# Marked phonemes vs marked allophones: segment evaluation in Stratal OT

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## OVERVIEW

§1 In classic OT (Prince and Smolensky 1993), grammars do not distinguish between contrastive and predictable tokens of a segmental feature (see e.g. Kirchner 1997).

However, having some means of encoding this distinction facilitates the analysis of allophony and of non-structure-preserving neutralization (i.e. of neutralizing processes creating segments that do not occur contrastively elsewhere):

e.g. Standard (Central) Catalan…
- allows [v] as an allophone of /f/ in voicing neutralization environments

but
- forbids [v] in positions where voicing is contrastive.

§2 Stratal OT (e.g. Bermúdez-Otero 1999, forthcoming; Kiparsky 2000) captures the behaviour of Catalan [v] without difficulty (Bermúdez-Otero 2001, 2002, 2006):

the markedness constraint crucially penalizing [v]
- is ranked high at the stem level, filtering out every /v/ present in the rich base,

but
- is ranked low at the phrase level (where voicing assimilation takes place), allowing [v] to arise as an allophone of /f/.

This stratal analysis is independently corroborated by evidence from the morphosyntactic domains of the processes involved in laryngeal neutralization (namely, delaryngealization and voicing assimilation).

§3 In classic OT, in contrast, the behaviour of Catalan [v] creates a ranking paradox that cannot be solved without appealing to special forms of faithfulness.

In classic OT, more generally, non-structure-preserving neutralization calls for similar enrichments of the universal constraint set (CON) as opacity, the well-known Achilles' heel of strictly parallelist models.

§4 Catalan's divergent evaluation of [v] in laryngeally contrastive and noncontrastive positions leads to exactly the same conclusion as the analysis of opaque phenomena and of morphology-phonology interactions in Stratal OT:

- there are synchronic ranking reversals (including markedness reversals), in the sense that distinct hierarchizations of CON can coexist in the same grammar (Bermúdez-Otero 1999: 104-7, 186; cf. Benua 1997: 90, 218, 225);
- coexisting rankings are associated with different cyclic domains.

## DISCRIMINATING BETWEEN CONTRASTIVE AND PREDICTABLE FEATURES IN OT

§5 In classic OT, there is no level of phonological representation where the grammar can discriminate between contrastive and predictable tokens of a segmental feature:

- not in surface representations, because individual markedness constraints do not know about contrast;
- not in underlying representations, because of Richness of the Base;
- not at an intermediate level of representation, because of Strict Parallelism.

### Contrastivity is not encoded in surface representations

§6 Ranking schemas for contrast, allophony, and neutralization (Pulleyblank 1997):

*Contrast*

(1) FAITH-[F] » *[F] — [F] contrastive in all environments

*Allophony*

(2) *A[¬F]B » *[F] » FAITH-[F] — no [F] except predictably in A__B

*Neutralization*

(3) C__D-FAITH-[F] » *[F] » FAITH-[F] — no [F] except contrastively in C__D

(4) *X[F]Y » FAITH-[F] » *[F] — [F] contrastive everywhere except X__Y

§7 Individual markedness constraints do not know about contrast; contrast emerges from constraint interaction: e.g.

- in the neutralization scenario in §6(3), the context-free markedness constraint *[F] assesses every token of [F] equally, whether in C__D (the contrastive position) or outside C__D (the neutralization position);
- positional markedness constraints do not know whether the feature whose presence they require or forbid in a particular environment occurs predictably or contrastively elsewhere: cf. §6(2) and §6(4).

### Contrastivity is not encoded in underlying representations

§8 *Output Orientation*

OT has no devices capable of imposing phonological well-formedness conditions on the input to the phonology.

⇓

*Richness of the Base*

An observationally adequate grammar for a language *L* must map

- the set of all underlying representations permitted by the universal principles of the theory of phonological representations and by the morphosyntax of *L* (a.k.a. 'the rich base')

onto
- the set of all and only the well-formed surface representations in *L*.

§9 *Underlying representations are epiphenomenal*

Given a grammar $\mathcal{G}$, any lexical item *l* has a set of possible underlying representations $U = \{u_1, u_2, \ldots, u_n\}$ consisting of all the members of the rich base that $\mathcal{G}$ causes to be mapped onto the right surface alternants for *l*.

$\mathcal{G}$ is the primitive; *U* is defined in terms of $\mathcal{G}$, rather than vice versa. Therefore, the choice between the members of *U* (when $|U| > 1$) can never be crucial (see Prince and Smolensky 1993: §9.3).

⇓

The logical structure of OT therefore rules out analyses that crucially depend on the exclusion of noncontrastive information from underlying representations.

**Can predictable information be factored out at an intermediate level of representations?**

§10 *In classic OT, no.*

In classic OT there are no intermediate representations; underlying representations are mapped onto surface representations in a single step.

§11 *In stratal OT, yes.*

underlying representation ← Richness of the Base holds only here
⇩
stem-level constraint hierarchy ← allophony/neutralization can happen here
⇩
stem-level representation
⇩
word-level constraint hierarchy ← allophony/neutralization can happen here
⇩
word-level representation
⇩
phrase-level constraint hierarchy ← allophony/neutralization can happen here
⇩
phrase-level representation (=surface representation, input to phonetics)

⇓

All levels of representation other than the UR arise as the output of some computation and are therefore nonrich (i.e. subject to structural restrictions).

If some neutralization or allophony process $\mathcal{P}$ applies at the word or phrase level, then the predictable information introduced by $\mathcal{P}$ is invisible to earlier levels.

⇓

It is possible for the stem-level or word-level representation to be simultaneously:

(i) free from the noncontrastive features in the rich base
and (ii) free from predictable information introduced at later levels.

## THE PROBLEM OF CATALAN [v] IN CLASSIC OT

### Basic facts

§12 All Catalan obstruents except /f/ come in pairs of contrasting voiceless and voiced phonemes; there is no */v/.

| | | | | |
|---|---|---|---|---|
| /p/ | /t̪/ | | | /k/ |
| /b/ | /d̪/ | | | /g/ |
| | /f/ | /s/ | /ʃ/ | |
| | ❒ | /z/ | /ʒ/ | |

See Hualde (1992: §3.1.1), Recasens (1991: 173), Wheeler (1979, 2005).

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.

The absence of /v/ in Standard (Central) Catalan is a historical innovation; conservative dialects retaining /v/ are found in the Balearic Islands, the Camp de Tarragona, and parts of Valencia (Recasens 1991: 183).

§13 Laryngeal contrasts are preserved in the onset and neutralized in the coda: obstruents are

- predictably voiced in the coda before voiced consonants (including sonorants)
- predictably voiceless in the coda before voiceless consonants and pause.

| | | /p/ | | /b/ | |
|---|---|---|---|---|---|
| contrast | { | *esco*[p]*ir* | ‘to spit’ | *llo*[β̪]*a* | ‘she-wolf’ |
| neutralization | { | *escu*[p] | ‘(s)he spits’ | *llo*[p] | ‘he-wolf’ |
| | | *escu*[p] *tot* | ‘(s)he spits all’ | *llo*[p] *trist* | ‘sad he-wolf’ |
| | | *escu*[b] *molt* | ‘(s)he spits a lot’ | *llo*[b] *lliure* | ‘free he-wolf’ |

See Hualde (1992: 393-94), Recasens (1991: chs. VI and VII, specially 176), Wheeler (1979: 310-13; 2005: ch. 5). Coda /t̪/, /d̪/, and /ʒ/ exhibit additional behaviours that are not relevant here: see Bermúdez-Otero (2006: §6) and references therein. On the issues of incomplete neutralization and gradient assimilation, see Bermúdez-Otero (2006: §19-§20)

Neutralization overapplies to suffix-final and word-final onsets: see §31 below.

§14 [v] occurs only in the coda as an allophone of /f/ before voiced segments:

e.g.

| /f/ | |
|---|---|
| *bu*[f]*ar* | ‘to puff’ |
| *bu*[f] | ‘puff’ |
| *bu*[f] *potent* | ‘powerful puff’ |
| *bu***[v]** *brusc* | ‘abrupt puff’ |

See Recasens (1991: 196), Wheeler (2005: 148-49). Cf. Hualde (1992: 394) and Wheeler (1979: 312), who claim that /f/ also undergoes assimilatory voicing word-finally before vowels, like the sibilants: see §34 below.

§15 The ban on [v] in laryngeally contrastive positions (i.e. in the onset) is productive, e.g. in loanword adaptation:

foreign onset [v] is adapted as Catalan /b/, with the corresponding allophony

| | | | | |
|---|---|---|---|---|
| French | **[v]***aude***[v]***ille* | > | **/b/***ode***/b/***il* | *un* **[b]***ode***[β̪]***il*, *de* **[β̪]***ode***[β̪]***il* |
| English | **[v]***olleyball* | > | **/b/***oleibol* | *en* **[b]***oleibol*, *a* **[β̪]***oleibol* |
| Russian | **[v]***odka* | > | **/b/***odka* | *un* **[b]***odka, de* **[β̪]***odka* |

This pattern of loanword adaptation matches the diachronic development of early Catalan /v/:
e.g. *serva* 'serf.F' /servə/→[ser.və] > /ser**b**ə/→[ser.β̪ə].

**Beckman's classic account of laryngeal neutralization**

§16 The standard account of Catalan laryngeal neutralization in classic OT is Beckman (1998: §1.3.1):

ONSIDENT-[voice], AGREE-[voice] » VOP » IDENT-[voice]

where VOP = *[−son, +voi]

- Top-ranked ONSIDENT-[voice] preserves voice constrasts in onsets.
- In heterosyllabic clusters, top-ranked AGREE-[voice] demands assimilation, which, given ONSIDENT-[voice], must be anticipatory.
- In prepausal codas, VOP demands devoicing.

§17 Beckman's account is observationally inadequate in a number of respects:

(i) AGREE-[voice] is problematic: it is usually defined as targeting obstruent clusters (e.g. Lombardi 1999: 272) but, in Catalan, coda obstruents assimilate even to sonorants: see §13.

(ii) Beckman does not address the voicing of word-final prevocalic sibilants (see §34 below).

(iii) Beckman does not explain what happens to /β/ in the rich base: why does surface [β̪] alternate with [p] rather than [f] in devoicing environments? (See §13 above and §30 below.)

Very few Catalan roots show a [β̪]~[f] alternation: *ser*[f] 'serf.M' vs *ser*[β̪]-*a* 'serf.F'. The alternation is clearly unproductive: see §29 below.

(iv) Crucially for a purposes, Beckman does not address the absence of onset [v].

Wheeler (2005: 152) notes (i) and (ii), but does not mention (iii) and (iv).

**Using context-free markedness leads to a ranking paradox**

§18 The logic of OT requires that the restricted distribution of [v] in Catalan should be interpreted as an effect of the marked status of this segment.

First attempt: invoke a context-free markedness constraint

e.g. *VD[−cor]FR = *[−son, +cont, −cor, +voi]

[Strong typological support: e.g.
the presence of voiced fricatives typically implies that of voiceless fricatives,
the presence of noncoronal oral fricatives implies that of coronal fricatives.]

§19 In order to exclude [v] from the onset, we need a ranking of the form

*VD[−cor]FR » ONSIDENT-[F], IDENT-[F]

where [F] is some feature of input /v/.

The evidence of loanword adaptation in §15 suggests that, in the onset, input /v/ should be mapped onto the contextually appropriate allophone of /b/, i.e. the plosive [b] or the approximant [β̞]. This requires the following:

*VD[−cor]FR » ONSIDENT-[strid], ONSIDENT-[cont], IDENT-[strid], IDENT-[cont]

[For the sake of argument, assume that [β̞], which is phonetically frictionless, does not violate *VD[−cor]FR.]

§20

| | *un* /v/*odka* | *VD[−cor]FR | ONSIDENT-[cont] | IDENT-[cont] |
|---|---|---|---|---|
| | *un* [v]*odka* | *! | | |
| ☞ | *un* [b]*odka* | | * | * |

§21 Since we don't want *VD[−cor]FR to interfere with the application of voicing assimilation to /f/, we must rank it below both AGREE-[voice] and ONSIDENT-[voice]:

| | *bu*/f b/*rusc* | AGREE-[voice] | *VD[−cor]FR | ONSIDENT-[voice] |
|---|---|---|---|---|
| | *bu*[f.b]*rusc* | *! | | |
| 💣 | *bu*[f.p]*rusc* | | | * |
| ☹ | *bu*[v.b]*rusc* | | *! | |

§22 However, the ranking ONSIDENT-[voice], AGREE-[voice] » *VD[−cor]FR still yields the wrong results: [v] arising from assimilatory voicing of /f/ is incorrectly repaired.

| | *bu*/f b/*rusc* | ONSIDENT-[voice] | AGREE-[voice] | *VD[−cor]FR | IDENT-[cont] |
|---|---|---|---|---|---|
| | *bu*[f.b]*rusc* | | *! | | |
| | *bu*[f.p]*rusc* | *! | | | |
| ☹ | *bu*[v.b]*rusc* | | | *! | |
| 💣 | *bu*[b.b]*rusc* | | | | * |

The problem: if *VD[−cor]FR can trigger a violation of IDENT-[F] for onset /v/, then it can also trigger a violation of IDENT-[F] for /f/ in the coda before a voiced consonant.

**Non-structure-preserving neutralization can be problematic in classic OT because the same constraint that prevents a segment from functioning contrastively can prevent it from emerging as an allophone.**

**Using positional markedness is typologically undesirable**

§23 The paradox in §22 disappears if we use a positional markedness constraint specifically banning [v] in onsets, but this incorrectly predicts the existence of languages where [v] is forbidden in the onset but occurs contrastively in codas:

| | | *[$_{\sigma}$v | ONSIDENT-[voice] | IDENT-[voice] |
|---|---|---|---|---|
| /fa/ | fa ☜ | | | |
| | va | *! | * | * |
| /va/ | fa ☜ | | * | * |
| | va | *! | | |

| | | *[$_{\sigma}$v | ONSIDENT-[voice] | IDENT-[voice] |
|---|---|---|---|---|
| /af/ | af ☜ | | | |
| | av | | | *! |
| /av/ | af | | | |
| | av ☜ | | | *! |

**A possible way out? Constraint conjunction**

§24 IDENT-[voice]&$_{seg}$IDENT-[cont] forbids the fell swoop /f/→[b]:

| *bu*/f b/*rusc* | ONSIDENT-[voice] | AGREE-[voice] | IDENT-[voice]&$_{seg}$IDENT-[cont] | *VD[−cor]FR | IDENT-[cont] |
|---|---|---|---|---|---|
| *bu*[f.b]*rusc* | | *! | | | |
| *bu*[f.p]*rusc* | *! | | | | |
| ☞ *bu*[v.b]*rusc* | | | | * | |
| *bu*[b.b]*rusc* | | | *! | | * |

§25 IDENT-[voice]&$_{seg}$IDENT-[cont] will have to be ranked judiciously so as not to prevent alternations like

| | |
|---|---|
| *llo*[β̪]*a* | 'she-wolf' |
| *llo*[p] *trist* | 'sad he-wolf' |

where the alternants differ simultaneously in continuancy and voicing

§26 More generally, this solution is stipulative and uninsightful: the ranking of IDENT-[voice]&$_{seg}$IDENT-[cont] does not follow from anything else in the grammar of Catalan.

In contrast, the stratal alternative (§28-§34 below) crucially depends on locating laryngeal neutralization at some stratum below the stem level. This assumption is independently confirmed by the evidence from cyclic domains (§31): in fact, this evidence requires a two-step account of laryngeal neutralization (§32), with word-level delaryngealization followed by phrase-level assimilation and voiceless default. This two-step account solves the problem of the word-final prevocalic sibilants for free (§34).

§27 The local conjunction of two faithfulness constraints, as in IDENT-[voice]&$_{seg}$IDENT-[cont], creates a 'distantial faithfulness effect' that can be used to deal with some *prima facie* opaque phenomena: notably, synchronic contextually-conditioned chain shifts (Kirchner 1996).

Similarly, Krämer (2006) uses comparative markedness (McCarthy 2002, 2003) to solve a case of non-structure-preserving neutralization in German: epenthetic [ʔ]. Again, comparative markedness is a technical patch for classic OT that has some opacity applications (McCarthy 2003: §5.3, 2003: §5.2).

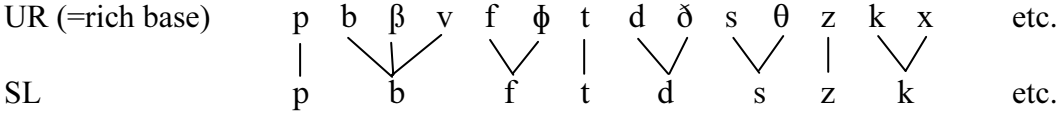
This is not a coincidence:

> **The property of classic OT that makes non-structure-preserving neutralization difficulty to deal with is strict parallelism.**
>
> **That is why any technical patch that can mimic a serial derivation in classic OT may be useful for coping with some instances of non-structure-preserving neutralization.**

## THE STRATAL ALTERNATIVE

### The stem level: collapsing the rich base onto contrastive elements

§28 At the stem level, the obstruents in the rich base are collapsed onto a roughly phonemic set:




*VD[−cor]FR is top-ranked in the determination of phonemic contrast.

In fact, the rankings that effect this mapping are relatively trivial: for one proposal, see Bermúdez-Otero (2001: §3.4).

§29 Implications of §28 for [v]:

- Since [v] is altogether absent at the stem level, it cannot surface in contrastive positions, but must always arise as a predictable realization of some other segment.
- Since /v/ in the rich base is mapped onto [b] in the output of the stem-level, /v/ undergoes exactly the same allophonic processes as /b/ at later level, such as phrase-level spirantization: e.g.

SL /**b**/*odka* (< Russian **[v]***odka*)

PL *un* **[b]***odka* *de* **[β̞]***odka*

One could conceivably posit more complex mappings for input /v/ in order to derive alternations such as *ser*[f] 'serf.M' vs *ser*[β̞]-*a* 'serf.F' and *me*[w] 'my.M' vs *me*[β̞]-*a* 'my.F', but these are entirely isolated and unproductive (see Wheeler 2005: 147).

§30 Another advantage:

Since the nonsibilant voiced phonemes /b, d, g/ are stops at the stem level, it automatically follows that they surface as stops when devoiced at later levels (see Bermúdez-Otero 2001, 2002, 2006):

SL *llo*/**b**/-

PL *llo***[p]** *llo***[β̞]***a*

* *llo***[ɸ]**

**The word and phrase levels: laryngeal neutralization is non-structure-preserving**

§31 The level ascription of laryngeal neutralization

- Laryngeal neutralization must occur at the word level, since it applies to prevocalic word-final obstruents, which are in the coda at the word level but are undergo resyllabification into the onset at the phrase level:

  e.g. *llo*/b/ *amic* → [ʎo.**p**ə.mik] 'friendly he-wolf'

  [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:

  e.g. *llo*[p] *trist* 'sadhe-wolf'
  *llo*[b] *lliure* 'free he-wolf'

§32 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.

Cf. the classic rule-based autosegmental account in Mascaró (1987). On voicing neutralization as delaryngealization, see Steriade (1999). For discussion of the relevant constraint rankings, see Bermúdez-Otero (2001: §3.5)

§33 Implications of §32 for [v]:

The high ranking of *VD[−cor]FR at the stem level (see §28) does not interfere with the derivation of [v] from /f/ at the word and phrase levels:

☞ No special stipulation is needed to capture the fact that word-level and phrase-level processes need not be structure-preserving.

§34 Another advantage:

Sibilants can assimilate in voicing to a following vowel, but only word-final (and prefix-final) sibilants do so, because only they are in the coda, and therefore delaryngealized, at the word-level (Bermúdez-Otero 2006: §17-§18)

| | *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’ |

Observe that the overapplication of voicing neutralization to onset /s/ in [go.**z**ə.nor.mə] cannot be explained by OO-correspondence, since the citation form *gos* has [s].

## THEORETICAL IMPLICATIONS

§35 In Stratal OT, the highest phonological stratum (the stem level) recaptures the insight that the inventory of segmental contrasts of a language is defined by the ‘cyclic rule component’ (Kiparsky 1982).

§36 Since each phonological stratum has its own constraint ranking, stratal OT automatically predicts that word-level and phrase-level allophony need not be structure-preserving.

§37 The evidence of non-structure-preserving word-level and phrase-level allophony independently supports the same conclusion as the analysis of opaque phenomena and of morphology-phonology interactions in Stratal OT:

- there are synchronic ranking reversals (including markedness reversals), in the sense that distinct hierarchizations of CON can coexist in the same grammar
- coexisting rankings are associated with different cyclic domains.

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