Phonological domains and opacity effects: a new look at voicing and continuancy in Catalan

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INTRODUCTION

§1 This paper reports on the results of Bermúdez-Otero's (2001, 2002) Stratal OT analysis of obstruent voicing and continuancy in Catalan.

(For Stratal OT, see e.g. Bermúdez-Otero 1999, forthcoming; Kiparsky 2000, 2003; Orgun 1996.)

§2 The Stratal OT analysis enjoys a number of advantages:

- the ascription of each phonological process to the corresponding phonological level is solely determined by the grammatical domain within which the process applies;
- opacity effects in nonalternating environments are generated by the same means as opaque alternations;
- in consequence, learners are able to use evidence from alternations to acquire opaque nonalternating outputs.

§3 At the same time, the stratal analysis highlights important challenges to other approaches to opacity in OT:

- strictly parallel models face a Richness-of-the-Base paradox owing to their inability to select a single allophone of each Catalan obstruent phoneme as basic;
- the analysis crucially requires two intermediate stages between underlying and surface representation;
- some nonalternating forms go through a nonvacuous Duke-of-York derivation.

§4 In the light of the Catalan data, the paper will conclude by reflecting on the main issues confronting research into phonological opacity within OT.

VOICING AND CONTINUANCY IN CATALAN: THE FACTS

Catalan obstruents

§5 Standard (Central) Catalan possesses the following obstruent phonemes :

p	t̪			k
b	d̪			g
	f		s	ʃ
			z	ʒ

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

NB: It is unclear whether /ts, dz, tʃ, dʒ/ should be treated as single segments or as bisegmental clusters. As they are not crucial to the argument, I shall ignore them here.

Voicing neutralization

Voice contrasts are neutralized in the coda.

[On the problem of incomplete neutralization, see §19 below.]

§6 • Voiceless realizations in the coda before a voiceless segment or pause:

/p/→[p]	/t̪/→[t̪][1]		/k/→[k]
/b/→[p]	/d̪/→[t̪][1]		/g/→[k]
/f/→[f]	/s/→[s]	/ʃ/→[ʃ]	
	/z/→[s]	/ʒ/→[tʃ][2]	

e.g.	/p/	*escu*[p]	‘(s)he spits’	cf. *esco*[p]*ir*	‘to spit’
		escu[p] *tot*	‘(s)he spits everything’		
	/b/	*llo*[p]	‘he-wolf’	cf. *llo*[β]*a*	‘she-wolf’
		llo[p] *trist*	‘sad he-wolf’		
	/f/	*bu*[f]	‘puff’	cf. *bu*[f]*ar*	‘to puff’
		bu[f] *calent*	‘warm puff’		

[1] When the following segment is [−continuant], /t̪/ and /d̪/ normally undergo total assimilation (Hualde 1992: §3.4.1.1.4):

e.g.	*atleta*	[ə**l**.lɛ.tə]	‘athlete’
	advertir	[ə**b**.bər.ti]	‘to warn’

[2] /ʒ/ undergoes affrication in the coda (Wheeler 1979: 309-310; Mascaró 1984: §4, 1986: 165-166:

e.g.	*boja*	[bɔ.**ʒ**ə]	‘madwoman’
	boig	[bɔ**tʃ**]	‘madman’

§7 • Voiced realizations in the coda before voiced segments (including sonorants):

/p/→[b]	/t̪/→[d̪]		/k/→[g]
/b/→[b]	/d̪/→[d̪]		/g/→[g]
/f/→[v]	/s/→[z]	/ʃ/→[ʒ]	
	/z/→[z]	/ʒ/→[dʒ]	

e.g.	/p/	*escu*[b] *molt*	‘(s)he spits a lot’
	/b/	*llo*[b] *lliure*	‘free he-wolf’
	/f/	*bu*[v] *brusc*	‘abrupt puff’

However, voice neutralization overapplies to prefix-final and word-final obstruents resyllabified into the onset:

§8 • Prefix- or word-final stops resyllabified into the onset surface as voiceless:

e.g.	/p/	*escup això*	[əs.ku.**p**ə.ʃɔ]	‘spit this’
	/b/	*llop amic*	[ʎo.**p**ə.mik]	‘friendly he-wolf’
	/p~b/	*subalpí*	[su.**p**əl.pi]	‘subalpine’

NB Pronominal enclitics are part of the morphological word (Bermúdez-Otero 2006; cf. Harris 1993):

e.g.	/p/	*escup=ho*	[əs.ku.**p**u]	‘spit it’		
	/b/	*rep=ho*	[rɛ.**β**u]	‘receive it’	cf. *re*[β]*re*	‘to receive’

§9 • Prefix- or word-final fricatives resyllabified into the onset surface as voiced:

e.g.	/f/[1]	*buf enorme*	[bu.**v**ə.nor.mə]	‘enormous puff’	
	/s/	*gos alat*	[go.**z**ə.lat]	‘winged dog’	cf. *go*[s]*a* ‘bitch’
	/z/	*vas enorme*	[va.**z**ə.nor.mə]	‘enormous glass’	cf. *va*[z]*os* PL
	/s~z/	*bes-avi*	[bə.**z**a.βi]	‘great-grandfather’	

[1] According to Wheeler (1979: 312) and Hualde (1992: 394), /f/ behaves like the sibilant fricatives. Recasens (1991: 196) denies this, asserting that /f/ is realized as [f] before word-initial vowels in all dialects; so too Wheeler (2005: 148-149). Below I follow Wheeler (1979) and Hualde (1992), but the point is not crucial to the overall argument.

Spirantization

The nonsibilant voiced obstruent phonemes /b, d̪, g/ have noncontinuant and continuant allophones:

§10 In voicing neutralization environments, /b, d̪, g/ have noncontinuant allophones:

• /b, d̪, g/ → [p, t̪, k]

in the coda before pause	*llo*[p]	‘he-wolf’
in the coda before a voiceless segment	*llo*[p] *trist*	‘sad he-wolf’
in prefix-final or word-final onset position	*llo*[p] *amic*	‘friendly he-wolf’

• /b, d̪, g/ → [b, d̪, g]

in the coda before a voiced segment	*llo*[b] *lliure*	‘free he-wolf’

§11 Outside voicing neutralization environments, the continuancy of /b, d̪, g/ is determined allophonically by a process of spirantization:

• /b, d̪, g/ → [b, d̪, g] in the onset…

after pause	[**b**]*asta!*	‘Enough!’		
after an oral stop	*ami*[g **b**]*o*	‘good friend’		
after a nasal stop	*a*[ɲ **b**]*inen*	‘next year’		
/d̪/→[d̪] after laterals	*e*[ʎ **d̪**]*iu*	‘he says’	cf. *e*[ʎ β]*a*	‘he goes’
/b/→[b] after /f/	*bu*[v **b**]*rusc*	‘abrupt puff’	cf. *a*[vɣ]*à*	‘Afghan’
in gemination	[pɔ**b.b**lə]	‘people’		

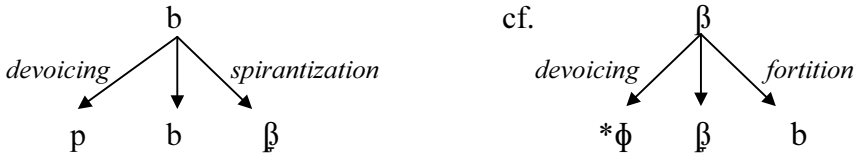
• /b, d̪, g/ → [β̪, ð̪, ɯ] in other onset positions:

e.g.	*l*[ə **β̪**]*aca*	‘the cow’
	é[z **β̪**]*lau*	‘is blue’
	e[ʎ **β̪**]*a*	‘he goes’
	ma[r **β̪**]*onic*	‘pretty sea’

AN ANALYSIS IN STRATAL OT

The 'basic allophones'

§12 Intuitively, one would want to say that the 'basic allophone' of /b/ is [b], as the other allophones, viz. [p] and [β̞], can be easily derived from [b] by small featural changes:



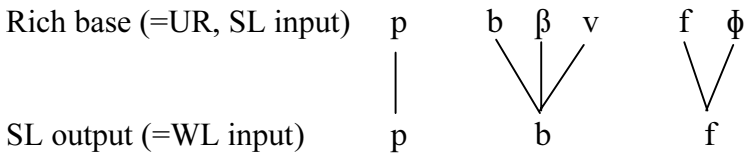
§13 However, Richness of the Base prevents one from stipulating predictable, noncontrastive properties in underlying representations:

Lexically contrastive specifications of the labial obstruents of Standard Catalan

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

§14 In Stratal OT, however, the stem-level constraint hierarchy imposes systematic restrictions upon the input to the word-level (and phrase-level) phonology.

This enables us to fix the redundant continuancy and stridency values of the Catalan obstruents:



§15 Some high-ranking constraints at the stem level:

- NOVOICEDFRICATIVE
  Bans [β, v, ð, ɣ]; outranked by faithfulness constraints protecting the sibilants /z, ʒ/.
- *[−strident]
  Bans [ɸ, θ].

For further details, see Bermúdez-Otero (2001: §3.4).

Voicing neutralization

§16 The level ascription of voicing neutralization

- Voicing neutralization must apply at the word level, since it affects prevocalic word-final obstruents, which are in the coda at the word level but are undergo resyllabification into the onset at the phrase level (§8, §9).

  [For prefixes, assume a prosodic word boundary at the prefix-stem juncture, crossed by onset-satisfying resyllabification only at the phrase level: see Bermúdez-Otero (2001: 3.31).]

- On the other hand, the surface voicing of neutralized obstruents is determined by assimilation, which must be phrase-level since it applies across word boundaries (§6, §7).

§17 A two-step solution

- Coda obstruents lose their laryngeal node at the word level.
- Delaryngealized obstruents are supplied with voicing specifications by assimilation at the phrase level, with [−voice] assigned by default in the absence of a suitable assimilation trigger.

[A following vowel can trigger assimilatory voicing in fricatives, but not in stops. The analysis correctly predicts that fricatives assimilate in voicing to a following vowel only when they are syllabified in the coda at the word-level (i.e. prefix- or word-finally).]

Cf. the classic rule-based autosegmental account in Mascaró (1987). On voicing neutralization as delaryngealization, see Steriade (1997: §1.2). For discussion of the relevant constraint rankings, see Bermúdez-Otero (2001: §3.5)

§18 Examples

	llo/b/ *tri*/st/	*llo*/b/ *lliure*	*llo*/b/ *ami*/g/
SL	.ʎob. .tɾist.	.ʎob. .ʎiw.ɾə.	.ʎob. .ə.mig.
WL	.ʎo**P**. .tɾi**ST**.	.ʎo**P**. .ʎiw.ɾə.	.ʎo**P**. .ə.mi**K**.
PL	.ʎo**p**.tɾi**st**.	.ʎo**b**.ʎiw.ɾə.	.ʎo.**p**ə.mi**k**.
	‘sad he-wolf’	‘free he-wolf’	‘friendly he-wolf’
	go/s/*a*	*go*/s/	*go*/s/ *enorme*
SL	.go.sə.	.gos.	.gos. .ə.nor.mə.
WL	.go.sə.	.go**S**.	.go**S**. .ə.nor.mə.
PL	.go.sə.	.go**s**.	.go.**z**ə.nor.mə.
	‘bitch’	‘dog’	‘enormous dog’

§19 The problem of incomplete neutralization

Under certain circumstances, some Catalan speakers produce minute but instrumentally detectable phonetic differences between /p, t̪, k/ and /b, d̪, g/ in voicing neutralization environments (Dinnsen & Charles-Luce 1984, Charles-Luce 1993; see further references in Wheeler 2005: 149):

i.e. /sek/ ‘dry’ and /seg/ ‘I sit down’ may not be completely homophonous.

Is this compatible with an account based on categorical delaryngealization?

Yes. Possible mechanisms for the partial maintenance of the underlying contrast under delaryngealization:

- extralinguistic factors (e.g. Manaster Ramer 1996)
- biased exemplar-based phonetic implementation (Pierrehumbert 2002)
- prior to delaryngealization (i.e. at the stem level), the laryngeal contrast between /p, t̪, k/ and /b, d̪, g/ is redundantly enhanced by other (nonlaryngeal) features (e.g. 'sonorant voicing' in Rice & Avery 1989: 76).

§20 Assimilation: gradient or categorical?

Cuartero Torres (2001) provides phonetic evidence to suggest that Catalan laryngeal assimilation operates

- sometimes categorically (i.e. by feature spreading in the phonology)
- sometimes gradiently (i.e. by gestural overlap in phonetic implementation)

The stratal analysis is compatible with both, since the domain evidence only shows that assimilation applies across the board:

- phrase level → across the board, categorical
- phonetic implementation → across the board, gradient

The interaction of delaryngealization and spirantization

§21 Properties of spirantization:

- Domain: applies across word boundaries, e.g. *a*[ɲ b]*inen* 'next year',
  ma[r β̪]*onic* 'pretty sea';
  therefore phrase-level.
- Input: applies to nonneutralized [b, d̪, g] in the input to the phrase level;
  does not apply to delaryngealized [P, T, K] in the input to the phrase level.

E.g.	*llo*/b/*a*	*llo*/b/ *lliure*
SL	.ʎo.ba.	.ʎob. .ʎiw.ɾə.
WL	.ʎo.**b**a.	.ʎo**P**. .ʎiw.ɾə.
PL	.ʎo.**β̪**a.	.ʎo**b**.ʎiw.ɾə.

§22 A distantial faithfulness effect (Kirchner 1996): no fell swoop from P to β̪

assimilation (✓)	P ⟶ b	violates IDENT-[voice]
spirantization (✓)	b ⟶ β̪	violates IDENT-[cont]
fell swoop (✗)	P ⟶ β̪	violates IDENT-[voice]&$_{seg}$IDENT-[cont]

Accordingly,

- the markedness constraint driving spirantization dominates IDENT-[cont];
- the markedness constraint driving assimilation dominates IDENT-[voice];
- but IDENT-[voice]&$_{seg}$IDENT-[cont] and the markedness constraint driving assimilation both dominate the markedness constraint driving spirantization.

EVALUATION AND COMPARISON WITH OTHER APPROACHES

Noteworthy properties of the Catalan grammar

§23 Two crucial intermediate stages between UR and SR (cf. McCarthy 1999)

e.g. *llo*/**b**/ *lliure*

rich base (= UR, SL input) **b β v**

SL output (= WL input) **b**

↓

WL output (= PL input) **P**

↓

PL output (=SR, input to phonetics) **b**

- The stem-level hierarchy maps a continuancy-rich and stridency-rich underlier onto a (voiced) stop, thereby guaranteeing that word-level delaryngealization will produce noncontinuant allophones.
- Word-level delaryngealization crucially bleeds phrase-level spirantization.

§24 A nonparadigmatic bleeding Duke-of-York gambit (cf. McCarthy 1999)

e.g. *objecte* [ub.ʒek.tə] 'object'

UR	u**{b,β,v}**ʒektə
SL	u**b**.ʒek.tə
WL	u**P**.ʒeK.tə
PL	u**b**.ʒek.tə

- Surface [ub.ʒek.tə] can also derive from underlying /up.ʒek.tə/, but /u{b,β,v}ʒektə/ must be countenanced under Richness of the Base.
- The Duke-of-York gambit is nonvacuous because word-level delaryngealization crucially bleeds phrase-level spirantization.
- In *o**b**jecte*, the Duke-of-York gambit is nonparadigmatic in the sense that the opaque output is nonalternating: cf. alternating *llob* in *llob lliure*.

§25 Correspondence between domains and levels:

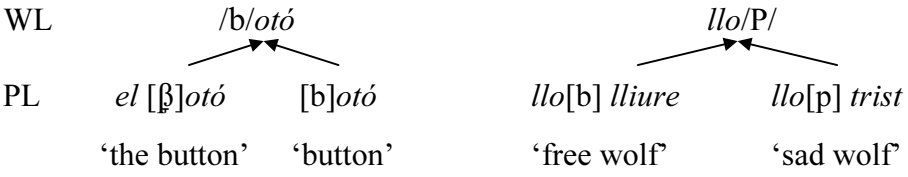
- Delaryngealization cannot see across word boundaries → word level
- Assimilation and spirantization can see across word boundaries → phrase level

§26 Learnability (Bermúdez-Otero 2003; see also McCarthy 2006)

How does the child learn that surface *o*[b]*jecte* derives from word-level *o*[P]*jecte*?

The child first analyses alternating items, proceeding from lower to higher levels. Then she uses the information learned from alternating items to assign input representations to nonalternating items (Archiphonemic Prudence).

- 1st step: Analysis of phrase-level alternations:



- 2nd step: Word-level phonotactic learning over phrase-level inputs such as /b/*otó* vs *llo*/P/:
  ⇨ in the word-level output, [b] occurs only in onsets,
  [P] occurs only in codas.

- 3rd step: Selection of phrase-level input for nonalternating items like *o*[b]*jecte*:
  ① two possible mappings: /b/→[b] as in [b]*otó*
  /P/→[b] as in *llo*[b] *lliure*
  ② *o*/b/*jecte* violates known word-level phonotactics ([b] in coda);
  o/P/*jecte* fulfils known word-level phonotactics ([P] in coda);
  ⇨ the phrase-level input must be *o*/P/*jecte*.

The challenge for strictly parallel models: a Richness-of-the Base paradox

On Richness-of-the-Base paradoxes, see Itô & Mester (2001).

§27 Some questions:

- Why are the voiced continuants [β̪, ð̪, ɰ̪] excluded from the coda?
  (see Fabra 1912: §3, §15-III*; Mascaró 1984: 294; Hualde 1992: 369)
- Why does [v] occur only in the environments $\_\_\ _{\sigma}]$, $[_{\sigma}\ \_\_\ _{\text{prefix}}]$, $[_{\sigma}\ \_\_\ _{\text{word}}]$?

§28 Hypothesis: NoCodaFricative bans [β, ð, ɣ] in the coda (McCarthy 1998: §5).

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

Solution Conjoin NoCodaFricative with *[−strident].

New problem: Given Richness of the Base, this still fails to prevent alternations such as /av/→[af] vs /av-ə/→*[avə].

§29 It looks as if a strictly parallel model can only capture the distribution in §27 by means of *ad hoc* constraints such as $*[_{\sigma}v$.

A SURVEY OF GENERAL ISSUES

Our Catalan case-study highlights several issues of importance for research into phonological opacity

Opaque or not opaque?

§30 *Morphology vs phonology*
All the processes involved in our Catalan case-study are exceptionlessly allophonic. In other cases, however, the alleged opaque process may have been morphologized.

§31 *Phonology vs phonetics*
Our analysis of Catalan assumes categorical delaryngealization at the word level, and hence requires that the evidence for incomplete voicing neutralization should be dealt with in one of the ways suggested in §19.

§32 *Representational issues*
One can often eliminate opacity by changing one's assumptions about the relevant representations:
e.g. Cebrian (1997) suggests that word-final prevocalic consonants are ambisyllabic in Catalan and hence transparently subject to coda neutralization (cf. §8, §9).

§33 *Assumptions about* CON
One can often eliminate opacity by changing one's assumptions about CON:
e.g. the Richness-of-the-Base paradox in §27-§29 disappears if we can postulate a constraint such as *[$_{\sigma}$v.

Richness of the Base

§34 Strictly parallel versions of OT cannot accommodate the notion of a 'basic allophone' (cf. §12-15): the rich base must be directly mapped onto the output. This gives rise to Richness-of-the-Base paradoxes, which may be far more frequently than acknowledged so far.

Paradigmatic vs nonparadigmatic opacity

§35 Stratal OT provides the same analysis for the opaque failure of spirantization in *llo*[b] *lliure*, where *llob* alternates, as in *o*[b]*jecte*, which does not alternate (§24).

Cf. McCarthy (1999): paradigmatic opacity → OO-correspondence
nonparadigmatic opacity → ❀O-correspondence

Do such approaches miss generalizations? Do they waste valuable learning cues?

Restrictiveness vs learnability

§36 Our Catalan case-study shows that certain formal restrictions on the space of possible opacity effects are empirically untenable (cf. McCarthy 1999):

- opaque interactions may involve more than one intermediate stage (§23);
- there are nonvacuous nonparadigmatic Duke-of-York gambits (§24).

However, formally restricting the range of opacity effects permitted by UG does not automatically guarantee improvements in learnability (see Chomsky 1986: 55; Tesar & Smolensky 2000: 2-3).

Should we therefore prioritize research on models likely to foster effective learning algorithms (Bermúdez-Otero 2003)?

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