Storing morphologically complex forms: convergent evidence from grammar and psycholinguistics

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Introduction

General theme

§1 The assertion that morphologically complex forms can be lexically stored is often supported with psycholinguistic evidence: e.g.

- recognition latencies (e.g. Baayen et al. 2002)
- priming (e.g. Clahsen et al. 2003)

§2 But the lexical storage of complex forms can also be supported with arguments from linguistic theory: e.g.

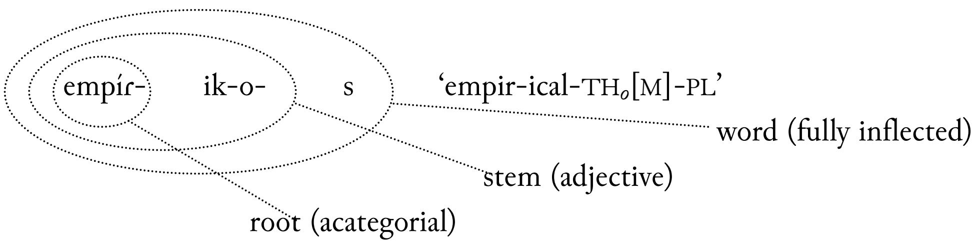
- local domains from allomorph selection (e.g. Bermúdez-Otero 2013, 2016)
- mismatches between semantics and morphophonology (e.g. Köhnlein 2015)

§3 The case for the lexical storage of complex forms is particularly persuasive when then two types of evidence, psycholinguistic and grammatical, converge.

Today's question: does the Spanish lexicon store <u>roots</u> or <u>stems</u>?

§4 Traditional definition of *stem*:
what remains of a lexical item after stripping away inflectional markers.

E.g. Spanish



§5 Most Spanish stems are complex: even when they do not contain an overt derivational suffix added to the root, they generally exhibit a theme vowel.

E.g. Spanish noun classes: the athematic set (d) constitutes a small minority.

Class		*Theme*	*Singular*	*Plural*	*Gloss*	*Gender*
a. *o*-stem		/-o-/	[lí-o]	[lí-**o**-s]	'muddle'	M
			[mán-o]	[mán-**o**-s]	'hand'	F
b. *a*-stem		/-a-/	[dí-a]	[dí-**a**-s]	'day'	M
			[kán-a]	[kán-**a**-s]	'grey hair'	F
c. *e*-stem	ordinary *e*-stem	/-{e,∅}-/	[lápiθ-∅]	[lápiθ-**e**-s]	'pencil'	M
			[lúθ-∅]	[lúθ-**e**-s]	'light'	F
			[páðɾ-e]	[páðɾ-**e**-s]	'father'	M
			[máðɾ-e]	[máðɾ-**e**-s]	'mother'	F
	e-only stem	/-e-/	[kɾúθ-e]	[kɾúθ-**e**-s]	'crossing'	M
			[éliθ-e]	[éliθ-**e**-s]	'propeller'	F
d. athematic		none	[fan]	[fan-s]	'fan'	M

§6 *The coupling question*

Theme vowel selection is lexically idiosyncratic:

- In nouns and adjectives, inflectional class is not predictable from gender:

e.g.	M	[lí-**o**]	'muddle'	vs	[dí-**a**]	'day'
	F	[kán-**a**]	'gray hair'	vs	[mán-**o**]	'hand'

- Inflectional class is not predictable from the phonological shape of the root either:
  e.g. roots ending in [án]

	sg.	pl.	
o-stem	[mán-o]	[mán-o-s]	'hand'
a-stem	[kán-a]	[kán-a-s]	'gray hair'
ordinary *e*-stem	[pan-∅]	[pán-e-s]	'bread'
e-only stem	[inán-e]	[inán-e-s]	'inane'
athematic stem	[fan]	[fan-s]	'fan'

§7 Two approaches to the coupling question:

(i) *Root storage*

- The lexicon stores bare roots.
- Roots bear inflectional class features that drive theme vowel selection.

Bonet (2006), Harris (1983, 1985a, 1991, 1992, 1996), Oltra-Massuet (1999), Oltra-Massuet and Arregi (2005), Roca (1990, 1991, 2005).

(ii) *Stem storage*

- The lexicon stores full stems, complete with their theme vowels.

Bermúdez-Otero (2006, 2007, 2013, 2016), Pena (1999), Pensado Ruiz (1999), Rainer (1993).

Background issue: the debate that pits grammatical frameworks assuming minimal storage and minimal redundancy against frameworks assuming a measure of lexical redundancy.

See Bermúdez-Otero (2012: 21ff) for references and discussion.

Preview of the argument from cyclic locality in allomorph selection

§8

- General strategy:

  Assuming a cyclic grammatical architecture, test the empirical predictions of the hypotheses of root storage and stem storage concerning local domains for allomorph selection.

- Diagnostic tool: the Spanish diphthongal alternation

  Allomorphs with stressed [jé, wé] alternate with allomorphs with unstressed [e, o]:
  e.g. ‘count/tell’ [k**wé**nt-a] 3SG ~ [k**o**nt-á-mos] 1PL

- Predictions:

  (i) If the Spanish lexicon stores allomorphs of roots, then allomorph selection should take place in the first cycle of the derivation, triggered by root-to-stem derivation.

  (ii) If the Spanish lexicon stores allomorphs of stems, then allomorph selection should take place in the second cycle of the derivation, triggered by a stem-based operation.

- Outcome:

  The predictions of the root storage hypothesis are falsified; those of the stem storage hypothesis are upheld. Attempts to rescue the root storage hypothesis are problematic.

- Corroborating evidence:

  (i) The hypothesis of stem storage correctly predicts that stems derived from the same root can diverge in their allomorphic behaviour.

  (ii) The hypothesis of stem storage makes correct predictions in psycholinguistic tests: e.g. effects of token frequency on recognition latencies.

THE DIPHTHONGAL ALTERNATION

The diphthongal alternation as phonologically driven allomorph selection

§9 Spanish has a large set of lexical items displaying an alternation between

	the diphthongs	/je, we/	in tonic syllables
and	the monophthongs	/e, o/	elsewhere.

	/e/~/jé/		/o/~/wé/	
a.	[pl**e**ɣ-á-ɾ]	'fold.INF'	[k**o**nt-á-ɾ]	'count-tell.INF'
	[pl**e**ɣ-a-ðóɾ-∅]	'(one) that folds'	[k**o**nt-a-ðóɾ-∅]	'counter'
	[pl**e**ɣ-á-βl-e]	'foldable'	[k**o**nt-á-βl-e]	'countable / accountant'
	[pl**jé**ɣ-a]	'fold.3SG'	[k**wé**nt-a]	'count-tell.3SG / sum(N)'
	[pl**jé**ɣ-o]	'fold.1SG / fold(N)'	[k**wé**nt-o]	'count-tell.1SG / tale'
	[s**e**nt-í-ɾ]	'feel.INF'	[k**o**θ-é-ɾ]	'boil.INF'
	[s**e**nt-i-ðóɾ-∅]	'that feels or can feel'	[k**o**θ-e-ðóɾ-∅]	'boiler'
	[s**jé**nt-e]	'feel.3SG'	[k**wé**θ-e]	'boil.3SG'
b.	[t**e**nd-éɾ-o]	'shoopkeeper'	[p**o**ɾt-éɾ-o]	'doorman'
	[t**jé**nd-a]	'shop'	[p**wé**ɾt-a]	'door'
c.	[d**e**nt-ál-∅]	'dental'	[m**o**ɾt-ál-∅]	'mortal'
	[d**jé**nt-e]	'tooth'	[m**wé**ɾt-e]	'death'
d.	[s**e**r-án-o]	'from the mountains'	[beneθ**o**l-án-o]	'Venezuelan'
	[s**jé**r-a]	'mountain range'	[beneθ**wé**l-a]	'Venezuela'
e.	[θ**e**ɣ-eðá^{ð}-∅]	'blindness'	[n**o**β-eðá^{ð}-∅]	'novelty'
	[θ**jé**ɣ-o]	'blind'	[n**wé**β-o]	'new'

§10 Membership in the alternating set is unpredictable:

- There are items in which /e, o/ fail to alternate between tonic and atonic syllables:

e.g.	[θ**é**st-a]	'basket'	[θ**e**st-éɾ-o]	'basket weaver'
	[k**ó**ɾ-o]	'choir / chorus'	[k**o**ɾ-ál-∅]	'choral'

- There are items in which /je, we/ fail to alternate between tonic and atonic syllables:

e.g.	[b**jé**n-a]	'Vienna'	[b**je**n-és-∅]	'Viennese'
	[sek**wé**stɾ-a]	'kidnap.3SG'	[sek**we**stɾ-á-ɾ]	'kidnap.INF'

- Though not abundant, there are even items containing morpheme-medial atonic /je, we/ lacking tonic correspondents:

e.g.	[aβ**je**tíno]	'pertaining to firs'	[ant**we**ɾpjénse]	'from Antwerp'
	[**ʝe**ɾátiko]	'hieratic'	[kons**we**tuðináɾjo]	'customary'
	[x**je**nénse]	'from Jaén'	[p**we**ɾíl]	'puerile'

Psycholinguistic experiments indicate that native speakers use lexical statistics to make informed guesses as to whether an item, e.g. a nonce probe, will alternate or not: see Eddington (2004: §6.1) for a survey of the literature, including Bybee and Pardo (1981) and Albright et al. (2001). This behaviour is expected and consistent with the results of similar 'deneutralization' experiments (e.g. Nevins and Vaux 2008).

§11 Implications:

(i) phonology (more narrowly, stress) controls the distribution of alternants;

but (ii) participation in the alternation is a lexical property,

and (iii) the quality of the alternating vowels is also lexically determined.

In support of (iii), note that there are lexical items that display exactly parallel stress-controlled alternations involving different vowel pairs (Harris 1985b: 32):

e.g.	**/i/~/jé/**	[aᶞ̥k**i**ɾ-í-ɾ]	'acquire.INF'	~	[aᶞ̥k**jé**ɾ-e]	'acquire.3SG'
	/u/~/wé/	[x**u**ɣ-á-ɾ]	'play.INF'	~	[x**wé**ɣ-o]	'play.1SG'

§12 Analysis:

<u>phonologically driven allomorph selection by output optimization</u>

(as opposed to phonologically driven allomorph selection by input subcategorization)

e.g. Kager (1996), Mascaró (1996, 2007), Nevins (2011), Rubach and Booij (2001), etc;

though cf. Paster (2006), Bye (2007), Embick (2010).

§13 Bermúdez-Otero (2013: 62)

<table>
<tr><th></th><th></th><th></th><th>IDENT</th><th>*PEAK_{FOOT}/e,o</th><th>*COMPLEXNUC</th></tr>
<tr><td rowspan="4">{kón.ta / kwén.ta} -doɾ</td><td rowspan="2">kón.ta - doɾ</td><td>kon.ta.dóɾ ☞</td><td></td><td>(*)</td><td></td></tr>
<tr><td>kwen.ta.dóɾ</td><td>*!</td><td>(*)</td><td>*</td></tr>
<tr><td rowspan="2">kwén.ta - doɾ</td><td>kon.ta.dóɾ</td><td>*!</td><td>(*)</td><td></td></tr>
<tr><td>kwen.ta.dóɾ</td><td></td><td>(*)</td><td>*!</td></tr>
</table>

Assumptions:

- Low-sonority nuclei are disfavoured as designated terminal elements of feet:
  i.e. *PEAK$_{\text{FOOT}}$/i,u ≫ *PEAK$_{\text{FOOT}}$/e,o ≫ ... (Kenstowicz 1997: 162)
- Diphthongal nuclei are more sonorous than pure vowels:
  i.e. *PEAK$_{\text{FOOT}}$/e,o ≫ *PEAK$_{\text{FOOT}}$/je,we

Opacity through stratification

§14 The alternation misapplies in the presence of certain affixes (in semantically compositional uses):

notably,

- diminutive *-(ec)it-o*
- augmentative *-az-o*
- augmentative *-ón-∅* in denominal and deadjectival uses only
- superlative *-ísim-o*
- causative *a-…-á-r* in deadjectival change-of-state verbs only

a. *normal application*	[b**je**x-o]	'old man / old'	[b**wé**n-o]	'good'
	[b**e**x-éθ-∅]	'old age'	[b**o**n-dá$^{\text{ð}}$-∅]	'goodness'
b. *misapplication*	[b**je**x-ón-∅]	'old_man.AUG'	[b**we**n-ón-∅]	'good.AUG'
	[b**je**x-áθ-o]	'old_man.AUG'	[b**we**n-áθ-o]	'good.AUG'
	[b**je**x-eθít-o]	'old(_man).DIM'	[b**we**n-eθít-o]	'good.DIM'
	[b**je**x-ísim-o]	'old.SUPL'	[b**we**n-ísim-o]	'good.SUPL'
	[a-β**je**x-á-ɾ]	'make_old.INF'		

§15 Analysis:

- the suffixes in §14 in are word-level;
- allomorph selection in the diphthongal alternation must take place in a stem-level cycle.

viejísimo

domain structure $[\![_{\text{WL}}\ [\![_{\text{SL}} \left\{\begin{matrix}\text{bex-o}\\ \text{bjex-o}\end{matrix}\right\}]\!]\ \text{ísim-o}\ ]\!]$

stem-level phonology bjéxo

word-level phonology bjexísimo

All stratal approaches draw this conclusion: e.g. Halle et al. (1991: 146), Bermúdez-Otero (2006: 286).

PROBLEMS FOR THE HYPOTHESIS OF ROOT STORAGE

Root allomorphy incurs the problem of the missing cycle

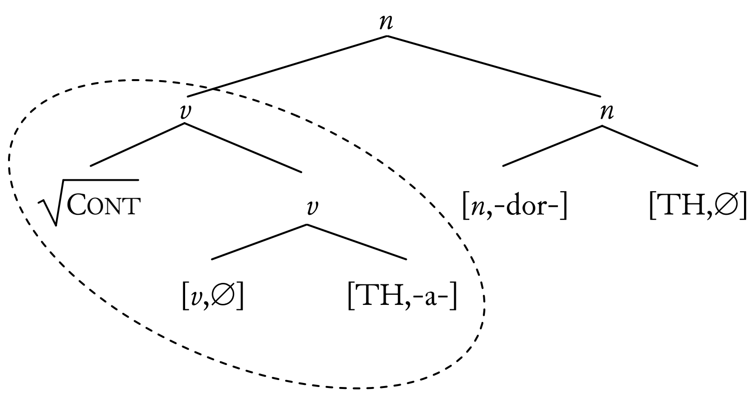
§16 All cyclic models subscribe to the following assumptions:

- The stem level is internally cyclic: stem-level morphosyntax defines multiple cyclic domains, and stem-level morphophonology applies iteratively over them.
- Roots do not define cyclic domains, but stems do (e.g. Kiparsky 1982a: 32-33, 1982b: 144-45; Inkelas 1989: §3.5.5; among many others);
- Consequently, operations of root-to-stem derivation trigger stem-level cycles.

For our purposes, phase-theoretic models (e.g. Embick 2010) yield roughly equivalent generalizations.

§17 The morphosyntax of *cont-a-dor-∅* 'counter' (see §9a)

I use DM-style representations for illustrative purposes only and without theoretical commitment. I adjoin TH positions to the corresponding category-giving heads in the manner of Oltra-Massuet (1999: 12, 26, 79), rather than that of Embick (2010: 76): see Harris (1999: 54) and Oltra-Massuet and Arregi (2005: 46).



§18 If there is a cycle of the stem-level phonology over the highlighted inner stem in §17 (as per §16), and root allomorphs are selected during this cycle, then the wrong results follow:

a. *cyclic domain structure* $[\![^{SL}\, [\![^{SL} \left\{\begin{array}{c}\text{koNt}\\ \text{kweNt}\end{array}\right\} \text{-a}\,]\!]\ \text{doɾ-} \left\{\begin{array}{c}\varnothing\\ \text{e}\end{array}\right\}]\!]$

b. *first cycle* kwén.ta

c. *second cycle* *kwen.ta.dóɾ

We fail to observe the effects of the inner cycle of √-to-*v* derivation!

Bad solutions: the word-level phonological rule of Halle, Harris, and Vergnaud (1991)

§19 Halle, Harris, & Vergnaud (1991) reanalyse the diphthongal alternation as a word-level phonological rule, but at an exorbitant cost to phonology:

- extrinsic ordering of segmental transformations before prosodification within a cycle;
- absolute neutralization.

§20 *The extrinsic-ordering gambit*

Stress shift counterbleeds diphthongization within a word-level cycle:

		buen	*buen-ísim-o*
domain structure		⟦WL ⟦SL bOn⟧⟧	⟦WL ⟦SL bOn⟧ isim-o⟧
stem-level phonology	stress assignment	bÓn	bÓn
word-level phonology	diphthongization	bwén	**bwénisimo**
	stress assignment	—	**bwenísimo**

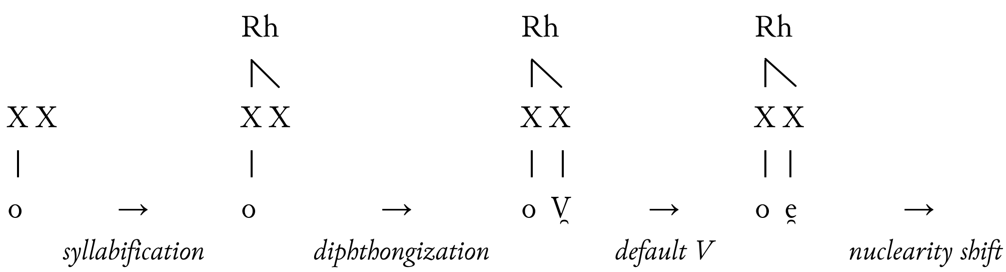
§21 ☠ A particularly nasty type of extrinsic ordering:

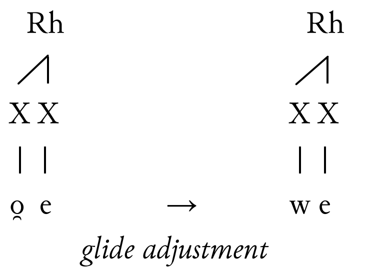
- Independently argued never to be necessary even in rule-based models: e.g. Kaisse (1999).
- Destroys the empirical content of the concept of cyclic domain: diphthongization applies in word-level domains but cannot see word-level affixes.
- Incompatible with learning models such as Bermúdez-Otero (2003).

§22 *Absolute neutralization*

What is the phonological nature of the nonsurfacing underlying /E, O/ in the word-level analysis?

Harris (1985b): /E/ = /eX/
/O/ = /oX/





☠ Four *ad hoc* derivational steps:

Harris observes that none of his four rules looks particularly unnatural and that the insertion of [e] as a default vowel is well motivated in Spanish; but

- they must apply precisely in the order stated and
- their extrinsic ordering has no justification beyond the facts to be described:

  e.g. if glide adjustment were to take place immediately after the insertion of default [e] without waiting for nuclearity shift, the result would be the legal diphthong [oj], creating alternations like *[k**o**θéɾ ~ k**ój**θe] 'cook.INF ~ cook.3SG'.

STEM STORAGE

Stem storage gets the local domains for allomorph selection just right

§23 Key ideas:

- The Spanish lexicon stores stem allomorphs, rather than root allomorphs:

  i.e. not /√ koNt/ ~ /√ kweNt-/

  but /V kont-a/ ~ /V kwent-a/

- Each stem defines a cyclic domain by itself.
- When two stem allomorphs compete, the domain for selection is the cyclic domain triggered by the first syntactic operation on the stem.

§24 Correct results!

a. *cyclic domain structure* ⟦SL {⟦SL koNt-a⟧ / ⟦SL kweNt-a⟧} doɾ-{∅ / e}⟧

b. *first cycle* {kón.ta / kwén.ta}

c. *second cycle* kon.ta.dóɾ

§25 Technical implementation:
Lexical entries of the stem allomorphs of the verb CONTAR

	592
…	
	V_{γ}
SYN	$\surd_{\alpha}$ TH_{β}
PHON	$[\![^{\mathcal{SL}}\ \text{koNt}_{\alpha} - \text{a}_{\beta}]\!]_{\gamma}$
SUBCAT	$\mathcal{P}[\![^{\mathcal{SL}}(X)\_\_(Y)]\!] \succ \mathcal{P}[\![^{\mathcal{SL}}(X)_{593}(Y)]\!]$

	593
…	
	V_{γ}
SYN	$\surd_{\alpha}$ TH_{β}
PHON	$[\![^{\mathcal{SL}}\ \text{kweNt}_{\alpha} - \text{a}_{\beta}]\!]_{\gamma}$
SUBCAT	$\mathcal{P}[\![^{\mathcal{SL}}(X)\_\_(Y)]\!] \succ \mathcal{P}[\![^{\mathcal{SL}}(X)_{592}(Y)]\!]$

Main points (see Bermúdez-Otero 2013 for details):

- Lexical entries formalized as interface rules in the sense of Jackendoff (2002: 131).
- Coindexation (Greek letter subscripts) marks correspondence between constituents of representations in different modules (e.g. SYN and PHON).
- SUBCAT attribute triggers the phonological competition between the allomorphs, and stipulates that it should be resolved in a stem-level cycle.

Supporting evidence (I): stems with the same root but different allomorphic behaviour

§26 Stem storage predicts that allomorphy may fail to cross lexical category boundaries.

- The verb CONTAR participates in the diphthongal alternation because it has two listed stem allomorphs: $/_{\text{V}}$ kont-a/ and $/_{\text{V}}$ kwent-a/.
- But there is nothing to guarantee that a noun derived from the root $\sqrt{\text{CONT}}$ will also have two listed allomorphs; the noun may not alternate.

That is correct!

E.g. the noun CUENTO doesn't alternate in the presence of any affix:

[**kwé**nt-o]	'story'
[**kwe**nt-éɾ-o]	'story-teller'
[**kwe**nt-íst-a]	'story-teller'

Supporting evidence (II): stem storage and recognition latencies

§27 The hypothesis of stem storage makes very precise predictions about the effects of token frequency on response latencies in lexical recognition tasks (see e.g. Baayen et al. 2002: 62-63):

If • token frequency produces its effects by boosting the resting activation of lexical entries,
and • there is one lexical entry per stem (rather than per lexeme or per wordform),
then recognition latencies will be a function of stem frequency (rather than lexeme frequency or wordform frequency).

§28 E.g. the adjective CIEGO 'blind'

lexeme CIEGO

stems /θjeg-o/ *o*-stem[M] /θjeg-a/ *a*-stem[F]

wordforms [θjéɣ-o] M.SG [θjéɣ-o-s] M.PL [θjéɣ-a] F.SG [θjéɣ-a-s] F.PL

The box highlights the items whose frequency counts are predicted to govern recognition latencies.

§29 This is correct! Evidence from Domínguez, Cuetos, and Seguí (1999: 488-91, 2000: 394):

(i) CIEGO 'blind' vs VIUDO 'widowed'

- CIEGO is masculine-dominant: frequency of *cieg-o*(*-s*) > frequency of *cieg-a*(*-s*)
- VIUDO is feminine-dominant: frequency of *viudo-o*(*-s*) < frequency of *viud-a*(*-s*)

→

- recognition speed for *cieg-o*(*-s*) > recognition speed for *cieg-a*(*-s*)
- recognition speed for *viud-o*(*-s*) < recognition speed for *viud-a*(*-s*)

(ii) *cult-o* 'cultivated.M' vs *bell-o* 'beautiful.M'

- frequency of *cult-o*(*-s*) = frequency of *bell-o*(*-s*)

→

- recognition speed for *cult-o*(*-s*) = recognition speed for *bell-o*(*-s*)

even though

- frequency of CULTO < frequency of BELLO

because

- frequency of *cult-a*(-s) < frequency of *bell-a*(*-s*)

(iii) *rat-o-s* ‘while.PL’ vs *bot-a-s* ‘boot.PL’

- frequency of wordform *rat-o-s* = frequency of wordform *bot-a-s*

yet

- recognition speed for wordform *rat-o-s* > recognition speed for wordform *bot-a-s*

because

- frequency of stem *rat-o*(*-s*) > frequency of stem *bot-a*(*-s*)

as

- frequency of wordform *rat-o* (SG) > frequency of wordform *bot-a* (SG)

§30 **Nice convergence of internal evidence (local domains for allomorph selection) and psycholinguistic evidence (recognition latencies).**

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