Cyclicity or sympathy? A case study

Ricardo Bermúdez-Otero
University of Newcastle

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AIMS

(1) This paper aims to:

- address the problem of modelling *opaque* phonological generalizations in OT;
- demonstrate that solutions relying on *cyclicity* and *stratification* are superior to monostratal approaches relying on multiple parallel relationships of correspondence, notably *sympathy*.

(2) To this end, the paper will:

- refute Sympathy Theory's claim to greater restrictiveness by demonstrating the existence of *nonparadigmatic nonvacuous Duke-of-York gambits* with an example from Catalan;
- prove that Sympathy Theory is liable to *Richness-of-the-Base paradoxes* by showing that it cannot deal with the facts of Catalan whilst respecting Richness of the Base;
- show that, unlike Sympathy Theory, cyclic implementations of OT account for the *learnability* of opaque phonological generalizations.

WHY IS OPACITY INTERESTING?

Definition

(3) Kiparsky's (1982 [1971]: 75; 1973: 79) rule-based definition:

A rule ℜ of the form *a*→*b* / *c*__*d* is opaque if there are surface representations in the language having

either	(i) *a* in the environment *c*__*d*	(underapplication)
or	(ii) *b* derived by ℜ in an environment other than *c*__*d*	(overapplication)

Topical interest

(4) A large set of phonological phenomena previously modelled by means of opaque rules cannot be described in strictly parallel (monostratal) OT as classically presented in Prince & Smolensky (1993).

The signature of underapplication:

- a language has grammatical output forms containing [AXB],
- yet there is independent evidence requiring the ranking *AXB » FAITH-X.

The signature of overapplication:

- a language has expressions where input /X/ is unfaithfully mapped onto output [Y],
- yet there is no markedness constraint 𝔐 ranked above FAITH-X such that the mapping /X/→[Y] in these expressions increases harmony with respect to 𝔐.

NB: Not all phenomena analysed opaquely in rule-based theory are problematic for OT; the term 'opacity' has different extensions in the two contexts (Bermúdez-Otero 1999: §3.2.3).

Long-term interest

(5) Opacity constitutes one of the clearest instances of *Plato's Problem* in phonology, as the learner faces the challenge of acquiring a generalization that is not true on the surface.

For this reason, opacity provides a key argument for *autonomous phonology* (i.e. phonology that is irreducible to phonetics and/or general cognition); cf. Carr (2000), see Bermúdez-Otero (forthcoming).

By implication, explaining the acquisition of opaque phonological generalizations should become a *raison d'être* for phonological theory in the generative paradigm.

OPACITY IN OT: CYCLICITY VS SYMPATHY

Cyclic OT

(6) Some refs: Orgun (1996, 1999), Bermúdez-Otero (1999), Kiparsky (2000, forthcoming).

Key ideas:

(7) • *Cyclic application*
Given a linguistic expression *e* with a phonological input representation *I*, the phonological function $\mathcal{P}$ applies recursively within a nested hierarchy of phonological domains associated with (but not necessarily isomorphic with) the morphosyntactic constituent structure of *e*:

i.e. if $I = [[x][[y]z]]$, then $\mathcal{P}(I) = \mathcal{P}(\mathcal{P}(x),\mathcal{P}(\mathcal{P}(y),z))$

(8) • *Level segregation*
The phonology of a language does not consist of a single function $\mathcal{P}$ but of a set of distinct functions or 'cophonologies' $\mathcal{P} = \{\mathcal{P}_1, \mathcal{P}_2 \ldots \mathcal{P}_n\}$, such that the specific function $\mathcal{P}_i$ applying to domains of type d_i is determined by the type of morphosyntactic construction associated with d_i :

i.e. phonology = {stem-level phonology, word-level phonology, phrase-level phonology}

(9) • Each cycle involves a pass through $\mathcal{G}en$ and $\mathcal{E}val$: $\mathcal{P}(x) = \mathcal{E}val(\mathcal{G}en(x))$

There is no misapplication within cycles; opacity arises in the interaction between cycles.

Sympathy Theory

(10) Key refs: McCarthy (1998, 1999, to appear).

Key ideas:

(11) ❀O-*identity*
Apparent misapplication (opacity) is caused by constraints enforcing identity between the output O and a failed co-candidate possessing special status: the sympathy or ❀-candidate.

(12) *Selection of the ❀-candidate*
The ❀-candidate is the most harmonic among the set of candidates that satisfy a designated selector constraint or '✯-constraint', which must be an IO-faithfulness constraint.

Technical problems:

(13) *The asymmetry of ❀O-correspondence*
Unlike IO-faithfulness, which is symmetrical and reversible, ❀O-correspondence is stipulatively asymmetrical: ❀O-constraints affect the selection of O, but not that of ❀, for otherwise underapplication would be impossible (Bermúdez-Otero 1999: 143-148).

(14) *The failure of ✯-confinement*
The principle that the selector constraint must be an IO-faithfulness constraint has been empirically falsified (Itô & Mester 1997, de Lacy 1998, Bermúdez-Otero 1999).

Restrictiveness

Restrictions on opacity in cyclic OT

(15) Since there is no opacity within cycles...

- the complexity of opaque interactions is bound by the number of cycles, which is in turn bound by the morphosyntactic complexity of the linguistic expression;
- the phonology of the most inclusive domain (≈ the postlexical phonology) must be transparent.

See Bermúdez-Otero (1999: §3.3.3.1).

Restrictions on opacity in Sympathy Theory

(16) • Opaque interactions involve <u>at most one intermediate representation</u>:

A→B→C	≈	I→❀→O
A→B→C→D		✗

(17) • McCarthy has sought to <u>proscribe nonparadigmatic nonvacuous Duke-of-York gambits</u>:

(i)	*Duke-of-York gambit*	A→B→A
(ii)	*nonvacuous*	{ B escapes a process applicable to A (bleeding) B undergoes a process not applicable to A (feeding)
(iii)	*nonparadigmatic*	B does not surface as (part of) a grammatically related expression

(18) However, McCarthy's effort to render nonparadigmatic nonvacuous Duke-of-York gambits impossible within Sympathy Theory proves technically unsuccessful:

(i) it requires that ✯-constraints should be confined to the class of IO-faithfulness constraints (McCarthy 1999: 380-2), but this principle is empirically untenable —see (14) above;

(ii) it requires a completely *ad hoc* correspondence constraint ❀O-CUMUL that penalizes output candidates that are more faithful to the input than the ❀-candidate.

In any case, we shall demonstrate below that nonparadigmatic nonvacuous Duke-of-York gambits do in fact exist in natural language.

Learnability

(19) From the viewpoint of learnability, restrictiveness is largely irrelevant as a criterion for choosing between cyclic OT and Sympathy Theory:

If two theories of grammar T_1 and T_2 define the grammar spaces S_1 and S_2, and if both S_1 and S_2 are too large for convergence to be guaranteed by brute-force searching, then the prime determinant of learnability will be the relative efficiency of the learning algorithms associated with T_1 and T_2, rather than the relative size of S_1 and S_2 (see Tesar & Smolensky 2000: 2-3).

> The richness of the class of languages admitted by UG (its generative capacity) is a matter of no obvious empirical import. What is important is a requirement of "feasibility" that has no clear relation to the scope of UG [...] A theory of UG might fail to satisfy the feasibility requirement [even] if its scope were finite.
>
> Chomsky (1986: 55)

In other words, it is not enough to restrict the space of possible opacity effects; one must show how the learner is able to search that space effectively.

(20) Evaluating Sympathy Theory and cyclic OT with reference to learnability:

- There is, to date, no theory of the acquisition of sympathy-theoretic grammars (McCarthy 1999: 340).
- In cyclic OT, the learner may be able to identify the processes involved in an opacity effect by noting their transparent applications and then order them appropriately by referring to their morphosyntactic domain, which provides cues to their stratal ascription (see below).

NONSIBILANT VOICED OBSTRUENTS IN CATALAN: FACTS AND QUESTIONS

The facts

(21) *Catalan system of obstruent phonemes*:

p		t			k	
B		**D**			**G**	} nonsibilant voiced obstruents
			(ts)	(tʃ)		} bisegmental clusters?
			(dz)	(dʒ)		
	f		s	ʃ		
			z	ʒ		

Wheeler (1979: xxii, 222, 234, chs V and VI), Recasens (1991: 173), Hualde (1992: §3.1.1).

(22) *Allophones of the nonsibilant voiced obstruents* /B, D, G/:

- voiced continuants: [β, ð, ɣ] —phonetically frictionless [β̞, ð̞, ɰ]
- voiced noncontinuants: [b, d̪, ɡ]
- voiceless noncontinuants: [p, t̪, k]

(23) *Distribution*:

[p, t̪, k]		
• in the coda before a voiceless segment or pause:	[ʎo**p**]	'he-wolf'
	[ʎo**p**.tɾist]	'sad wolf'
	cf. [ʎo.**β**ə]	'she-wolf'
• in the onset only when prefix-final or word-final:	[ʎo.**p**ə.mik]	'friendly wolf'
	[su.**p**əl.pi]	'subalpine'
[b, d̪, ɡ]		
• in the coda before a voiced segment:	[ʎo**b**.ʎiw.ɾə]	'free wolf'
	[u**b**.ʒek.tə]	'object'
• after pause:	[**b**astə]	'enough!'
• after an oral stop:	[əmiɡ **b**ɔ]	'good friend'
• after a nasal:	[um **b**uto]	'a button'
• if coronal, after a lateral:	[əl̪ **d̪**iə]	'the day'
	[eʎ **d̪**iw]	'he says'
	cf. [eʎ **β**a]	'he goes'
• if labial, after a labial fricative:	[buv **b**ɾusk]	'abrupt puff'
	cf. [əv**ɣ**a]	'Afghan'
• in gemination:	[pɔ**bb**lə]	'people, village'
[β, ð, ɣ]		
• elsewhere:	[əna**β**ə]	'he went' imperf.
	[lə **β**akə]	'the cow'
	[əz**β**os]	'draft'
	[ez **β**law]	'is blue'
	[kər**β**o]	'coal'
	[mar **β**unik]	'pretty sea'

Underlying representation

(24) *The principle of Richness of the Base*

In OT there are no formal devices capable of imposing restrictions upon inputs.

In consequence, the predictable properties of the output must emerge from constraint interaction. Analyses in which the predictable properties of the output are simply stipulated in URs and then transmitted to SRs by faithfulness are inadmissible.

(25) NB:
- Richness of the Base is a constraint on the operation of the grammar, NOT on the actual content of the lexicon. Notably, the actual content of the lexicon is NOT indeterminate, but is fixed by optimization relative to surface forms (Prince & Smolensky 1993: §9.3; Inkelas 1995; Itô, Mester & Padgett 1995).
- Richness of the Base is a logical necessity in OT, but it also has empirical applications, notably in loan nativization (cf. Reiss 2000).

(26) In cyclic OT, only URs are subject to Richness of the Base:

The input to a noninitial level *n* is provided by the output of the previous level *n−1*. In consequence, the input to *n* will possess systematic properties defined by the constraint hieararchy of *n−1*.

(27) *Underlying specifications for* [continuant]

As shown in (23), one can predict the value of the feature [±continuant] for Catalan /B, D, G/ in all contexts.

In consequence, Catalan /B, D, G/ are underlyingly rich in continuancy specifications.

Underlying specifications for [strident]

I focus on /B/:

(28) • Standard Catalan has no /v/:

	/p/	/f/	/B/
Place	LAB	LAB	LAB
[voice]	−	−	+
[continuant]	−	+	
[strident]			

Constrastive specifications of the Catalan labial obstruents

(29) • Phonetically, [v] occurs only as a predictable allophone of /f/ in voicing assimilation contexts, viz. in the coda before a voiced segment:

e.g.	/buf/	[buf]	‘puff’
		[buv brusk]	‘abrupt puff’

[Wheeler (1979: 312) and Hualde (1992: 394) claim that /f/ also undergoes assimilatory voicing in prefix- or word-final position before a vowel, where it is resyllabified into the onset. Recasens (1991: 196) contradicts this claim. The discussion below follows Recasens, but it would require minimal adjustments to make it compatible with Wheeler’s and Hualde’s claims regarding the allophony of /f/.]

(30) • In addition, [β] fails to occur in the environments where /f/ undergoes voicing assimilation to [v], viz. in the coda. As a result, the stridency values of labial fricatives are fully predictable on the surface:

$$\begin{bmatrix}-\text{son}\\ +\text{cont}\\ -\text{voi}\\ \text{LAB}\end{bmatrix} \rightarrow [+\text{strid}] \qquad \begin{bmatrix}-\text{son}\\ +\text{cont}\\ +\text{voi}\\ \text{LAB}\end{bmatrix} \rightarrow \begin{Bmatrix}[+\text{strid}] & / & \overset{\text{Rh}}{\underline{\ \ |\ \ }} \\ [-\text{strid}] & / & \text{elsewhere}\end{Bmatrix}$$

(31) • In consequence, <u>Catalan /B/ is underlyingly rich in stridency specifications</u>.

Possible URs for /B/ include *b*, *β*, and *v*. The grammar must generate the correct surface realizations regardless of which of these URs is adopted.

The questions

(32) Why are the voiced continuants [β, ð, ɣ] excluded from the coda?
(Fabra 1912: §3, §15-III*; Mascaró 1984: 294; Hualde 1992: 369)

This fact is puzzling because:
- the syllable coda is a prime target for lenition processes such as spirantization;
- other Iberian languages such as Spanish and Basque have near-identical allophonic patterns, yet in neither is spirantization blocked in the coda (Mascaró 1984).

(33) Why do /B, D, G/ become noncontinuant when devoiced?

Note that:
- by Richness of the Base, these phonemes may be instantiated by continuants in URs —see (27);
- Catalan tolerates [f] and [s] in the devoicing environment.

CYCLIC ANALYSIS: A LEARNABLE NONVACUOUS DUKE-OF-YORK GAMBIT

The failure of spirantization in the coda

The interaction of voicing assimilation and spirantization

(33) /Gat/ 'cat'

(a)	*gat*	[gat]	'cat' masc.	
(b)	*gata*	[ga.tə]	'cat' fem.	
(c)	*gat gelós*	[ga**d**.ʒə.los]	'jealous cat'	cf. *[ga**ð**.ʒə.los]

(c) shows that
- there is a postlexical process of voicing assimilation targeting codas;
- word-level [p, t, k] do not undergo spirantization, even if voiced by assimilation.

(34) Postlexically, IDENT[voi]&IDENT[cont] outranks NOVOICEDSTOP

✓	[p] → [b]	*IDENT[voice]	*assimilation*
✓	[b] → [β]	*IDENT[cont]	*spirantization*
✗	[p] ——→ *[β]	*IDENT[voi]&IDENT[cont]	*fell swoop*

For the modelling of 'distantial faithfulness' through constraint conjunction, see Kirchner (1996).

Word-level devoicing

(35) /ʎoB/ 'wolf'

(a)	*lloba*	[ʎo.βə]	'she-wolf'
(b)	*llop*	[ʎo**p**]	'he-wolf'
(c)	*llob amic*	[ʎo.**p**ə.mik]	'friendly wolf'
(d)	*llob lliure*	[ʎo**b**.ʎiw.ɾə]	'free wolf'

- (b) shows that codas are subject to devoicing;
- (c) shows that devoicing must be word-level, as it overapplies to word-final codas resyllabified into onset position postlexically;
- in (d), word-level [p] undergoes postlexical voicing assimilation, but escapes spirantization, confirming the finding that spirantization only applies to segments that are voiced in the input to the postlexical level —see (33).

Devoicing and continuancy

(36) Why do /B, D, G/ become noncontinuant when devoiced?

- As shown in (35), devoicing applies at the word level.
- But, as shown in (26), the input to the word level is not subject to Richness of the Base, for it coincides with the output of the stem level.
- We must therefore conclude that /B, D, G/ are noncontinuant in the output of the stem level.

i.e. UR /B/ where /B/ = { b, β, v} as demonstrated in (28)—(31)
↓
Stem Level b
↓
Word Level p

(37) Stem-level hierarchy: IDENT[sibilant], IDENT[voi] » NOVOICEDFRICATIVE » NOVOICEDSTOP, IDENT[cont], IDENT[strid]

A nonvacuous Duke-of-York gambit

(38) In consequence, noncontinuant [b, d̪, g] in coda position arise through a bleeding Duke-of-York gambit:

UR		*Stem level*		*Word level*		*Phrase level*
/B/	→	[b]	→	[p]	→	[b]

Crucial intermediate steps in the derivation:
(i) the stem-level hierarchy maps continuancy-rich underliers onto stops, thereby guaranteeing that subsequent devoicing produces noncontinuant allophones;
(ii) word-level devoicing crucially bleeds postlexical spirantization.

☞ <u>Opaque derivations may crucially involve more than a single intermediate representation</u>; cf. (16).

(39)

	llop lliure	*enigma*		
UR	/ʎoB ʎiwɾə/	/əniGmə/	or	/ənikmə/
Stem Level	.ʎob. .ʎiw.ɾə.	.ə.nig.mə.		.ə.nik.mə.
Word Level	.ʎop. .ʎiw.ɾə.	.ə.nik.mə.		.ə.nik.mə.
Phrase Level	.ʎob.ʎiw.ɾə.	.ə.nig.mə.		.ə.nig.mə.

- In the derivation of *llop lliure*, the intermediate step in the Duke-of-York gambit, namely the devoiced word-level representation [ʎop], surfaces as an independent word.
- However, in the case of *enigma* from underlying /əniGmə/, the word-level representation [ənikmə] never surfaces. [Note that one cannot stipulate /ənikmə/ as the only possible UR because coda obstruents are subject to Richness of the Base in respect of voice.]

☞ <u>Nonparadigmatic nonvacuous Duke-of-York gambits do exist</u>; cf. (17).

(40) Is the Catalan Duke-of-York gambit learnable?

Yes!
- The child knows that voicing assimilation and spirantization are postlexical because both apply normally across word-boundaries.
- The child also knows that devoicing is word-level because it overapplies to word-final consonants resyllabified into the onset
- Alternations such as [ʎop]~[ʎobʎiwɾə] provide direct evidence that consonants subject to postlexical voicing assimilation do not spirantize.
- This, in turn, allow the child to assign a voiceless word-level representation to nonalternating consonants such as the [g] in [ənigmə].

Cf. Harris's (1993) analysis in rule-based LPM, which relies upon *extrinsic rule ordering within strata*. In Harris's analysis there is no consistent correlation between the morphosyntactic domain of a rule and its stratal ascription. Its learnability is therefore doubtful.

A RICHNESS-OF-THE-BASE PARADOX IN SYMPATHY THEORY

First attempt: forbidding (nonstrident) fricatives in the coda

(41) McCarthy (1998: §5) suggests that the underapplication of spirantization in Catalan codas is caused by a constraint against coda fricatives: NoCodaFricative.

Problem: Catalan tolerates the fricatives [f, v, s, z, ʃ, ʒ] in the coda.

Solution: The fricatives permitted in the coda are all strident: conjoin NoCodaFricative with Fricative→Strident so as only to exclude nonstrident [β, ð, ɣ] from the coda.

New problem: What prevents spirantization from circumventing this constraint by mapping /B/ onto strident [v]?
—Markedness? —No, voicing assimilation creates coda [v] from /f/.
—Faithfulness? —No, Richness of the Base prevents /B/ from being stipulatively specified as underlyingly nonstrident.

Second attempt: ❀-candidates with coda devoicing

(42) Key idea:
- Set up ❀-candidates with coda devoicing (analogous to the word-level representation): selector = ✭NoVoiObsInCoda
- Outputs cannot be unfaithful to the voicing and to the continuancy of the ❀-candidate simultaneously: ❀O-Ident[voice]&❀O-Ident[cont]

Problem I: The ✭-constraint in not an IO-faithfulness constraint; see (14) and (18i).

Problem II: How do we guarantee that devoicing of /B, D, G/ in the ❀-candidate produces stops? In particular, what prevents input /B/ from being mapped onto [f]?
—Markedness? —No, in Catalan [f] is fine in the coda.
—Faithfulness? —No, /B/ is underlyingly rich in continuancy and stridency specifications.
—Another sympathy relationship? —No, ❀O-constraints cannot affect the selection of ❀-candidates? See (13).

(43) **Third attempt: ❀-candidates without voiced nonsibilant fricatives**

Key idea:
- Set up ❀-candidates without nonsibilant voiced fricatives (analogous to the stem-level representation), blocking /B/→[v] and /B/→[β] and enforcing /B/→[b]:
  selector = ✭{NoVoiObs&Fric→Sibil}
- Output codas must be faithful to the continuancy of their correspondents in the ❀-candidate: NoCoda&❀O-Ident[cont]

Problem I: The ✭-constraint is not an IO-faithfulness constraint; see (14) and (18i).

Problem II: The ✭-constraint incorrectly blocks assimilatory voicing of /f/ to [v], since [v] is strident but not a sibilant.

Problem III: We still have no answer for what prevents /B/→[f] in devoicing environments. See (42).

CONCLUSIONS

The morphology-phonology interface, paradigm effects, and opacity

(44)
- McCarthy treats paradigm effects and opacity as different problems:
  paradigm effects → OO-correspondence
  opacity → ❀O-correspondence
  As a result, monostratal OT fails to capitalize on one of the basic cues for the acquisition of opaque phonology, viz. the correlation between the morphosyntactic domain of processes and their stratal ascription.
- In cyclic OT, in contrast, the principles that govern the interface of phonology with morphology and syntax, namely cyclicity and stratification, independently account both for the existence of opacity effects and for their learnability.

Restrictiveness vs learnability

(45) With no effective line of attack on the learnability problem, Sympathy Theory must target the lesser goal of contriving formal restrictions on the space of possible opacity effects. However, these factitious restrictions have proved empirically untenable:

- opaque interactions may involve more than one intermediate representation;
- nonparadigmatic nonvacuous Duke-of-York gambits are formally possible and, as the Catalan case shows, they actually occur when they can be acquired on the back of paradigmatic ones.

Richness-of-the-Base paradoxes and basic allophones

(46)
- Monostratal versions of OT cannot accommodate the notion of a 'basic allophone': input representations subject to Richness of the Base must be directly mapped onto the output. This gives rise to Richness-of-the-Base paradoxes ─as Itô & Mester (2001) also observe.
- In cyclic OT, in contrast, the scope of Richness of the Base is limited to the first stratum. In this context, the realization of an underlying segment in the output of the initial stratum (the stem level) takes on the rôle of the 'basic allophone' in classical structuralist or SPE phonology.

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