature of the repair will depend on (i) the ranking of the other constraints in the grammar—thus cross-linguistic “heterogeneity of repair” (McCarthy 2002:93) is accounted for; and (ii) the particular environment that a particular marked configuration appears in—some repairs might be good in one situation and less so in another. Hence “heterogeneity of repair” within a language is potentially explicable as well.

2.1.1.1. The putative *NÇ Conspiracy

A famous case study of a conspiracy from the OT literature is Pater's (1996) discussion of the proposed *NÇ constraint in Austronesian languages. Pater begins by observing the case of nasal substitution from the paradigm of the Indonesian prefix *məN-* (on which see also Halle and Clements 1983:125). Where this prefix is added to root with an initial voiceless stop, the nasal disappears and the stop is replaced by a homorganic nasal (1a). If the root begins with a voiced stop, the nasal assimilates to the place of the stop and there is no deletion (1b). However, combinations of nasals and voiceless stops inside a root are not affected by this process (1c) (Pater 1996:2, his (1)):

- | | | | | |
|-----|----|---------------|-------------|----------------------|
| (1) | a. | /məN + pilih/ | məmilih | 'to choose, to vote' |
| | | /məN + tulis/ | mənulis | 'to write' |
| | | /məN + kasih/ | məŋasih | 'to give' |
| | b. | /məN + bəli/ | məmbəli | 'to buy' |
| | | /məN + dapat/ | məndapat | 'to get, to receive' |
| | | /məN + ganti/ | məŋanti | 'to change' |
| | c. | əmpat 'four' | untuk 'for' | muŋkin 'possible' |

Pater points out that a variety of processes in Austronesian languages and in the world's languages more generally are similar to nasal substitution in that they eliminate an NÇ cluster—these include denasalization, post-nasal voicing and nasal deletion. Pater identifies this as a conspiracy to avoid NÇ configurations, and proposes to capture it as follows. The “functional unity” of these processes is explained by positing a *NÇ constraint. A range of faithfulness constraints militate against each of the imaginable repairs for the NÇ configuration, and their ranking determines which repair surfaces in a given language or phonological context.

Nasal substitution (as seen in Indonesian in (1)) is analysed as Fusion, a process whereby two adjacent segments merge into one. Under the Correspondence theory of Input-Output relations (McCarthy and Prince 1994), Fusion does not violate MAX constraints, which punish wholesale deletions. However, it does violate LIN(EARITY), which requires the linear

order of output segments to be faithful to the order in the input³. Hence, a language where NÇ configurations are eliminated by Fusion can be derived by ranking LIN below *NÇ, and by ranking the constraints that punish other repairs above *NÇ.

(2) nasal substitution (cf. Pater 1996 figure (7))

/məN + pilih/	other FAITH	*NÇ	LIN
✓ [məmilih]			*
[məmpilih]		*!	

Two other possible repairs for *NÇ are segmental deletion and insertion. The relevant constraints in these cases are DEP and MAX. Beginning with deletions, there is a curious generalisation that the nasal is always eliminated in this configuration, never the obstruent. Pater points out (p.14) that no satisfactory explanation for this is known⁴. The Kelantan dialect of Malay is an example of a language of this sort. The following tableau illustrates how this result is derived (Pater 1996:15, his (10)):

(3) tableau for Kelantan-like languages

/NT/	*NÇ	OBSMAX	NASMAX
[NT]	*!		
[N]		*!	
✓ [T]			*

It seems that no known language repairs *NÇ violations via epenthesis, a gap that is not predicted by Pater's factorial typology.

3 LIN therefore also punishes metathesis.

4 However, he conjectures that “a fixed ranking of OBSPLACE IDENT >> NASPLACE IDENT” may be behind the generalisation. See below for a general critique of such importations of typological markedness hierarchies into synchronic constraint rankings, which are a commonplace of the OT literature (e.g. Prince and Smolensky 1993 on sonority constraints), and for an alternative approach.

A third option is to denasalize the offending nasal. This is what happens in Toba Batak, Kaingang and Mandar, as illustrated here for the latter (Pater 1996:16, his (11)):

(4) Mandar maN- prefixation

- a. /MaN + dundu/ mandundu 'to drink'
- b. /MaN + tunu/ mattunu 'to burn'

Denasalization is effected via deletion of a [nasal] feature⁵. Such feature elimination is punished by IDENT(ITY) constraints. Languages like Mandar can thus be derived by ranking the IDENT[nasal] constraint below *NÇ, with all other relevant Faithfulness constraints above *NÇ (Pater 1996:20 his (16)):

(5) Mandar denasalization

/maN-tunu/	DEP	MAX	LIN	*NÇ	IDENTNAS
[manunu]			*!		
[mantunu]				*!	
✓[mattunu]					*
[matunu]		*!			
[majatunu]	*!				

A fourth option is to voice the obstruent. Pater's illustration of this repair comes from Puyo Pungo Quechua (p.21, his (17)), where the voicing process occurs only in derived environments⁶ (root-internal instances of NÇ are allowed)⁷:

(6) a. Root-internal NÇ

5 Pater assumes that [nasal] is a unary feature.

6 Such root/affix asymmetries often err towards preserving Faithfulness in lexical morphemes. For this reason separate Faithfulness constraints have been postulated (by Pater and also by McCarthy and Prince 1994b; Urbanczyk 1996) to deal specifically with root-internal Faith violations.

7 We have corrected some errors in Pater's Quechua glosses, which have no bearing on Pater's discussion.

šĩŋki ‘soot’ čũntina ‘to stir the fire’
 pampal^vina ‘skirt’

- b. sinik-pa ‘porcupine’s’ kam-ba ‘yours’
 sača-pi ‘in the jungle’ hatum-bi ‘in the big one’
 wasi-ta ‘the house (acc.)’ wakin-da ‘the other (acc.)’

This repair is punished by another IDENT constraint, this time IDENT[OBSVOICE], which requires obstruents in the output to maintain the voicing specification that their input forms have. Thus, the ranking OTHERFAITH > *NÇ > IDENT[OBSVOICE] is needed to ensure this result.

All of the constraints so far and the ranking needed to derive nasal substitution are depicted in this tableau (Pater 1996:23, his (20)):

(7) Pater’s final tableau for nasal substitution

/məN-pilih/	DEP	IDENTNAS	MAX	ROOTLIN	IDENTOBSVOI	*NÇ	LIN
✓ [məmilih]							*
[məmpilih]						*	
[məppilih]		*					
[məmbilih]					*		
[məpilih]			*				
[məŋəpilih]	*						

The factorial typology of this system also predicts that there should be languages where one repair is used in the default case, but a different repair is used in situations where the first repair is for some reason blocked. This prediction is seemingly vindicated in certain African languages in which nasal substitution occurs in combinations of nasals and voiceless stops, but nasal deletion is invoked to deal with combinations of nasals and fricatives (p.24, Pater’s (22)):

- (7) a. Umbundu (Schadeberg 1982)

/N + tuma/ [numa] ‘I said’

/N + seva/ [seva] ‘I cook’

- b. Si-Luyana (Givón 1970)

/N + tabi/ [nabi] ‘prince’
 /N + supa/ [supa] ‘soup’

The constraint ranking $*N\text{C}\text{̥} > > \text{IDENT} [\text{continuant}] > > \text{MAX} > > \text{LIN}$ derives such behaviour (Pater 1996:25-6, his (23) and (24)):

(8) Ranking for (7)

/N-tabi/	*N $\text{C}\text{̥}$	IDENTCONT	MAX	LIN
[ntabi]	*!			
✓[nabi]				*
[tabi]			*!	
/N-supā/				
[nsupa]	*!			
[nupa]		*!		*
✓[supa]			*	

Having introduced the apparent conspiracy between nasal substitution and nasal deletion, Pater argues that his OT approach is superior to a rule-based account on the grounds that “[u]nder a purely rule-based analysis [...] the functional connection between nasal substitution and nasal deletion would have to be stated independently of the rules themselves; their shared property of eliminating N $\text{C}\text{̥}$ clusters is only obliquely retrievable from the rule formulation. This contrasts with the present Optimality Theoretic analysis of African nasal substitution and nasal deletion, in which the functional motivation for these processes is directly incorporated into the formal explanation, thus allowing for a perspicuous account of the conspiracy between them” (1996:26).

This claim to superiority seems under-motivated to us, insofar as this factorial typology also yields an array of problematic predictions about intra-language variation when paired with OT devices for capturing optionality. (See also Blust 2004 for a catalog of empirical and conceptual problems with Pater’s argumentation.) We now show this by looking at the Constraint Tie approach. Similar problems can be shown to arise for other approaches to optionality in OT, including the Gradual Learning Algorithm (Boersma 1999;

Boersma and Hayes 1999) and Markedness Suppression (Kaplan 2009), but we cannot discuss these here for reasons of space.

Constraint ties are a standard device for capturing free variation in the OT literature (see for example McCarthy and Prince 1993, footnote 59). Tied constraints are said to be evaluated in all of their logically possible rankings, so that the grammar will be able to produce more than one grammatical output for a single underlying form.

This mechanism has bizarre consequences when it interacts with Pater’s factorial typology. Firstly, it leaves open the possibility of a language with complete freedom of choice between two repairs. For example, the repair for a $*N\underset{\circ}{C}$ violation in Mandar is to denasalize the nasal consonant. Its near neighbour Konjo, however, instead nasalizes the obstruent and creates a geminate nasal. Pater describes how these two language types can be derived in his system as follows: “[to derive Konjo], IDENTO→I[NAS] can be ranked beneath IDENTI→O[NAS], so that having an Output nasal in correspondence with an Input obstruent (i.e. NT→NN) is a better resolution of $*N\underset{\circ}{C}$ than having an Input nasal in correspondence with an Output obstruent (i.e. NT→TT). In Mandar, of course, the ranking between these constraints would be reversed” (1996:20). The OT mechanism for constraint ties yields a third option: a mixed language in which IDENTO→I[NAS] and IDENTI→O[NAS] are tied. In such a language, both *mattunu* and *mannunu* would be grammatical outputs for /maN + tunu/, and the same optionality would reproduce itself in all combinations of a nasal and a voiceless obstruent in the language. In effect, OT allows for what we call *Conspiratorial Cascades*, an apparently unattested situation in which each individual manifestation of a conspiracy is optionally repaired by the same set of two or more tied phonological operations.

(9) tied F constraints → tied conspiracies

/maN-tunu/	DEP	MAX	LIN	$*N\underset{\circ}{C}$	IDENTI-ONAS	IDENTO-INAS
[manunu]			*!			
[mantunu]				*!		
✓[mattunu]					*	
✓[mannunu]						*
[matunu]		*!				

[maɲatunu]	*!				
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The same problem is replicable for any given pair of repairs, even such unlikely bedfellows as epenthesis and deletion. We are not aware of any such cases attested in the literature. Rule-based analyses do not make analogous predictions.

2.1.1.2. Conspiracies and synchronic teleology

While constraints certainly allow a perspicuous statement of synchronically avoided or favoured configurations, it is a mistake to argue that they are the exclusive prerogative of OT, and that therefore only it can formulate such statements. In fact, Vaux (2008:29-30, fn 10) notes that by 1993 “most rule-based theories employed a suite of inviolable output constraints, such as the OCP, which were perfectly capable of generating conspiratorial effects”.

One should also be skeptical of OT’s driving assumption that cross-linguistically avoided configurations and cross-linguistically common processes all need to be manifest in some way in synchronic grammar, and that in general the theory of grammar is the appropriate locus of explanation for these typological generalisations. The perceived need to formulate all explanation in terms of synchronic teleology also fuels the OT account for conspiracies, and the critique of RBP based on them. We believe that in general the phenomena attributed to such teleology by OT are better accounted for within a diachronic/evolutionary approach to phonological typology, as pioneered by such works as Ohala (1973, 1974, 1981, 1989, 2005), Blevins (2004) and Ritt (2004) (see also Section 3). On this view, the locus of typological explanation lies outside of the phonological grammar *per se*, and thus the argument from conspiracies against RBP is neutralized.

It is not obvious to us that the sort of synchronic teleology entertained in OT, even if empirically well-motivated, leads to an overall more deeply explanatory account of the nature of natural language phonologies than that available in a rule-based theory allied with the diachronic/evolutionary approach to typology. Notice that the teleological aspect of the OT approach to conspiracies has to come from the pre-existence of the markedness constraint implicated in a given conspiracy. As for why there should be such a markedness constraint in UG in the first place, the answer would

presumably have to be ‘because that’s what evolution did’. But this is almost the same as the claim made by the alliance of RBP with diachronic/evolutionary phonology, with the following difference. In the OT case biological evolution would have to be appealed to—that is, the genetic basis for the faculty of language itself has evolved such that it contains the markedness constraint. In the RBP case, historical linguistic evolution would be appealed to, since by hypothesis there is no synchronic teleology encoded in UG itself: the appearance of a conspiracy, and all cross-linguistically avoided or favoured configurations, emerges from the winnowing effect of human perceptual and articulatory mechanisms, coupled with the nature of the acquisition process. A form of natural selection is being appealed to in each case, and by no means is the OT approach obviously better in its coverage. Nor is it more likely to be true, for the reasons outlined above.

Along similar lines, we should not be too hasty to assume that a given set of processes is controlled by a synchronically-active conspiratorial global constraint. As Kiparsky (1972) states, the elements putatively implicated in conspiracies “are linguistically complex configurations, and rules eliminating or avoiding them are accordingly highly natural and occur frequently in the languages of the world. It is therefore only to be expected that there should be some languages in which several rules should eliminate or avoid these configurations, and that there should be languages in which no instances of these configurations appear on the surface...What I am questioning, then, is whether there is any fundamental sort of difference between the cases in which just one or two rules reflect general phonological conditions of this type, and the cases in which several rules are involved, which would be termed a ‘conspiracy’.”

Kiparsky 1972 adds that “concrete empirical differences are clearly also involved: Is there any evidence for a true ‘functional unity’ of the rules in a conspiracy which would not simply be characterizable by their sharing a common target? Are there cases in which they are subject to parallel historical changes at some point in the development of a language? Are there cases in which apparently diverse changes in the rules of a language at some point in time can be shown to be consequences of the imposition of a single derivational constraint? Are there cases where the rules in a conspiracy have the same set of lexical exceptions? This would be strong evidence in favor of

derivational constraints.” Kiparsky noted in 1972 that he had not found any cases of the sort he identified, leaving the reader to infer that the case for synchronic conspiracies had not been carried. To the best of our knowledge these questions have not subsequently been investigated; since 1993 it has simply been taken for granted that conspiracies exist, with no evidence for their existence in a synchronic grammar requested or provided.

A final concern with OT’s attribution of conspiracies to the activity of synchronic markedness constraints is the fact that these constraints do not always appear to suffice to account for the conspiracies in question. The famous Yawelmani Yokuts conspiracy, for example, has been attributed by Heinz 2008 and others to the high ranking of a markedness constraint *COMPLEX triggering avoidance of complex syllable margins, but *COMPLEX on its own fails to account for Newman’s observation that “no combination of the two syllabic types can result in a vowel cluster; all vowels must appear singly in Yokuts [...] no syllable has an initial vowel” (1944:27). Zoll 1993 proposes that the conspiracy actually aims to make all syllables be of the shape CV(X), which accounts for Newman’s generalization but requires a conspiracy between *COMPLEX, ONSET, and *SUPERHEAVY in Zoll’s analysis. Moreover, neither Heinz nor Zoll’s analysis accounts for all elements of the putative conspiracy, such as the fact that */CCC/ strings are banned in the underlying forms of morphemes (Kisseberth 1970) and “the initial syllable of [the underlying form of] bases is always open” (Newman 1944:27).

One might object that the morpheme structure constraints proposed by Kisseberth and Newman are simply products of the history of the language, and need not be encoded in the synchronic grammar. This reasonable move leaves one wondering whether the entire Yokuts conspiracy might be solely historical. Blevins (2004:47) suggests that claims about the synchronic activity of conspiracies can be tested by investigating the behavior of loanwords. To the best of our knowledge this has not been done by proponents of the optimality-theoretic conspiracy analysis, but Gamble 1989 has found that Spanish loans in the closely-related Wikchamni Yokuts do *not* employ consistent strategies to avoid word-initial CC- clusters (e.g. cruz ‘cross’ → kuluʃ but clavo ‘nail’ → la:wu), and Weigel 2005 has found that some Yawelmani loans from Spanish do allow complex onsets, such as escuela ‘school’ → eskwela.

When evaluating the phonological behavior of loanwords one must always be wary of the possibility that the words in question have come into the recipient language via one or more intermediate languages, as Gamble 1989 points out. At our current state of knowledge about Yokuts, though, it is fairly clear that a satisfactory case has not been made for a single markedness constraint synchronically producing conspiratorial effects.

2.1.1.6. Conclusions

In this light, it is premature to assert that Optimality Theory offers a predictive advantage over RBP with respect to conspiracies. The synchronic existence of conspiracies has not been securely established, and in the Yokuts case the behavior of loanwords suggests that the internal and sociolinguistic histories of the language may play the key explanatory roles. The Yokuts case reveals moreover that even if a conspiracy is produced by the synchronic grammar, a single markedness constraint does not suffice in accounting for it; as in RBP, a conspiracy of players (rules in RBP, constraints in OT) is required to generate the desired patterns.

Even if it does turn out that conspiracies exist in non-trivial numbers, it is not clear that an account relying on the genetic substrate of the language faculty having evolved appropriate markedness constraints would provide the most insightful explanation of this. We find the Evolutionary Phonology position persuasive in this context: if independently-required human perceptual, articulatory, and acquisitional mechanisms operating over time suffice to account for the appearance of conspiracies, then there is no reason to postulate additional synchronic machinery to duplicate the same effect.

2.2. Predictive differences suggested to favor RBP

Turning to predictive differences that have been suggested to favor RBP over OT, Anderson 2010 states that “some of the same issues that rule-based phonology dealt with (and at least largely resolved) have re-surfaced as serious challenges to the architecture of grammar generally assumed in constraint based theories.” He singles out opacity as a particular challenge, and this phenomenon is the focus of our next section. We then briefly review “crazy rules”, morpheme structure constraints, and the larger issue of locality vs. globality.

2.2.1. Opacity

The phenomenon of opacity is frequently cited as showing a need for a phonological architecture in which processes can interact in series (Kiparsky 2000, Clements 2000; McCarthy 2007; Vaux 2008; many others). Since serialism is one of the major theoretical fault-lines dividing RBP from classical OT, the existence of opacity has often been taken as an important argument favoring RBP (indeed, RBP was the framework which allowed opacity to be discovered and investigated for the first time). The reason why has been rehearsed in many places in the literature; we therefore provide only a brief illustration here. Following this illustration, we consider two issues which might seem to complicate the use of opacity as a test-bed for comparing RBP with OT, ultimately concluding that the evidence from opacity still comes down heavily in favor of RBP.

The notion of phonological opacity, and the surface diagnostics used to identify it, originate with Kiparsky (1971:621-622; 1973:79). The following definitions, taken from Kiparsky (1973:79), are usually taken as canonical:

- (13) A process P of the form $A \rightarrow B / C_D$ is opaque to the extent that there are surface representations of the form:
- a. A in the environment C_D, or
 - b. B derived by P in environments other than C_D.

McCarthy (1999) dubs the subcase in (a) *underapplication* opacity: a process fails to apply despite having apparently had an opportunity to do so. Subcase (b) is termed *overapplication* opacity by McCarthy, since it involves a process applying despite its usual conditioning environment not being met on the surface. Both of these classical subcases of opacity are predicted to exist by RBP, since both are easily expressible in terms of serial rule interaction.

A popular example of overapplication opacity occurs in Tiberian Hebrew, where a process of epenthesis crucially applies before a process that deletes glottal stops in syllable codas. In RBP terms, input-output mappings involving these two processes such as $/daʔ/ \rightarrow [deʔ]$ vs. $/daʔ-o:/ \rightarrow [daʔo:]$ can be derived with the three rules in (14) (Green 2004):

(14) Tiberian Hebrew counterbleeding in RBP

	UR	a. / daʃʔ /	b. / daʃʔ-o: /
Rule 1	$\emptyset \rightarrow [\varepsilon] / C_C\#$	daʃʔ	--
Rule 2	$a \rightarrow \varepsilon / _ C \varepsilon$	dɛʃʔ	--
Rule 3	$\? \rightarrow \emptyset _]_{\sigma}$	dɛʃ	--
	SR	[dɛʃɛ]	[daʃʔo:]
		‘grass’	‘his/its grass’
		Gen1:11	(unattested)

In derivation (14a), Rule 1 counterbleeds Rule 3: if Rule 3 were to apply before Rule 1, it would bleed the latter’s opportunity to insert an epenthetic vowel.

In contrast, both types of opaque interaction pose problems for Classic OT analyses. In the case of underapplication opacity, easily analysed as a case of counterfeeding rule ordering in RBP, there is no way to prevent process P from applying once its conditioning environment is met on the surface. Given the constraint ranking needed to cause the process to exist in the language in the first place, it will be forced to apply in any surface form where its structural description is met.⁸

Similarly, overapplication opacity of the sort dealt with by counterbleeding rule interactions in RBP poses insuperable difficulties for any account in terms of Classic OT. Consider how the counterbleeding interaction in (14) might be modeled in Classic OT (Green 2004):

(15) Tiberian Hebrew counterbleeding in Classic OT

⁸ Strictly speaking, this is only true in cases where the counterfeeding effect is produced by changing the environment surrounding the would-be-affected segment, as in the present example. Another type of counterfeeding involves processes applying to the same segment, such that one should feed the other, but fails to. Such *counterfeeding-on-focus* has been suggested by McCarthy 1999 to be amenable to an OT treatment employing faithfulness constraints which punish “too great” a change. Counterfeeding-on-focus therefore cannot be used to contrast the two theories, and for this reason we ignore it here.

/daʃʔ/	*CC] _Σ	*ʔ] _Σ	DEP-IO(V)	MAX-IO(C)
[daʃʔ]	*!	*		
[dɛʃɛʔ]		*!	*	
☞ [dɛʃɛ]			*!	*
☞ [daʃ]				*

The key in (15) is the harmonic bounding of the desired counterbleeding candidate [dɛʃɛ] by the transparent bleeding candidate, *[daʃ]: because [dɛʃɛ] violates all of the same constraints as *[daʃ], and also violates additional constraints, there is no ranking of the constraints that can select the counterbleeding candidate over its transparent competitor.

The reason stems from the very logic of constraint interaction in the theory. Processes can only exist when a given (set of) markedness constraint(s) outranks a certain faithfulness constraint. Therefore, processes are predicted not to apply if the markedness violation which would trigger them is not present on the surface—there is no room in Classical OT for gratuitous violation of a faithfulness constraint. The issue created by overapplication opacity is that, by its very definition, it inevitably involves such a gratuitous faithfulness violation.

Since both of these types of opacity are a productive part of the phonologies of many languages, there can be no doubt that they constitute a strong argument in favor of RBP against Classical OT. However, it should be pointed out that this argument from opacity turns on the parallelist nature of Classical OT in combination with its commitment to ranked constraints, and not on its constraint-based nature alone. Various ways of allowing OT evaluations to interact serially are currently being actively pursued. One of these allows an OT grammar to evaluate entire candidate derivations (Optimality Theory with Candidate Chains, q.v. McCarthy 2007, Wolf 2008). Another combines an Optimality Theoretic phonology with the stratal morphophonological architecture of Lexical Phonology and Morphology, allowing the output of one stratum to serve as input to a subsequent one in a serial fashion (LPM-OT; see Kiparsky 2000; Bermúdez-Otero 2013, forthcoming, this volume).

These models have been independently criticized (see Kiparsky 2011 on OT-CC; Embick 2010: Ch 1, 6, and 7 on LPM-OT), and are subject to many of the other criticisms of OT raised elsewhere in this chapter. Nevertheless, if a serial variant of OT proves viable in the long run, the relevance of opacity phenomena as a way of contrasting the predictions of RBP with those of OT may be put into doubt.

A separate issue which seems to complicate the use of opacity as a test-bed for RBP and Classical OT has recently been raised by Baković (2007, 2010). Baković argues that traditional definitions of opacity, properly applied, include certain phenomena which do not receive a satisfying analysis under RBP, unless it is supplemented by additional mechanisms. The importance of Baković's argument is that, if indeed RBP does not have a fully unified analysis of opaque phenomena, it can no longer be taken to be inherently superior to Classical OT as an approach to opacity. Before discussing the details of the problematic phenomena identified by Baković, we would point out that the structure of this argument contains an important flaw: Classic OT and most of its variants lack *any* satisfactory mechanism for generating or learning (large classes of) counterfeeding and counterbleeding systems. It follows that RBP is to be preferred even if Baković is correct that RBP cannot achieve a unified analysis of all opaque phenomena—having a non-uniform analysis is better than having no analysis.

The two cases of opacity which Baković points out as problematic for RBP are Blocking and Cross-Derivational Feeding. We discuss these in turn.

Blocking includes a number of effects which are well-known in the phonological literature, but had not previously been widely acknowledged to fulfill the definition of opacity, including: blocking of one process by another via the Elsewhere condition; non-derived environment blocking (where processes fail to apply outside of derived environments), and do-something-except-when blocking (where processes fail to apply exactly where they would create a configuration which is banned on the surface). As Baković astutely observes, all of these types of blocking fall under the heading of underapplication opacity given Kiparsky's canonical definition. Baković points out that all of these phenomena require ancillary conditions beyond pure rule interaction in RBP in order to account for them. While correct, this argument is subject to our earlier objection: this does nothing to alleviate

Classical OT's inability to deal with counterbleeding and counterfeeding-on-environment.

Cross-derivational feeding is Baković's term for a class of interactions which he argues cannot be captured in RBP without loss of generalization. A simple example comes from the interaction of Epenthesis with Voicing Assimilation in English phonology. As is well known, English inflectional suffixes with underlying forms /z/ and /d/ are devoiced to [s] and [t] when they follow a voiceless obstruent. However, this process is bled by a process of Epenthesis which applies to separate a sequence of two (near-)identical consonants. This interaction is illustrated for the English regular plural inflection in (16):

(16) Epenthesis and Voicing Assimilation in English

a. rules

Epenthesis (Ep) $\emptyset \rightarrow \text{ə} / [-\text{son}, \alpha\text{Place}] _ [-\text{son}, \alpha\text{Place}]$
 Voicing Assimilation (VA) $[-\text{son}] \rightarrow [-\text{voice}] / [-\text{voice}] _$

b. derivations

	'days'	'dads'	'plates'	'cakes'	'dishes'	'buses'
UR	/dɛɪ-z/	/dæd-z/	/plɛɪt-z/	/kɛɪk-z/	/dɪʃ-z/	/bʌs-z/
Ep	--	--	--	--	dɪʃəz	bʌsəz
VA	--	--	plɛɪts	kɛɪks	--	--
SR	[dɛɪz]	[dædz]	[p ^h lɛɪts]	[k ^h ɛɪks]	[dɪʃəz]	[bʌsəz]

The core of Baković's observation is as follows (the ensuing discussion is based on Fruehwald & Gorman 2011:37). Epenthesis applies in this instance to (in Baković's opinion) break up sequences of sounds which are "too similar". Baković claims that the only feature that doesn't "count" in determining whether two sounds are different or not is [voice]—if two sounds differ in [voice] but are otherwise the same, Epenthesis still applies. Crucially, [voice] is exactly the feature manipulated by the assimilation rule. Baković argues that this dual role of the [voice] feature is not a coincidence, and is a generalization which should be captured by the grammar. This relationship can be captured in OT, thanks to the global nature of its computations. This is because the constraint which favors epenthesis (the

anti-gemination constraint NOGEM) interacts with the constraint favoring agreement of voicing in word-final obstruent clusters (AGREE(VOICE)). Provided that these two markedness constraints are undominated⁹ and are not ranked with respect to each other, the correct result is captured:

(17) Cross-Derivational Feeding in OT

/bʌs-z/	NOGEM	AGR(VOI)	DEP(V)	ID(VOI)
a. bʌsz		*!		
b. bʌs:	*!			*
☞ c. bʌsəz			*	
d. bʌsəʃ			*	*!

This interaction is termed “cross-derivational feeding” because the ultimate reason for the application of Epenthesis is that there *would be* a geminate if AGREE(VOICE) alone were satisfied (see candidate (17b))—that is, the winning candidate can only be determined by reference to the output of a counterfactual derivation in which assimilation does apply. RBP grammars disallow such cross-derivational comparison, and so can offer no grammatical account of this interaction. Furthermore, Baković points out a strong prediction made by the OT approach to cross-derivational feeding which is not made by the RBP approach: note that candidate (17d), in which both Epenthesis and Voicing Assimilation have applied, is harmonically bounded by candidate (17c)¹⁰. Thus, OT predicts that it should be impossible for

⁹ A problem for this analysis is that NOGEM cannot in fact be undominated in English, which allows Level II and Phrase Level geminates (e.g. un-known, pen name, one nation).

¹⁰ We are not convinced that this is a case of harmonic bounding. Consider the English voicing example, which is isomorphic to Baković's Lithuanian example, but with different constraints. Candidate (17c) does not in fact harmonically bound (17d), once one considers a more complete set of the constraints in the universal set CON. Many of the constraints in CON are actually violated by (17c) and *not* (17d), such as whatever constraint(s) make [z] more marked than [s] (e.g. *LAR in Lombardi's (2001) theory), and whatever constraint triggers final devoicing (e.g. *VCD OBS_{JPW_D} in Staroverov's

assimilation to counterbleed epenthesis cross-linguistically, a prediction which Baković (2007) defends against the only known apparent counter-example (from New Julfa Armenian, see Vaux 1998; see Fruehwald & Gorman 2011:44 for a telling reply to Baković's defense).

While interesting, there are at least four important problems with Baković's argument from cross-derivational feeding. The first is that the OT approach in (17) rests its most impressive typological prediction on OT's general inability to cope with counterbleeding. This is, to say the least, a dubious move: it makes a small virtue out of an otherwise crippling liability for the theory. The next two problems are pointed out by Fruehwald & Gorman (2011). They note that epenthesis does not always systematically ignore all and only the features relevant to assimilation, as predicted by Baković's approach. In fact, there are exceptions even in English, with respect to the alveolo-palatal affricates: note that applying Voicing Assimilation to /dʃ-z/ does not yield a geminate. They further note that the interaction of Voicing Assimilation and Epenthesis in modern English can be given a plausible extragrammatical explanation in terms of its historical origin as a syncope rule which was blocked where it would have given rise to a geminate (a blocking which Fruehwald and Gorman 2011:38-41 attribute to homophony-avoidance pressures operating over time). There is thus no need to capture the generalization at the level of the grammar, and the apparent disadvantage of RBP evaporates.

The fourth problem is that Baković's strong prediction that epenthesis cannot counterbleed assimilation is actually false—such grammars do in fact appear to exist: for example, epenthesis has been argued to counterbleed laryngeal assimilation in some English idiolects (Anderson 1973), the Armenian dialects of Maragha and Nor Nakhichevan (Vaux 2016), Japanese (Davis & Tsujimura 1991), and some northern Greek dialects (Newton 1972: 207).

(2010) theory). Though Baković's formulation of the situation in terms of harmonic bounding appears to be unwarranted, his conclusion that Classic OT is not capable of generating such systems is nonetheless correct.

Overall, then, it seems that the phenomenon of opacity still favors the predictions of RBP over those of at least Classic OT, and that Baković's arguments to the contrary are not convincing.

2.2.2. Other predictive differences claimed to favor RBP

Anderson 2010 states that cases “seem to exist in which the specific changes through which a language achieves conformity with a general constraint on surface forms do not follow directly from the content of the constraint (together with other interacting generalizations). In such a case, something like a re-writing rule might be necessary, as a supplement to the constraint system – a notion which is clearly antithetical to the basic philosophy of OT.” Here he appears to be referring to “unnatural” or “crazy” processes, that is (to invert Donegan and Stampe's (1979:126) characterization of Natural Phonology) ones which are not a natural reflection of the needs, capacities, and world of its users (Bach and Harms 1972, Anderson 1981).

One such example is consonant epenthesis, which in many languages inserts a segment that appears to result from historical reanalysis of an earlier consonant deletion process, rather than from minimal departure from the underlying representation in order to satisfy markedness constraints, as we would expect in OT. Cases like this abound in the world's languages, most famously with English *r* but also with Mongolian *g*, Dominican Spanish *s*, and many others (Vaux and Samuels to appear).

The problem for all varieties of OT in this context arises in our opinion from the fact OT descends philosophically from Natural Phonology (NP), one of whose tenets is that phonology is essentially natural in the sense defined earlier. In NP this naturalness is captured for the most part in the idea that Universal Grammar provides a set of “processes” such as Final Devoicing; their initial state in the acquisition process is to be active, but the learner can suppress them upon sufficient exposure to primary linguistic data showing that the process in question is not active in that language. In the case of Final Devoicing, for example, exposure of the learner to surface forms showing a voicing contrast in word-final obstruents would suffice to deactivate the process.

In OT the analog is a universal set of constraints with a particular initial ranking (typically some form of $M > > F$) thought to reflect/produce

the same phenomena encoded as processes in NP. Parallel to the deactivation of natural processes in NP, markedness constraints in OT can be demoted below relevant conflicting faithfulness constraints when the learner observes output forms that violate these markedness constraints.

NP and OT diverge, though, when it comes to *unnatural* phenomena. While NP asserts that phonology is fundamentally natural, it acknowledges the existence of another module of operations that precede Processes in the derivation. These operations, called Rules (analogous to lexical rules in Lexical Phonology and morphophonemic rules in traditional phonology), are not provided by UG but instead have to be constructed by the learner. It is this class of operations, and particularly the subset classified as unnatural by Anderson 1981, that has been abandoned by OT, the claim being that one cannot for example have a phonological process that inserts a random consonant—if a language has a consonant insertion process, the choice of consonant must be the one that deviates minimally from the underlying form while optimally satisfying the constraint ranking of the language.

Technically the machinery of OT is capable of generating insertion of any given consonant, given that no relevant bounds have been placed on the inventory of constraints in Universal Grammar. There is nothing to stop us from postulating additional markedness and faithfulness constraints that will suffice to produce [g]-insertion between long vowels in Mongolian, for example. On a philosophical level, though, most practitioners of OT are not willing to allow for this degree of generative power¹¹, which leaves us with a predictive difference between RBP (which allows for unnatural operations such as Mongolian [g]-insertion) and OT (which philosophically at least does not).

Another area where the computational power and the philosophical predilections of OT differ involves morpheme structure constraints, or more generally constraints on the form of underlying representations. Optimality-Theoretic constraints have the ability to inspect underlying representations (this is an essential component of faithfulness constraints, for example), and there is currently no substantive proposal for the set of constraints contained

¹¹ Advocates of substance-free OT such as Blaho and Hamann would be possible exceptions to this generalization.

in UG, so there is no formal or computational reason why markedness constraints legislating the form of input representations should not exist. As with unnatural processes, though, the philosophical inclinations of most supporters of OT do not exactly align with what the formalism allows. In this case, adherents of OT generally believe that UG does not contain constraints on underlying forms, a principle called Richness of the Base. The reasoning generally cited is that OT allows one to capture all of the significant generalizations about a language without recourse to such constraints, and therefore by Occam’s Razor they should not be postulated.

Nevins and Vaux (2007) argue, though, that there is extensive cross-linguistic evidence for precisely this sort of constraint on underlying representations. Becker and Gouskova (2016) give experimental evidence that speakers extend generalizations over underlying forms in Wug tests. Rasin and Katzir (2014) demonstrate, moreover, that under standard principles of acquisition in OT, language-specific constraints on underlying representations are required in order to avoid treating some systematic gaps as accidental and some accidental gaps as systematic.

A final class of predictive differences where the facts appear to support RBP over OT involves locality effects that OT’s globality of optimization makes difficult to capture. A range of such cases have already been discussed by Paster 2006 and Embick 2010; we therefore limit ourselves to a somewhat different case involving localized iterative clash deletion.

Meeussen’s Rule (MR) avoids strings of three adjacent High tones; when handed an /H-H-H/ string by the morphology, languages with MR produce either [HLL] (as in Ganda; Hyman 1982) or [HLH] (as in Shona; Odden 1980). We provide a Ganda example in (18).

(18) Ganda (Hyman 1982 apud Hyman 2000 fig.14)

UR	H	H	H	
	ba -	li -	lab - a	‘they will see’
SR	H	L	L	

The two variants of MR are traditionally analysed as OCP-driven High-tone delinking, applying iteratively either from left to right (as in Ganda) or right to left (as in Shona). In an OT framework, though, we only expect to find the HLH treatment and not the HLL treatment, as the latter involves an unnecessary second MAX violation (Odden 2008:71). We thus have a predictive difference between RBP, in which configurations are evaluated and operated on locally, and OT, in which the same is done globally: the former predicts the existence of both types of MR, where the latter generates only the type of MR found in Shona.

A parallel to the behavior of MR in Bantu surfaces in the Abkhaz stress system (see also Vaux 2008:39-40; on which the ensuing discussion is partly based). The core stress system in Abkhaz is governed by Dybo's Rule, which can be formulated as in (19):

(19) Dybo's Rule (Dybo 1973, 1977, 1978; cf. Hewitt 1979, 1989, Spruit 1986:38, Trigo 1992, Kathman 1992, 1994, 1996)

Assign word stress to (i) the leftmost underlyingly accented element (ii) not followed by another accented element; otherwise (iii) stress falls on the final element¹².

We illustrate the workings of Dybo's Rule with the forms in (20) – (21). In the notation employed here, underscored “x” represents a lexically accented element and an acute accent “á” represents an element that is stressed in the surface form.

(20) nominal root: /madza/ ‘secret’ (Spruit 1986:42)

- a. [á-madza] ‘DEF-secret’
- b. [madzá-k'] ‘secret- INDEF’

(21) verbal roots (Spruit 1986:46)

unaccented root

accented root

¹² Spruit 1986 discusses several classes of exception to generalization (iii) that we will not consider here as they are not germane to the point of this chapter.

- | | |
|---|--|
| a. <u>á</u> -p ^h a- <u>ra</u> ‘jump’ | d. a-p ^h <u>a</u> - <u>rá</u> ‘pleat’ |
| b. <u>á</u> -fa- <u>ra</u> ‘eat’ | e. a- <u>ja</u> - <u>rá</u> ‘lie down’ |
| c. <u>á</u> -t ^h a- <u>ra</u> ‘give’ | f. a-t ^h <u>a</u> - <u>rá</u> ‘go’ |

We can see the workings of condition (i) of Dybo’s Rule in (20a) and (21a-c). In (20a), the lexically accented definite prefix /a-/ is followed by the unaccented root /madza/; by dint of (19i) the /a-/, being the leftmost underlyingly accented element, receives the surface stress. The forms in (21) are verbal infinitives, which are constructed from the root by prefixing the accented definite morpheme /a-/ and suffixing the accented infinitive ending /-ra/. In the forms in (21a-c) the verbal roots are underlyingly unaccented; the lexical accents of the prefix and suffix are therefore non-adjacent, and condition (i) of Dybo’s Rule therefore holds again, assigning stress to the leftmost of these accents.

Using Halle and Idsardi’s (1995) formalism, we can derive the basic Abkhaz system in RBP via the operations in (22).

(22) Abkhaz stress in the Halle-Idsardi formalism

- i. Project stress-bearing elements.
- ii. Project a right bracket) for all lexical accents.
- iii. Line 0 Edge Marking: LLL
- iv. Clash Deletion:) → ∅ / _ *) [iterative, L→R]
- v. Project rightmost element of Line 0 feet to Line 1
- vi. Project leftmost element of Line 1 feet to Line 2

The conflicting directionality identified by Dybo results from Left vs Right headedness on Lines 0 and 1 respectively (22v, 22vi), and the iterativity and directionality via (22iv) (cf. Howard 1972).

In OT, on the other hand, it is difficult to derive the equivalent of iterative left-to-right clash deletion, for the same reasons we saw with Meeussen’s Rule earlier. The Classic OT tenets of globalism/parallelism and minimal violation favor outputs which do the global minimum necessary to avoid stress clash, which harmonically bound the desired winners with their greater number of clash deletions. OT therefore predicts that Abkhaz should delete as few underlying lexical accents as possible, yielding a Shona-style

system (which would produce forms like /a-p^ha-rá/ ‘pleat’ → *[á^hara]) and not the attested Ganda-type system (which produces forms like /a-p^ha-rá/ → *[ap^hará]).

Versions of OT that allow staged computation sensitive to morphological structure (e.g. Stratal OT or in a sense Orgun’s (1996) Cyclic OT) can deal with at least a subset of the cases where no more than one deletion happens per morpheme, but Stratal OT fails with forms involving more than one deletion per stratum and Cyclic OT fails with forms involving more than one deletion per morpheme. Harmonic Serialism has the power to generate the desired outputs, but cannot rule out equally harmonic outputs produced by derivations that do not apply clash deletion in L→R order.

What we conclude from the behavior of Meeussen’s Rule in Ganda and Dybo’s Rule in Abkhaz is that the phonological component of the human language faculty requires the ability to execute operations in a non-optional, (process-specific) directional, local manner. Theories designed to be unable to carry out such computations and/or select the outputs of such computations as the exclusive winners under EVAL face a serious challenge accounting for the relevant empirical phenomena.

We have seen in this section a representative selection of predictive differences that have been suggested in the literature to favor RBP over OT. In the case of opacity, RBP straightforwardly generates all attested types of counterfeeding and counterbleeding, whereas all mainstream forms of OT other than OT-CC struggle to account for the complete range of opacity effects (see McCarthy 2007 for an insightful review of the relevant theories and phenomena). Attempts by Baković to label additional phenomena as opacity effects are ultimately unsatisfying, as they brush under the rug the fact that OT cannot generate counterbleeding and counterfeeding-on-environment effects, and downplay the fact that RBP does in fact possess mechanisms to generate the effects in question.

We have seen that unnatural processes can be generated in some cases by the machinery of OT, but the philosophy of the theory precludes the existence of such processes, which then runs afoul of the fact that they are abundantly attested in the languages of the world. The same line of reasoning holds for morpheme structure constraints: nothing in the architecture of OT prevents them from existing, but proponents of the model have nonetheless

made Richness of the Base a central concept in practice, which poses significant problems both empirically and learning-theoretically.

Finally, iterative directional clash deletion processes of the sort we see in Ganda and Abkhaz are wrongly predicted not to exist by most varieties of OT. OT-CC is able to generate forms of the sort we observe in these languages, but these are predicted to tie with globally-optimal forms, contrary to fact.

3. An Outstanding RBP-internal issue: The Content of Universal Grammar

This section highlights an open issue internal to the theory of RBP: the content of Universal Grammar. Another major current issue within RBP is morphology-phonology interaction and the architecture of the grammar; see Newell (this volume) for an overview of current work on this topic.

Just under three decades ago, McCarthy (1988:84) was able to write that “[t]he goal of phonology is the construction of a theory in which cross-linguistically common and well-established processes emerge from very simple combinations of the descriptive parameters of the model”. Today, the view that generalizations about typological frequency should be made to fall out from the primitives made available by Universal Grammar has been challenged from a number of perspectives.

One line of criticism has been conceptual in nature: the aim of linguistic theory is to characterize the human language faculty. The core question of interest is therefore what is a *possible* language, not what is a *probable* language (see Hale & Reiss 2008; Newmeyer 2004). Moreover, of the unattested languages, only a subset of them will be unattested because they are not computable by the language faculty—others may be computable in principle, but unattestable for independent reasons. To take an extreme example, Hale & Reiss (2008:192) point out that there are no linguistic representations in human languages that contain physical bananas, but this is clearly for extragrammatical reasons and presumably requires no UG-based explanation.

Another line of criticism stems from the emergence of new kinds of explanation for why certain processes are more “cross-linguistically common and well-established” than others. Every currently existing phonological

grammar is the result of a baby acquiring its ambient language on the basis of the linguistic output of its care-givers and peers. Since this means that grammars are not transmitted directly, but rather “reassembled” by each individual acquirer, there is a good chance that transmission from one generation to the next will be imperfect, leading to language change. Work on phonetics has shown that, for fundamentally articulatory and perceptual reasons, certain such language changes are more likely to happen than others (Blevins 2004; Ohala 1971, 1972, 1975, 1981, 1983, 1997, 2005).¹³

These developments have raised the question of whether the notion of *markedness* has any status in Universal Grammar. This question is intimately related to a second one- namely, how sensitive is the phonological component to the fact that its features have phonetic content? If the grammar itself disfavors phonetically marked structures (i.e. ones which are difficult to articulate and/or perceive), then it clearly must be sensitive to the phonetic substance of distinctive features. On the other hand, if the effects of phonetic markedness are purely extragrammatical, then it could be that phonology itself is “substance-free”. It is important to point out that these issues arise in any theory, and in fact this discussion is independent of the Rule-Based nature of the framework. Within RBP, SPE (especially chapter 9), Natural Phonology (Stampe 1973/1979), and much work in Autosegmental Phonology can be regarded as substance-ful approaches to phonology; see Hale and Reiss (2008), Samuels (2009) for extended defenses of substance-free versions of RBP. Similarly, although most Optimality Theoretic literature from Prince and Smolensky (1993) onwards is in the substance-ful camp, Blaho (2008) proposes a substance-free implementation of OT.

One empirical front in this debate focuses on experimental phonetics and the predictions of a sound change-based theory for phonological typology. Do the set of phonetically natural mishearings and mispronunciations coincide with the set of common sound changes, and does the set of attested sound changes correctly predict the set of attested/unattested synchronic phenomena? Blevins (2004) argues that the answer to

¹³ Although this line of work is indeed relatively new in contemporary linguistics, Blevins (2004:79) notes that there is an antecedent for both Ohala’s and her own research program in the work of Baudouin de Courtenay (1910/1972:267), who stressed “the importance of errors of hearing [...] as a factor of change”.

both of these questions is “yes”. Kiparsky (2006), de Lacy (2002, 2006a, 2006b), and de Lacy and Kingston (2006) argue that the answer to the second question is “no”, on the grounds that certain phonetically natural and common sound changes, if chained together, are predicted to yield certain synchronic phenomena which turn out not to be attested. Miller et al. (2016) reply that while the changes cited by Kiparsky, de Lacy, and Kingston may be common individually, this does not mean that the chains of them needed to produce the anomalous patterns are expected to be common. Furthermore, Miller et al. show that many of the chains of changes suggested by Kiparsky actually yield commonly attested patterns, rather than the unattested ones claimed. This is a rich empirical domain which will continue to play an important role in the debate on how ‘substance-ful’ phonology is.

Another important domain in this respect has been language acquisition. If phonology is substance-free, then formal complexity and robustness of data should be the only determinants of how “easy” to acquire a given pattern is. All else held equal, a phonetically unnatural pattern should be no more difficult to acquire than a natural one (as we will see below, however, all else might well not be equal). On the other hand, if phonology is sensitive to phonetic substance and rules out certain unnatural patterns (for instance, via harmonic bounding in an OT framework), then phonetically unnatural patterns should be impossible to learn, whereas natural patterns which are otherwise equal in terms of formal complexity and robustness in the PLD should be easy to acquire.

Recent years have seen an explosion of experimental work on this issue (Moreton 2008; Finley 2008; Finley and Badecker 2009; Pater and Tessier 2003; Wilson 2003; Peperkamp, Skoruppa, and Dupoux 2006, Berent et al. 2007, Berent et al. 2008, Berent et al. 2009, Hayes et al. 2009, Pycha et al. 2003; see Hayes and White 2013 for an overview).

A particularly common paradigm involves the learning of artificial languages, whether by infants (Saffran & Thiessen 2003, many others), or by adults (Wilson 2006, many others). Another methodology involves comparing observational studies of the course of acquisition of phonology in L1, seeking correlations between phonetic markedness/typological rarity and lateness of acquisition (Buckley 2002).

The picture that emerges from this literature is not easy to interpret, however. As Hayes and White (2013:47) put it: “[o]ur reading of this literature is that the evidence is quite mixed and gives no comfort to advocates of either of the two possible extreme positions (all constraints are a priori knowledge/ all learning is purely inductive”. Hayes and White (2013:47-48) survey a number of artificial language-learning studies which show that unnatural rules can indeed be learned- in some cases more slowly than natural ones (as found by Schane et al. 1974/1975), and in some cases with no apparent difference (for example, Pycha et al. 2003, who found that adults acquired the typologically rare pattern of consonant harmony just as easily as the far more common process of vowel harmony). In addition, Buckley (2002) found that studies on the order of L1 acquisition of different processes cross-linguistically show no particular evidence that “natural” processes are easier to learn. On the other hand, they are also able to cite a range of experiments which support at least some role for phonetic naturalness. For instance, Wilson (2006) found that adult learners extended a palatalization process of $ke \rightarrow tʃe$ to $ki \rightarrow tʃi$, despite only having independent evidence in their training data for $ke \rightarrow tʃe$. However, participants trained on data which only carried evidence of a $ki \rightarrow tʃi$ process did not extend this rule to $ke \rightarrow tʃe$ when tested. This asymmetry accords with what phonetic naturalness would predict: high vowels are more likely to induce palatalization than mid vowels. The same asymmetry is reflected in the typological record- if /e/ triggers palatalization in a given language, then so will /i/, but the converse does not hold (Hayes and White 2013:48).

Summing up this mixed picture, Hayes and White (2013:49) note that “[in] several of the experiments just cited, the findings support a *bias* effect: the unnatural patterns are learnable but take longer to learn, or yield weaker experimental effects than comparable natural patterns”. This conclusion clearly rules out certain versions of the substance-ful approach (for example, it is incompatible with the sort of absolute absence of unnatural patterns which would be predicted by a harmonic bounding-based OT explanation), while being compatible with other substance-ful approaches. However, it does not rule out substance-free approaches either. The reason for this is that a learning bias need not emerge from the UG primitives from which phonological grammars are assembled. Instead, the learning bias could be

part of the evaluation metric in the sense of Chomsky (1955, 1957, 1965)-i.e., it is a way in which the Language Acquisition Device chooses amongst candidate grammars which account for the PLD, not part of those grammars themselves. The intuition here could be informally stated as follows.

(34) Naturalness Bias (presumably one of many in the evaluation metric)

Given a choice between two or more hypothesized rules which account for the PLD, choose the one which yields phonetically natural outputs.

Given something like (34), the experimental results can be explained even if the grammar itself is substance-free.

This section has reviewed research on an open issue which must be faced in all phonological frameworks, including RBP: that of the content of the phonological component of UG. We have focused on the question of whether UG itself contains any direct encoding of the notion of “markedness”. While most mainstream formal phonology through to the early 1990s was committed to a positive answer to this question, we have seen that the last two decades have given rise to an alternative position, according to which the generalizations covered by “markedness” emerge from the effects of articulatory, perceptual, and learning biases operating over time through language change. This latter position, if correct, makes it plausible that phonology itself is “substance-free” (Hale & Reiss 2008). We have attempted to outline the major empirical and conceptual parameters of this debate, which is ongoing.

4. Future Prospects

In this section we outline a few areas where we believe that phonological research could make significant headway, regardless of one’s theoretical predilections.

- **Language in other modalities**

Though many theoretical linguists have believed for some time now that the human language faculty (including its phonological component) is modality-independent, phonological research still focuses almost exclusively on the medium of oral speech and acoustic processing thereof. As discussed in the

previous section, this opens the door for confusions of speech-specific effects with general modality-independent phonological structures. In Optimality Theory, for example, many of the constraints proposed to form part of Universal Grammar are specific to the oral/aural modality, such as *g “[g] is prohibited” (McCarthy and Prince 1995:105), *a “assign one violation mark for each [a] in the output” (Rosenthal 2006), or IDENTF1 “the first formant values of the input and the output must be identical” (Flemming 2002:34).

We know from the study of signed languages, though, that language in non-speech modalities can also show phonological patterning and processes (Stokoe 1960, Brentari 1990, etc.), suggesting that phonology, like syntax, is modality-independent (and hence, in our opinion, part of the grammar/computational system that arguably forms the core of the human language faculty). As in our opinion there are at least hundreds and likely thousands of signed languages yet to be studied, this represents a rich test bed for the investigation of what is universal and what is not in the phonological component of the language faculty.

- **Language acquisition**

Though the importance of conceptual issues and empirical data in language acquisition is already widely recognized by phonologists, the types of questions investigated tend to be relatively superficial: In what order are segments and syllable types acquired? How are phonotactics learned? More promising in our opinion is the use of (both normal and abnormal) acquisition data to investigate more abstract workings of phonological and general computation: What kinds of phonological hypotheses are entertained by learners? What kinds of phonological processes do and don't transfer from one's native system when learning a second language? Can learners acquire opaque phonological generalizations, and if so how? The answers to these and similar questions have significant implications for competing phonological theories. For example, Ferguson (1992:487-8, citing Dunn 1983, Elbert et al. 1984, Gierut 1985, LSHSS 1988, Tyler et al. 1987) points out that generalization in the course of first- and second-language phonological development (“when intervention by the therapist or teacher focuses on a particular pronunciation problem of the learner, improvement in the trained pronunciation takes place, and then related improvements are observed in

untrained features of pronunciation”) is a “valuable and under-utilized tool of phonological research [because] the range of atypical, idiosyncratic phonological systems and the possibilities of phonological mismatches across languages are so great”. RBP encodes the cognitive phenomenon of generalization directly, in the form of rules. OT on the other hand normally employs demotion- and (in some variants) promotion-based learning algorithms, which do not encode rule-like generalizations directly and are typically taken to change the grammar gradually. These RBP and OT views of learning make strikingly different predictions about what sorts of intermediate systems should surface in the course of acquisition, and what sorts of systems are and are not learnable.

The acquisition of opaque phonological interactions has been investigated to a certain extent, both empirically (Jesney 2005, Dinnsen and Gierut 2008) and theoretically (Tihonova 2009, Tessier 2015). These studies typically operate within an OT perspective, without comparison to RBP and ignoring problems that the phenomena adduced pose for existing OT learning algorithms (Tessier 2010), a notable exception being the work of Andrew Nevins (e.g. 2009, 2010). Limiting one’s purview to OT (or to RBP, for that matter) necessarily restricts the questions one asks, and the interpretation of one’s findings. It is our opinion that investigation of acquisition with an eye towards identifying and testing predictive differences between theories offers more hope for progress.

One development in the field that may facilitate rapprochement between RBP and OT, and between rationalist and reductionist perspectives more generally, is the rise of sophisticated mathematical techniques for modeling the acquisition process, notably involving information theory and Bayesian probability (see e.g. Hayes and Wilson 2006, Goldsmith and Riggle 2012). The first two of these had significant effects on Jakobson and Halle and hence on seminal phonological works such as Jakobson, Fant, and Halle 1952 and Chomsky and Halle 1968, but their influence on phonological theorizing attenuated rapidly until these lines of thinking were (re-)introduced from computer science and statistics in recent years. Both Bayesian and information-theoretic models offer the prospect of integrating leading ideas from Chomskyan research (e.g. Bayesian priors are comparable to analytic biases in UG that constrain the hypothesis space) and more

empirically- and probabilistically-oriented models (e.g. the maintenance and weighting of competing hypotheses in Bayesian analysis is in principle compatible with variationist theories such as Yang 2002).

5. Conclusions

We have tried to emphasize in this chapter the importance of focusing on predictive differences between theories (particularly, though not exclusively, RBP and OT), as this method reduces the likelihood of falling into local optimality traps (ones where the linguist reaches the best possible solution given a particular set of theoretical assumptions, but misses a superior analysis made possible in a competing framework). We have suggested that, contrary to what some have claimed in the literature, leading implementations of RBP and OT do in fact reveal predictive differences. While the weight of these supports RBP overall, we hold out hope that the best insights of both perspectives may eventually be integrated in a more robust model of the phonological component.

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