Cyclicity

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1. Introduction[1]

Cyclicity is not an empirical phenomenon, but a theoretical construct: indeed, where many phonologists currently see cycles, others—perhaps a larger number—do not recognize them at all. Why, then, should there be a chapter on cyclicity in a phonological *summa* that professes to focus 'on empirical facts, rather than on theoretical insights'?[2] The answer must surely be that cyclicity possesses the desirable properties of a scientific hypothesis (empirical content, heuristic power, unifying insight) to such an extent that, having always retained a prominent place in generative work since its first formulation by Chomsky, Halle, and Lukoff (1956: 75), it remains a touchstone for all approaches to the interaction between morphosyntax and phonology.[3]

My examination of the phonological cycle begins with an attempt to distil the essence of cyclicity from its multifarious incarnations in the literature (§2). In particular, I shall argue that cyclicity should properly be regarded as an attribute of entire phonological derivations, and not of a subset of rules or processes.

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[1] This chapter draws mainly on research previously presented at the Old World Conference in Phonology 4 (Rhodes, 20 January 2007), the 15th Manchester Phonology Meeting (25 May 2007), the Workshop on Theoretical Morphology 3 (Leipzig, 23 June 2007), the 2nd International Conference on the Linguistics of Contemporary English (Toulouse, 3 July 2007), the Department of English Linguistics of the University of Groningen (22 February 2008), Generative Linguistics in Poland 6 (Warsaw, 6 April 2008), and the Institute of English Studies of the University of Warsaw (7 April 2008); I am grateful to the organizers and audiences on all these occasions for their comments and suggestions. I am also deeply indebted to Sonia Colina, Tobias Scheer, and Jochen Trommer for sharing their insights with me.

[2] As stated by the editors of this *Companion* in the notes for contributors.

[3] Scheer's (2008a) critical history of research into the morphosyntax-phonology interface includes an account of evolving theories of the phonological cycle. According to Scheer (2008a: §69), the concept of the cycle is a genuine generative innovation, unlike notions like 'rule', 'level', and 'distinctive feature', which trace their intellectual ancestry through neogrammarian and structuralist frameworks.

The following sections pitch the cycle against output-output correspondence (henceforth OO-correspondence) as rival accounts of the way in which morphosyntax affects the course of phonological derivations (§3). The discussion will focus on two empirical problems that have straightforward cyclic solutions but oppose intractable difficulties to OO-correspondence: in one case, represented by Quito Spanish /s/-voicing (§4) and by English linking and intrusive *r* (§5), the key properties of the base are masked by a phonological process applying in a later cycle; in the other case, exemplified by Albanian stress assignment (§7), the base of an expression fails to surface at all because the expression belongs in a noncanonical paradigm (e.g. one displaying deponency, defectiveness, suppletion, or heteroclisis). As we shall see, the sheer unavailability of suitable surface bases in these situations is only the most acute in a long list of obstacles confronting the theory of OO-correspondence: see Figure 2 in §8 for a synopsis.

Strikingly, the hypothesis of cyclic derivation casts light not only on static phonological patterns, but also on phonological variation and change. In §6 I show how an important theorem of cyclic theory correctly predicts the diachronic course that analogical innovations take during the medial stages in the life cycle of a phonological process; this is illustrated with English /ŋg/-simplification and /l/-darkening. The theory of OO-correspondence, in contrast, must stipulate the facts in an axiom.

The concluding section (§9) draws a methodological moral from the evidence surveyed in the chapter.

2. The concept of the phonological cycle

Early definitions of the phonological cycle (e.g. Chomsky, Halle, and Lukoff 1956: 75; Chomsky and Halle 1968: 20) are insufficiently abstract for the purposes of this chapter; we need a concept of phonological cyclicity that will generalize over different theories of phonological computation (e.g. rule-based vs constraint-based), different cyclic architectures of grammar (e.g. interactionist vs noninteractionist), and even different theories of the internal structure of words (e.g. morphous vs amorphous morphology).[4] In this section, I propose to build a suitably general definition of the phonological cycle on the basis of the concepts of 'function' and 'domain'.

Any complete theory of phonology contains a theory of representations, a theory of computations, and a theory of the interfaces (including a grammatical architecture): see e.g. Booij (1997: 261). As noted by Kaye (1995: 302), one can think of the theory of computations as providing the resources for specifying a set of phonological functions (henceforth $\mathcal{P}$-functions)

[4] The nature of these alternatives will become clearer in the following paragraphs.

(1) $$P = \{\mathcal{P}_1, \mathcal{P}_2, ..., \mathcal{P}_n\}.$$

Each member of the set P is a function $\mathcal{P}_x$ mapping any given input representation i onto a corresponding output representation o:[5]

(2) $$\mathcal{P}_x(i) = o.$$

In rule-based theory, for example, $\mathcal{P}$-functions are specified by means of batteries of ordered rewrite rules. In Optimality Theory (henceforth OT; see Prince and Smolensky 1993), a $\mathcal{P}$-function is specified as an application of $\mathcal{G}_{en}$ followed by an application of $\mathcal{E}_{val_x}$, where x refers to a particular ranking of the universal constraint set CON:

(3) $$\mathcal{P}_x(i) = \mathcal{E}_{val_x}(\mathcal{G}_{en}(i)).$$

If we consider all and only total rankings of CON, then by factorial typology OT specifies |CON|! $\mathcal{P}$-functions, where |CON| is the cardinality of CON: i.e.

(4) $$|P| = |\text{CON}|!$$

Regardless of the way in which a phonological function $\mathcal{P}_x(i)$ is specified, its argument i will consist of an assembly of phonological objects (e.g. morphs) bearing whatever morphosyntactic annotations are required by the theory of the morphosyntax-phonology interface. Depending on the particular grammatical framework, this may include a (possibly partial) linearization of the phonological objects in the assembly, information (possibly conveyed by coindexation) about relationships of realization or exponence between morphosyntactic constituents and phonological objects, etc. The concept of phonological cyclic domain can now be preliminarily defined as follows:[6] a phonological cyclic domain consists of an appropriately annotated phonological assembly realizing a morphosyntactic constituent and providing the argument for an application of a $\mathcal{P}$-function. The application of a $\mathcal{P}$-function to a domain is called a cycle.

The hypothesis of phonological cyclicity states that, in any complete linguistic expression e, several morphosyntactic constituents of e at various levels of granularity will trigger phonological cycles in the sense just defined. Crucially, the surface phonological

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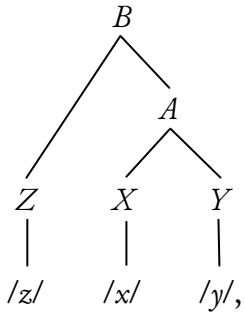
[5] In instances of phonological variation, a single input representation may be associated with more than one output. The theory of phonological computation is therefore more properly thought of as specifying relations, rather than functions (Smolensky 2006: 535-36; see also Kaye 1995: 330, note 18). Here we can safely set this question aside: we shall be concerned mainly with the possibility of composing one function with another, and relations afford this possibility too.

[6] This definition will be slightly revised below to accommodate amorphous theories of morphology.

representation of *e* will be computed by function composition. For example, given the lexically interpreted phrase-marker

(5)



let the nodes *A* and *B* define domains for the functions $\mathcal{P}_\alpha$ and $\mathcal{P}_\beta$, respectively: i.e.[7]

(6) $$[\![_\beta\ z\ [\![_\alpha\ x, y\ ]\!]]\!].$$

If so, then the surface phonological representation assigned to (5) is determined by the composite $\mathcal{P}$-function

(7) $$\mathcal{P}_\beta(\ z,\ \mathcal{P}_\alpha(\ x,\ y\ )).$$

In this view, $\mathcal{P}$-function composition naturally reflects part-whole relationships in the morphosyntax, and the order of $\mathcal{P}$-function application is intrinsically determined by morphosyntactic constituency.

This formulation, I believe, captures the common essence shared by all cyclic theories of phonology. Only a slight adjustment is necessary to accommodate amorphous theories of morphology, which assert that wordforms have no internal constituent structure but are rather generated by realization rules successively applying to a root (e.g. Anderson 1992, Stump 2001).[8] In such frameworks, one needs to say that a phonological cyclic domain may be defined either by a syntactic constituent or by a morphological operation; the latter alternative will cover cases where a phonological cycle is triggered over the output of a morphological realization rule.

Several observations are now in order. First, nothing in our formulation of the cyclicity hypothesis requires the same $\mathcal{P}$-function to apply to all the cyclic domains defined by the

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[7] I use hollow brackets to enclose morphosyntactic constituents and phonological cyclic domains. I reserve solid brackets to notate output phonological representations and to mark the edges of prosodic categories.

[8] In my own view, morphs do exist, and morphology is constrained to respect their integrity: in other words, the morphology cannot alter the phonological content of a morph—although it may scan it, in order, for example, to check the satisfaction of a phonological subcategorization requirement (Bermúdez-Otero forthcoming-b, forthcoming-a).

grammar (*pace* Kaye 1995). On the contrary, work in the broad tradition of Lexical Phonology (e.g. Kiparsky 1982b, 1982a; Kaisse and Shaw 1985; Hargus and Kaisse 1993) and Stratal OT (e.g. Booij 1997; Kiparsky 1998, 2000; Bermúdez-Otero 1999, 2003, forthcoming-a) has predominantly assumed that each grammar specifies three different $\mathcal{P}$-functions: the stem-level, word-level, and phrase-level $\mathcal{P}$-functions ($\mathcal{P}_{SL}$, $\mathcal{P}_{WL}$, and $\mathcal{P}_{PL}$).[9] A morphosyntactic constituent is said to be stem-level, word-level, or phrase-level if, in the event of its triggering a cycle, it is subject to $\mathcal{P}_{SL}$, $\mathcal{P}_{WL}$, or $\mathcal{P}_{PL}$, respectively. In affixal constructions, the ascription of the construction to the stem-level or word-level phonology is deemed to depend on properties both of the base (Giegerich 1999) and of the affix: the attachment of an affix to a root necessarily produces a stem-level category; the attachment of an affix to a stem may produce a stem-level or word-level category depending on the idiosyncratic affiliation of the affix (e.g. Bermúdez-Otero 2007a: 283).

Secondly, our definition of cyclicity by no means requires that all morphosyntactic constituents should define cyclic domains. In the literature, grammatical architectures in which every morphosyntactic node triggers a phonological cycle (e.g. Orgun 1996) are actually in the minority; according to the majority view, phonological domain structure is less rich than morphosyntactic constituency—often dramatically so. Notably, Lexical Phonology and Stratal OT both assert that, whereas every stem-level morphosyntactic node triggers a stem-level cycle, only full grammatical words trigger word-level cycles and only complete utterances trigger phrase-level cycles (e.g. Bermúdez-Otero 2007a: 283; see Scheer 2008a: §740ff).[10] Bermúdez-Otero (forthcoming-a) relies upon this postulate to preserve an important result: even though a word-level affix can occur inside a stem-level affix (contravening the Affix Ordering Generalization of Selkirk 1982: 91, after Siegel 1974: 182 and Allen 1978: 6; see Aronoff 1976: 85, Aronoff and Sridhar 1983, Fabb 1988), applications of $\mathcal{P}_{SL}$ are nonetheless intrinsically ordered to precede those of $\mathcal{P}_{WL}$. In the derivation of the English word *develop-ment-al* (8), for example, the word-level suffix *-ment* is closer to the root than the stem-level suffix *-al*, but *development-* does not trigger a word-level cycle[11] because it is a stem, not a fully inflected word: note its lack of number inflection (cf. **developments-al*).

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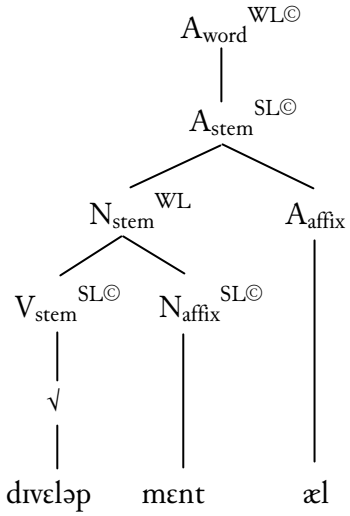
[9] According to Booij (1997: 264) and Scheer (2008a: §141ff), the cut between the 'lexical' (stem- and word-level) and 'postlexical' (phrase-level) phonology has a venerable precedent in the Praguian distinction between *phonologie du mot* and *phonologie de la phrase* (e.g. CLP 1931: 321, Jakobson 1931: 165). The Praguian distinction is currently accepted by scholars who do not otherwise subscribe to stratal theories of the interface (e.g. Itô and Mester 2001, Scheer 2008a: §772ff).

[10] For this reason, $\mathcal{P}_{SL}$ and $\mathcal{P}_{WL}$ are referred to as the 'cyclic' and the 'postcyclic' phonology in Booij and Rubach (1987), and as the 'cyclic' and the 'noncyclic' phonology in Halle and Vergnaud (1987b); I disapprove of this terminology for reasons that will become apparent later in this section. There remains the fact that stem-level morphosyntactic nodes are special in always triggering a phonological cycle: Bermúdez-Otero and McMahon (2006: §3.4), Bermúdez-Otero (2007c: §24ff), and Collie (2007, 2008) derive this observation from independent postulates about lexical listing and morphological blocking.

[11] In (8a) and thereafter, nodes that trigger cycles are flagged with a ©.

(8) *$\mathcal{P}_{SL}$ intrinsically ordered before $\mathcal{P}_{WL}$ without the Affix Ordering Generalization*

a. *Morphosyntactic structure*



b. *Phonological domains:* ⟦$_{WL}$ ⟦$_{SL}$ ⟦$_{SL}$ dɪvɛləp⟧ ⟦$_{SL}$ mɛnt⟧ æl⟧⟧

1st cycle ($\mathcal{P}_{SL}$)	[dɪ'vɛləp] ⌢ [mɛnt]	(stress assignment)
2nd cycle ($\mathcal{P}_{SL}$)	[dɪˌvɛləp'mɛntæl]	(stress assignment)
3rd cycle ($\mathcal{P}_{WL}$)	[dɪˌvɛləp'mɛntəl]	(vowel reduction)

Incidentally, diagram (8a) also reflects the assumption that a word-level suffix like *-ment* goes through a stem-level cycle on its own before combining with its base within a word-level domain (Baker 2005, Buckler 2009, Bermúdez-Otero forthcoming-a; see also Mohanan 1982, and cf. McCarthy 2007: 133-34).

Thirdly, our characterization of cyclicity as $\mathcal{P}$-function composition is neutral between interactionist and noninteractionist grammatical architectures. In interactionist architectures, morphosyntax and phonology are interleaved: a $\mathcal{P}$-function applies as soon as the relevant cycle-triggering morphosyntactic node has been constructed (e.g. Kiparsky 1982b, 1982a; Booij and Rubach 1984, 1987; Hargus 1993; Orgun 1996; Booij 1997; Scheer 2008a). In noninteractionist architectures, all morphosyntax precedes all phonology (e.g. Halle and Vergnaud 1987b, 1987a; Odden 1993). The empirical case for interactionism relies on the observation that morphosyntactic constructions can subcategorize for derived phonological properties assigned in an earlier cycle.[12]

[12] If Scheer (2008a: §648) is right, interactionism was invented by lexical phonologists, a fact not usually acknowledged in discussions of phase theory (Chomsky 2001). Scheer (2008a: §637ff) adjudicates in favour of interactionism largely on grounds of principle.

However, our definition of the phonological cycle does bring out a crucial fact: cyclicity is a property of entire phonological derivations, not of individual processes. In early Lexical Phonology it was customary to refer to stem-level rules as 'cyclic' because they reapplied every time a stem-level affix was added; word-level rules were concomitantly described as 'postcyclic' or 'noncyclic' (see note 10). This infelicitous terminology conceals the fundamental insight that the application of the word-level and phrase-level $\mathcal{P}$-functions is also impeccably cyclic, in the sense that the phonological properties of the whole (the utterance) are a function of the phonological properties of its parts (words), and that syntactic constituency therefore determines the intrinsic ordering of $\mathcal{P}_{\mathrm{WL}}$-application before $\mathcal{P}_{\mathrm{PL}}$-application. Odden (1993: 115) sought to highlight this fact by talking both of 'stratum-internal cyclicity' and of 'interstratal cyclicity'.[13]

3. Theories of morphosyntactic conditioning in phonology: cyclicity vs OO-correspondence

The phonological cycle seeks to explain how morphosyntax can cause phonological opacity. This may be conveniently illustrated with an abstract example of underapplication. Consider a language in which the phonotactic restriction

(9) $\quad *[xy]$

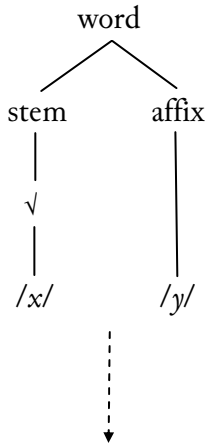
is normally enforced by the unfaithful mapping

(10) $\quad /xy/ \rightarrow [zy].$

Let us now suppose that the concatenation of a stem /*x*/ with a suffix /*y*/ causes underapplication:

[13] The misconception that the phonological cycle consisted solely of the reapplication of stem-level rules over progressively larger stem-level domains was encouraged by the Strict Cycle Condition (Mascaró 1976; see Kiparsky 1982b: 41, 1985: 89-91). In line with the Condition, the blocking of structure-changing rule applications in nonderived environments came to be regarded as a property that all stem-level rules should exhibit by virtue of being 'cyclic'. The claim proved empirically false (Kiparsky 1993, Bermúdez-Otero forthcoming-a).

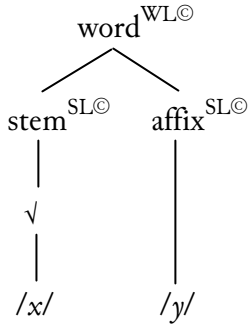
(11) a.



b. [*xy*] and not expected [*zy*].

A cyclic analysis of (11) in the tradition of Lexical Phonology and Stratal OT (§2) will proceed as follows. Assume, first, that the suffix /*y*/ is word-level. If so, the stem /*x*/ and the suffix /*y*/ will go through separate stem-level cycles before combining within a word-level domain.

(12) a.



b. $[\![_{\text{WL}}\, [\![_{\text{SL}}\, x\,]\!][\![_{\text{SL}}\, y\,]\!]]\!]$

Secondly, assume that mapping (10) takes place in stem-level cycles, but not in word-level cycles: i.e.

(13) $\mathcal{P}_{\text{SL}}(xy) = [zy]$,

but

(14) $\mathcal{P}_{\text{WL}}(xy) = [xy]$.

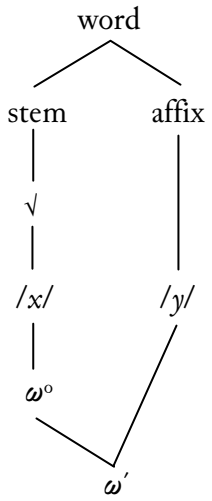
These assumptions yields the desired outcome:

(15) $\mathcal{P}_{\text{WL}}(\, \mathcal{P}_{\text{SL}}(x), \mathcal{P}_{\text{SL}}(y)\,) = \mathcal{P}_{\text{WL}}(xy) = [xy]$.

In this derivation, mapping (13) exhibits normal nonapplication within its domain, i.e. in stem-level cycles; opacity arises only because the domain of (13) is smaller than the whole expression.

However, the problem posed by (11) could also be solved prosodically (e.g. Selkirk 1981; Nespor and Vogel 1982, 1986). Let us suppose that the morphosyntactic structure of the word affects its prosodification, possibly through alignment constraints (McCarthy and Prince 1993), so that a prosodic-word (*ω*) boundary intervenes between the stem and the suffix:

(16)



If so, requiring that the conditions for mapping (10) should be met within a first projection of *ω*, i.e.

(17) $[_{\omega^\circ} \ldots xy \ldots] \rightarrow [_{\omega^\circ} \ldots zy \ldots]$,

will result in the desired nonapplication, even if the mapping does apply to word-level and phrase-level cyclic domains; cf. (14). In this scenario, therefore, the influence of morphosyntax leads to transparent nonapplication, rather than to opaque underapplication, since representation (16) simply fails to meet the structural description of (17).

In Scheer's (2008a: §3ff) helpful terminology, the opaque cyclic derivation shown in (12) to (15) is an instance of *procedural* morphosyntactic conditioning in phonology, whereas the transparent prosodic analysis outlined in (16) and (17) involves *representational* morphosyntactic conditioning: in the former, morphosyntax guides the course of phonological derivation by selecting the arguments for $\mathcal{P}$-function application; in the latter, morphosyntax controls the distribution of certain elements of phonological representation. Remarkably, there is near-unanimity on what Scheer (2008a: §5) calls *interface dualism*: morphosyntax intervenes in phonology both procedurally and representationally, and neither type of intervention can be reduced to the other. This dualism has been maintained throughout the history of generative linguistics: see Table 1.

Theory	*Representational intervention*	*Procedural intervention*	*Sample references*
SPE	boundary symbols (+, #)	the cycle	Chomsky and Halle (1968)
Lexical Phonology	prosodic units (built by rules)	the cycle (with levels)	Booij and Rubach (1984), Booij (1988b, 1992)
Stratal OT	prosodic units (controlled by ALIGN)	the cycle (with levels)	Kiparsky (1998), Bermúdez-Otero (forthcoming-b)
Classical OT	prosodic units (controlled by ALIGN)	OO-correspondence	Benua (1997)
Lateral Phonology	empty CV units	the cycle (phases)	Scheer (2008a, 2008b)

Table 1. *Interface dualism in the history of generative phonology.*

If the hypothesis of interface dualism is correct, then one must formulate diagnostic criteria for determining whether a particular instance of morphosyntactic intervention is procedural or representational: see Raffelsiefen (2005) and Yun (2008) for examples of this demarcation problem in English and Korean, respectively. Moreover, a fully explanatory theory of the interface will not merely list the correct demarcation criteria, but will derive them from first principles. Stratal OT, which advocates a cyclic account of procedural intervention and a prosodic account of representational intervention, enables one to deduce the following four diagnostics (Bermúdez-Otero forthcoming-b, forthcoming-a):

(18) *The gradience criterion*
Prosodic units are phonetically interpretable phonological objects (e.g. Gussenhoven and Rietveld 1992, Wightman et al. 1992, Byrd 1996, Clements and Hertz 1996). In contrast, a modular feedforward architecture of grammar does not allow for direct interaction between morphosyntax and phonetics (e.g. Bermúdez-Otero 2007e: 501ff). Therefore, gradient phonetic processes can be affected by surface prosodic structure, but cannot exhibit cyclic effects (e.g. Myers 2000: 263).

(19) *The variation criterion*
In the case of categorical phonological processes subject to sociolinguistic variation, morphosyntax can affect application rates either cyclically (e.g. Guy 1991b, 1991a) or prosodically. However, if the frequency of a variant differs between two expressions whose prosodification is held to be the same, then this difference must be explained cyclically (and vice versa).

(20) *The morphosyntactic mismatch criterion*
Each cyclic domain is exactly coextensive with a morphosyntactic constituent.[14] Application spans that do not satisfy this requirement must be defined prosodically.

(21) *The cyclic locality criterion ('Bracket Erasure')*
Prosodic structure assigned in an early cycle can persist, and continue to affect the application of phonological processes, throughout later cycles. In contrast, the morphosyntactic structure visible during a phonological cycle ceases to be accessible in the next cycle (see e.g. Orgun and Inkelas 2002: 116).[15] This criterion entails, for

[14] For an opposing view, see Inkelas (1989) and McHugh (1990, 2006), who assume that phonology cycles over prosodic categories; cf. Bermúdez-Otero (forthcoming-a) for a critique, and see Downing (2006) for a noncyclic implementation of the same idea.

[15] The idea of Bracket Erasure originates in *SPE*'s technical definition of the cycle. Kiparsky (1982a: 140, 1982b: 11) adopted a weaker version. Bermúdez-Otero (forthcoming-a) deduces the formulation given here from independent postulates.

example, that the contrast between American English *càpi*[ɾ]*alístic* and *mìli*[t]*arístic* (Withgott 1982) must be mediated by prosody, as /t/-flapping is demonstrably phrase-level (see (24) below) and so cannot access the internal morphological structure of words: see Kiparsky (1998), Jensen (2000: 208-11), Davis (2005), and Bermúdez-Otero and McMahon (2006: 403-4); cf. Steriade (2000).

Bermúdez-Otero and Luís (2009) deploy all four criteria in an intricate case study of morphosyntactic conditioning in European Portuguese.

These considerations suggest that it is both possible and desirable to seek a principled division of labour between prosody and the cycle (Booij 1988a, 1992). In contrast, the default hypothesis under interface dualism must surely be that the grammar affords a single mechanism for procedural morphosyntactic conditioning in phonology. Adopting the stratal-cyclic strategy outlined in (12) to (15) should therefore compel one to forgo all procedural alternatives. However, two competitors exist: cyclic freezing and OO-correspondence.

Returning to (11) for illustration, I shall first briefly consider and reject a solution based on cyclic freezing. Suppose that the grammar specified a single $\mathcal{P}$-function, applicable to all cyclic domains, such that

(22) $\mathcal{P}(xy) = [zy]$ = (10).

The opacity effect in (11) could still be derived cyclically by appealing to some sort of freezing device (like Chomsky's 2001 Phase Impenetrability Condition) preventing the output of a cycle from being altered in subsequent cycles: see e.g. Marvin (2002), Piggott and Newell (2006), Scheer (2010). Given an appropriate device of this nature, a domain structure like

(23) $[[\ x\ ]\ y\ ]$

would result in the underapplication of mapping (10), as /*x*/ would become frozen in the first cycle. However, even relatively weak freezing provisions (like the Strict Cycle Condition: see note 13) can wreak havoc if enforced throughout the phonological derivation. Consider, for example, the famous counterbleeding interaction between stem-level /aɪ/-raising before voiceless obstruents and phrase-level /t,d/-flapping in Canadian English *write up* vs *ride up*:[16]

[16] A vast literature on the analysis of this phenomenon has accumulated since Joos (1942) and Chomsky (1964: 74); for the empirical facts, see Chambers (1973) and Kaye (1990). Bermúdez-Otero (2003, 2004; also Bermúdez-Otero and McMahon 2006: 391-94) relied on previously neglected data to ascribe raising to the stem-level phonology. Stress-driven alternations like *cite* [səit] vs *citation* [ˌsaɪˈteɪʃn̩] refute Mielke, Armstrong, and Hume's (2003) inverted analysis, in which the distinction between [aɪ] and [əi] is phonemic, and the voicing of a following alveolar stop predictable.

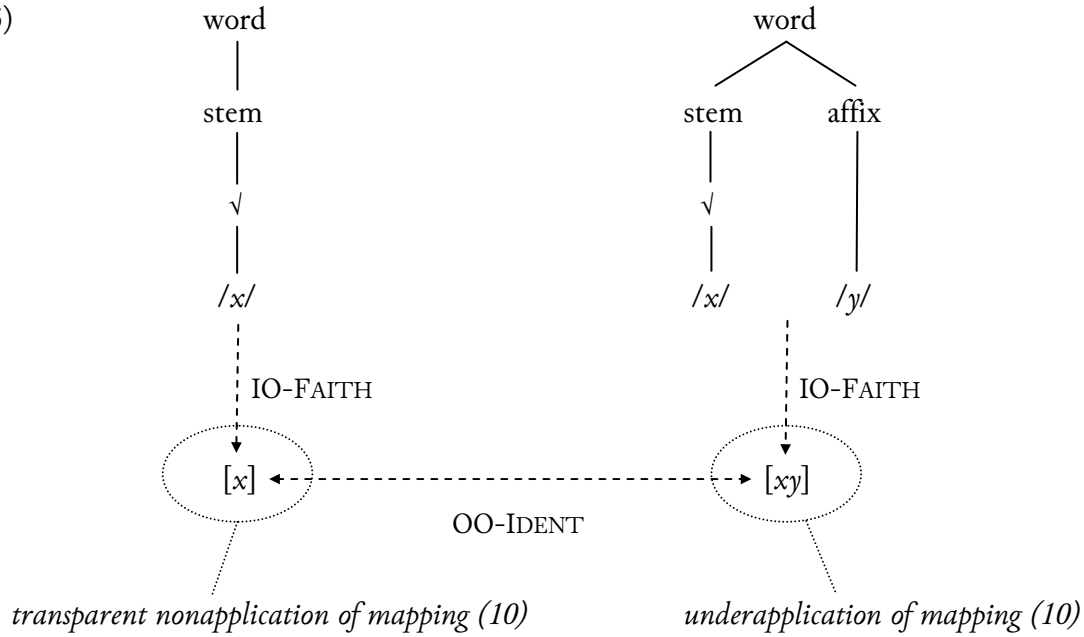
(24)

	⟦PL ⟦WL ⟦SL ɹaɪt⟧⟧⟦WL ⟦SL ʌp⟧⟧⟧		⟦PL ⟦WL ⟦SL ɹaɪd⟧⟧⟦WL ⟦SL ʌp⟧⟧⟧		
$\mathcal{P}_{SL}$	[ɹəit]	[ʌp]	[ɹaɪd]	[ʌp]	(raising)
$\mathcal{P}_{WL}$	[ɹəit]	[ʌp]	[ɹaɪd]	[ʌp]	—
$\mathcal{P}_{PL}$	[ɹəiɾʌp]		[ɹaɪɾʌp]		(flapping)

This cyclic analysis would not extend to tautomorphemic cases like *mitre* /maɪtəɹ/→[məiɾəɹ] vs *spider* /spaɪdəɹ/→[spaɪɾəɹ] if root-internal strings remained frozen in the phrase-level phonology, where flapping takes place.[17] The scope of a hypothetical freezing device would accordingly have to be severely restricted; but, since the distinction between stem-level, word-level, and phrase-level $\mathcal{P}$-functions can do the same job, it seems better to dispense with freezing altogether (see Scheer 2008a and 2010 for a different view).

Within OT, the most popular alternative to the cycle is OO-correspondence (e.g. Benua 1995, 1997; Kenstowicz 1996; Kager 1999; McCarthy 2005; etc.) An OO-correspondence solution to the underapplication problem in (11) requires that, alongside the phonologically opaque suffixal construction /*x*-*y*/→[*xy*], there should exist an appropriately related expression where the stem /*x*/ surfaces as [*x*] transparently. If so, high-ranking correspondence constraints requiring identity between the two surface forms can be used to inhibit mapping (10).

(25)



The implementation of this solution poses a number of technical challenges, such as motivating the selection of the surface base and preventing the satisfaction of OO-identity by

[17] Luce, Charles-Luce, and McLennan (1999) provide psycholinguistic support for the presence of /t/ and /d/ in the underlying representations of words like *mitre* and *spider*.

means of overapplication in the base (i.e. /*x*/→*[*z*] because /*x*-*y*/→[*zy*]); I return to these in §8 below.[18]

At this point, however, I should like to compare the core predictions of cyclicity and OO-correspondence. The comparison is in fact easy, because both theories share a fundamental assumption:

(26) *Ultimate Transparency*
If a phonological generalization $\mathcal{P}$ misapplies in the surface representation *s* of some linguistic expression, then $\mathcal{P}$ must apply transparently in some other representation *r*, with which *s* is in direct or indirect correspondence.

The theory of the cycle predicts that $\mathcal{P}$ will apply transparently in some cyclic domain defined by some morphosyntactic constituent of the expression: the output of this cycle is connected with the surface representation by relationships of input-output faithfulness. In contrast, OO-correspondence predicts that $\mathcal{P}$ will apply transparently in the surface representation of some appropriately related linguistic expression; the two surface representations are linked to each other by means of transderivational correspondence. In the following sections I adduce empirical evidence corroborating the first prediction and refuting the second.

4. Phonologically masked bases (I): Quito Spanish /s/-voicing

Spanish has a voiceless alveolar fricative phoneme /s/. In the dialect spoken in Quito (Robinson 1979, Lipski 1989), /s/ is realized faithfully in the onset (27a), but undergoes laryngeal assimilation in the coda: it surfaces as [s] in the coda before voiceless segments and utterance-finally (27b), and becomes [z] in the coda when followed by a voiced segment either in the same grammatical word or across a word boundary (27c).

(27)	a.	*gasa*	/gasa/	['ga.**s**a]	'gauze'
		ganso	/gaNso/	['gan.**s**o]	'gander'
		da sueño	/da sueɲo/	[ˌda.'**s**we.ɲo]	'makes one sleepy'
		el sueño	/el sueɲo/	[el.'**s**we.ɲo]	'the dream'
	b.	*rasco*	/rasko/	['ra**s**.ko]	'I scratch'
		gas	/gas/	[ga**s**]	'gas'
		gas caro	/gas karo/	[ˌga**s**.'ka.ɾo]	'expensive gas'

[18] Diagram (25) does not cover versions of OO-correspondence that reject the concept of underlying representation: e.g. Burzio (1996, 1998, 2002), Albright (2008). See Cole and Hualde (1998) and Booij (2009) for further attacks on underlying representations, and cf. Bermúdez-Otero (forthcoming-c) for a defence.

c.	*rasgo*	/rasgo/	[ˈra**z**.ɰo]	‘feature’
	plasma	/plasma/	[ˈpla**z**.ma]	‘plasma’
	gas blanco	/gas blaNko/	[ˌga**z**.ˈβlaŋ.ko]	‘white gas’
	gas noble	/gas noble/	[ˌga**z**.ˈno.β̞le]	‘noble gas’

Laryngeal assimilation overapplies to word-final prevocalic /s/, which undergoes voice spreading from the following vowel (28). In this instance, assimilation applies opaquely because phrase-level resyllabification causes word-final prevocalic /s/ to surface in the onset, where it ought to be immune to laryngeal spreading.[19]

(28)	a.	*gas acre*	/gas akɾe/	[ˌga.ˈ**z**a.kɾe]	‘acrid gas’
	cf.	*gasa*	/gasa/	[ˈga.**s**a]	‘gauze’
	b.	*has ido*	/as ido/	[a.ˈ**z**i.ð̞o]	‘hast gone’
	cf.	*ha sido*	/a sido/	[a.ˈ**s**i.ð̞o]	‘hath been’

This overapplication effect submits to a straightforward stratal-cyclic analysis. Observe that /s/ becomes susceptible to laryngeal assimilation when it occurs in the coda at the word level (i.e. in the coda before phrase-level resyllabification), but the process of assimilation itself must apply in phrase-level domains, since it crosses word boundaries. We can therefore infer that [z] is derived in two steps. At the word level, coda /s/ loses its laryngeal node. At the phrase level, delaryngealized input [S] assimilates to the voicing of the following segment, or becomes voiceless by default utterance-finally; laryngeally-specified input [s], in contrast, remains unchanged.[20]

(29)	⟦PL ⟦WL gasa⟧⟧	⟦PL ⟦WL gas⟧⟦WL akɾe⟧⟧	⟦PL ⟦WL gas⟧⟧
$\mathcal{P}_{WL}$ (coda delaryngealization)	[ga.sa]	[ga**S**] [a.kɾe]	[ga**S**]
$\mathcal{P}_{PL}$ (assimilation and default)	[ga.sa]	[ga.**z**a.kɾe]	[ga**s**]

In contrast, Quito Spanish /s/-voicing poses a severe challenge to OO-correspondence (Colina 2006). As we saw in §3, this theory can explain the opaque voicing of onset /s/ in *gas*

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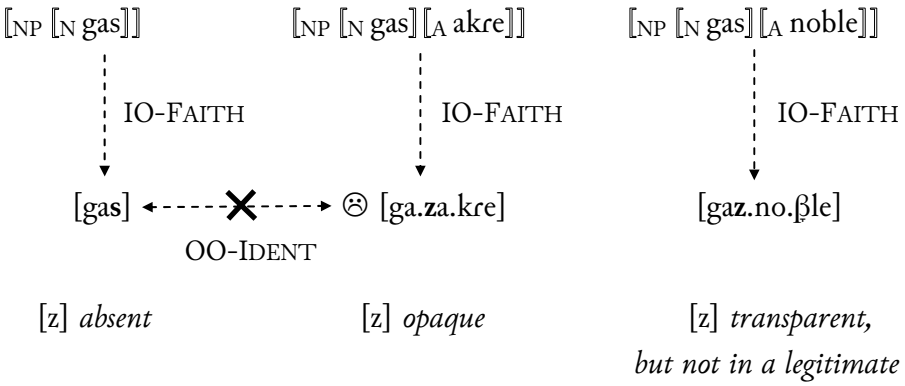
[19] The application of phrase-level resyllabification in Spanish is demonstrated, *inter alia*, by the fact that [ɾ] undergoes optional emphatic trilling in canonical coda positions, but not word-finally before a vowel (James Harris 1983: 70-71): e.g. [maɾ]~[mar] ‘sea’, [ˌmar.ˈne.ɰɾo]~[ˌmar.ˈne.ɰɾo] ‘Black Sea’; but [ˌma.ɾe.ˈxe.o] ‘Aegean Sea’, not *[ˌma.re.ˈxe.o].

[20] This cyclic derivation accords well with Mascaró’s (1987) reduction-and-spreading model of laryngeal phenomena, but I do not claim that Mascaró’s model covers all laryngeal alternations crosslinguistically. Bermúdez-Otero (2006b: §9, §17-§18; 2007b: §31-34) proposes a similar account for the voicing of word-final prevocalic sibilants in Catalan (cf. Jiménez 1999: 172-85, Wheeler 2005: 162-64). See also Rubach (1996b: 72, 82-85) on Cracow voicing.

acre [ˌga.ˈ**z**a.kɾe] (28a) only if there exists a surface base in which [z] occurs transparently in the coda. Many such expressions are found: e.g. *gas blanco* [ˌga**z**.ˈβlaŋ.ko], *gas noble* [ˌga**z**.ˈno.β̞le] (27c). However, none of them bears a nonarbitrary morphosyntactic relationship to *gas acre* [ˌga.ˈ**z**a.kɾe], and so none can qualify as its 'base'. Notably, the only plausible surface base by the containment criterion (Benua 1997: 28-29, Kager 1999: 215ff; cf. §8 below, and Trommer 2009) is the citation form *gas* [ga**s**], which consists of a subset of the morphs of *gas acre*; but this exhibits [s]. In contrast, *gas noble* [ˌga**z**.ˈno.β̞le], which contains the desired [z], has no better claim to being the base of *gas acre* than, say, *gas caro* [ˌga**s**.ˈka.ɾo] (27b), again showing [s]. Within inflectional paradigms some versions of OO-correspondence allow surface bases to be designated by arbitrary stipulation (e.g. Kenstowicz 1996: 387, 391), but even these loose models are of no avail here, since expressions like *gas*, *gas acre*, and *gas noble* do not belong in an inflectional paradigm.

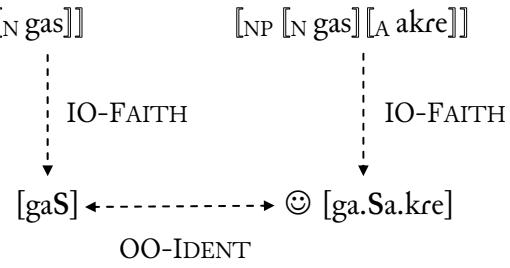
(30)



Thus, OO-correspondence fails because it relies on the transderivational transmission of surface properties, whereas Quito Spanish /s/-voicing illustrates the transmission of a nonsurfacing property (delaryngealization) between cycles; on the surface, the effect is masked by phrase-level assimilation.

Colina (2009: 8-10) seeks to rescue OO-correspondence from this perplexity by suggesting that, in Quito Spanish, the delaryngealization of coda /s/ persists on the surface. In this view, expressions like *gas acre* and *gas noble* simply display the effects of gradient passive voicing in the phonetics, rather than categorical laryngeal spreading in the phonology (Keating 1988, Steriade 1999). If one accepts this proposal, it becomes trivially easy to account for the overapplication effect shown by *gas acre* through OO-correspondence with the citation form *gas*: cf. (30) and (31).

(31)



However, it would be unwarranted to assume that the accommodation between the final sibilant of *gas* and the initial vowel of *acre* must be gradient rather categorical just because it takes place across a word boundary. Electropalatographic studies have indeed shown that many instances of assimilatory external sandhi involve gradient coarticulation (i.e. reduction, overlap, and blending of articulatory gestures), rather than categorical assimilation (i.e. delinking and spreading of discrete phonological features): see e.g. Barry (1985), Wright and Kerswill (1989), Nolan (1992), Hardcastle (1995), and Zsiga (1995). However, there is also compelling evidence for the existence of categorical external sandhi. Holst and Nolan (1995) and Nolan, Holst, and Kühnert (1996) argue persuasively that at least some instances of /s#ʃ/→[ʃ·] sandhi in British English do involve discrete feature delinking and spreading (cf. Browman 1995); the likelihood of categorical assimilation increases in the absence of the major prosodic boundary associated with a break between clauses. Similarly, Ladd and Scobbie (2003) report that, in Sardinian, total anticipatory assimilation between singletons across word boundaries yields long consonants that are phonetically equivalent to underlying geminates.[21] In an articulatory study of the utmost importance, Ellis and Hardcastle (2002) examined inter- and intra-speaker variation in fast-speech /n#k/ sandhi in British English, and found no fewer than four different idiolectal strategies:

(i) absence of accommodation between the two segments (in two out of ten subjects);
(ii) gradient coarticulation (in two out of ten subjects);
(iii) categorical assimilation (in four out of ten subjects);
and (iv) variation between categorical assimilation and absence of accommodation, with avoidance of coarticulation (in two out of ten subjects).

Crucially, type-(iv) speakers did not produce residual coronal gestures, but realized the nasal either without any tongue-tip raising at all or with full mid-sagittal linguoalveolar closure; this behaviour is inconsistent with gradient gestural reduction, but reflects the variable application of discrete feature delinking and spreading across word boundaries. Thus, Ellis and Hardcastle's findings, alongside those of Nolan and his collaborators, clearly indicate that a process of external sandhi may apply gradiently for a speaker in some tokens, and still be categorical for

[21] In a case of nonassimilatory external sandhi, seven of Scobbie and Wrench's (2003) eight English speakers exhibited a categorical alternation between word-final /l/ realized with linguoalveolar contact before a vowel and without linguoalveolar contact before a consonant.

other speakers, or for the same speaker in other tokens.[22] Accordingly, the fact that Quito Spanish /s/-voicing crosses word boundaries does not allow one to infer without further argument that it applies gradiently.

Unfortunately, I know of no instrumental studies of this dialect that can throw light on the matter. Nonetheless, Robinson (1979) and Lipski (1989) provide strong evidence that word-final prevocalic /s/ undergoes categorical voicing in Quito Spanish at least some of the time. First, the process applies regularly in all registers independently of speech rate: it 'may be frequently observed even in slow, disconnected or interrupted speech' (Lipski 1989: 53-54). Secondly, native speakers of the dialect rely on the difference between [s] and [z] to discriminate between minimal pairs like (28b): *ha sido* [a.ˈ**s**i.ð̞o] 'hath been' vs *has ido* [a.ˈ**z**i.ð̞o] 'hast gone' (Robinson 1979: 136, 140-1; Lipski 1989: 55). Thirdly, word-final /s/ voicing can be used as a turn-holding device before hesitation pauses (Robinson 1979: 141). Robinson records the following example, where she describes the realization of the /s/ of *es* as 'strongly voiced':

(32) *es … tres …*
[ez:: ↘ɾes:]
'it's ... uh ... three ...' (Robinson 1979: 141)

It appears that the speaker intentionally produced a sandhi form of *es* to signal the fact that he or she had not reached the end of the utterance. Lipski (1989: 54) adduces further cases. For all these reasons, Bradley and Delforge (2006: 39) conclude that the voicing of word-final prevocalic /s/ in Quito Spanish 'reflects a phonological [+voice] specification', as opposed to 'gradient interpolation of glottal activity through the constriction period of phonetically targetless [S]'.

Evidence suggestive of categorical application also comes from other Romance languages in which word-final sibilants become voiced before voiced segments, including vowels (see note 20 above). Wheeler (1979: 313) notes that, in Catalan, voicing spreads from a word-final prevocalic sibilant to a preceding sequence of obstruents: e.g. *disks antics* [ˌdi**zg.z**an.ˈtiks] 'old records'. His report is confirmed by Figure 1, which shows glottal pulsing and pitch during the /k/ in a token of Catalan *bo*/sks/ *naturals* 'natural forests': this effect would be entirely unexpected if voicing were merely passive, whereas it can easily be understood if the feature [+voice] spreads categorically over the whole cluster in the phonology, but, for aerodynamic reasons, receives an overt phonetic realization only during the closure phase of the stop.

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[22] This extreme variability within and across individuals goes a long way towards accounting for the difficulty of observing the diachronic process of *stabilization*, whereby a language-particular gradient sound pattern becomes categorical: see Labov (2006: §2.1) and Bermúdez-Otero (2007e: 505). The latter borrows the term *stabilization* from Hayes and Steriade (2004: 14).

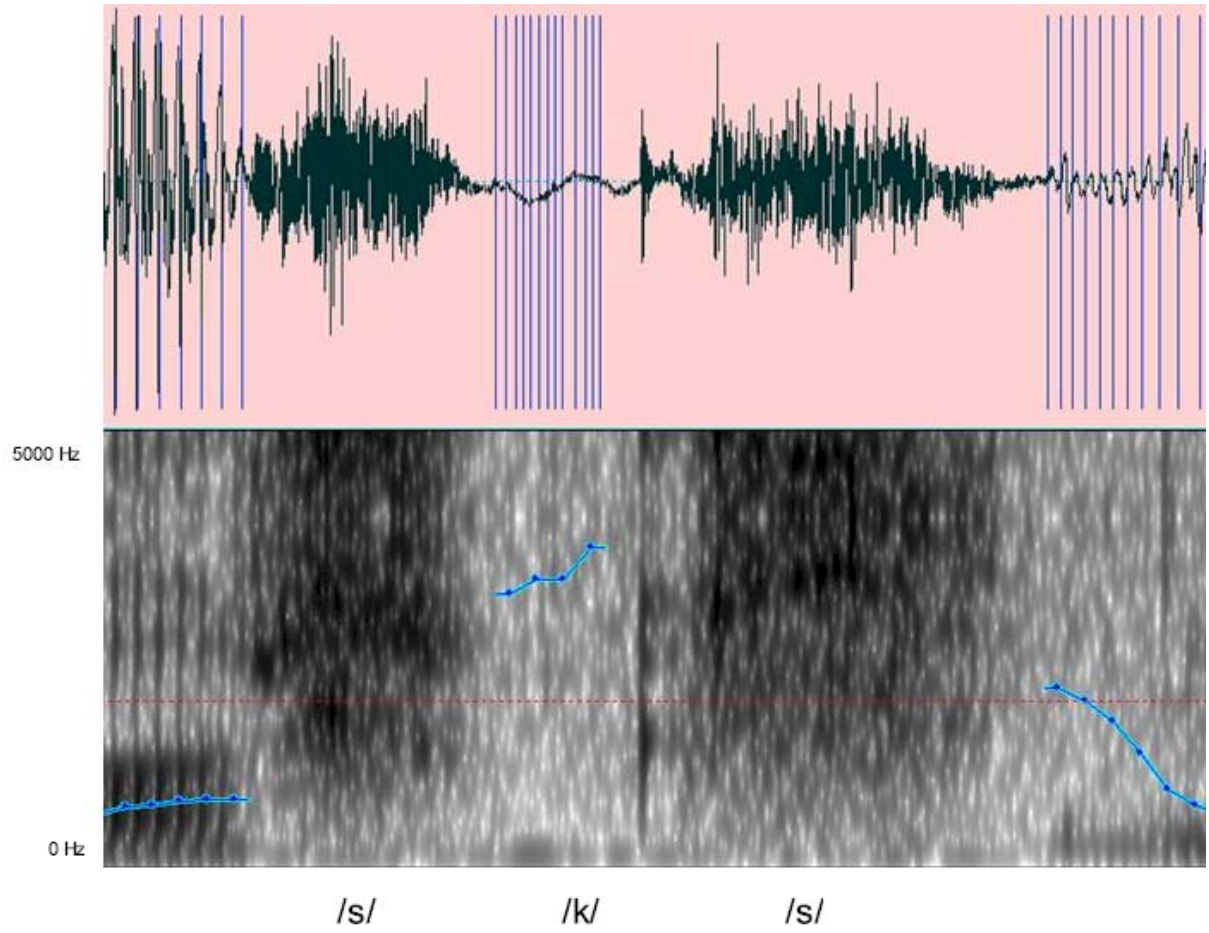

Figure 1. *Waveform (including glottal pulses) and spectrogram (including pitch contour) of a token of Catalan* bo/sks/ naturals *'natural forests', showing voicing of the underlying /k/ (by courtesy of Lluïsa Astruc-Aguilera).*

The cyclic derivations proposed in (29) for Quito Spanish can moreover be seen as the natural synchronic outcome of a series of commonplace diachronic innovations (see §5 and §6 below). We may assume that, in an initial round of phonologization and stabilization (note 22), the poor phonetic cueing of laryngeal features in codas was reinterpreted as phrase-level coda delaryngealization. Analogical change then caused this process of coda delaryngealization to percolate up to the word level. Finally, a second round of phonologization and stabilization caused the passive voicing of delaryngealized sibilants to be reanalysed as categorical phrase-level assimilation.

I conclude that the overapplication of assimilatory voicing to word-final prevocalic /s/ in Quito Spanish refutes the core predictions of OO-correspondence. As a theory of procedural morphosyntactic effects in phonology, more generally, the latter is in a very vulnerable position if it depends for its survival upon systematically relegating external sandhi to the phonetic implementation module.

5. Phonologically masked bases (II): English linking and intrusive *r*

Quito Spanish /s/-voicing is not an isolated case: it is not at all unusual for word-final prevocalic consonants to possess opaquely derived phonological properties that fail to match those of utterance-final consonants in citation forms. Linking and intrusive *r* in nonrhotic English dialects provides another instance of this phenomenon.

Most nonrhotic dialects of English (Wells 1982: 75-76, 218ff) allow [ɹ] in onset positions, such as word-initially or word-medially before a stressed or unstressed vowel (33a),[23] but forbid [ɹ] in coda positions, such as word-medially or word-finally before a consonant or pause (33b,c).

(33) a.

rack	[ɹăk]	*racoon*	[ɹə.ˈkʰuːn]
carouse	[kʰəˈ.ɹaːʊz]	*caramel*	[ˈkʰæ.ɹə.ˌmɛɬ]

b.

cart	[kʰɑːt], *[kʰɑːɹt]
car ‖	[kʰɑː‖], *[kʰɑːɹ‖]
the car came	[ðə.ˌkʰɑː.ˈkʰeːɪm], *[ðə.ˌkʰɑːɹ.ˈkʰeːɪm]

c. *CODA[ɹ]

Crucially, most nonrhotic dialects tolerate [ɹ] word-finally before a vowel, whether the consonant was present etymologically ('linking *r*') or not ('intrusive *r*').[24]

(34)

a.	*the car is new*	[ðə.ˌkʰɑː.ɻɪz.ˈnjuː]	linking *r*
b.	*the spa is new*	[ðə.ˌspɑː.ɻɪz.ˈnjuː]	intrusive *r*

The fact that linking and intrusive *r* escapes the phonotactic ban in (33c) indicates that it surfaces in the onset.[25] In English, however, word-final prevocalic *r* (including linking and intrusive *r* in nonrhotic dialects) exhibits lenition in comparison with canonical onset *r*, as shown by the distinction between unlenited [ɹ] in (33a) and lenited [ɻ] in (34). Notably, word-final prevocalic [ɻ] shows shorter duration (Cruttenden 2001: 289, Tuinman et al. 2007: 1905-6), less lip protrusion and rounding (Wells 1990), smaller magnitude of the tongue-tip gesture

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[23] John Harris (2006) reports that, in some Southern US dialects, [ɹ] is banned outside foot-initial onsets: e.g. *vé**r**y, shé**r**iff, Cà**r**olína*.

[24] Africa-American Vernacular English is nonrhotic but has no linking or intrusive *r* (Gick 2002: 171).

[25] Minkova (2003: ch. 4) shows that the phrase-level resyllabification of word-final prevocalic consonants into the onset entered the grammar in the Middle English period.

(Gick 1999: 47-49), and greater intensity at all frequencies (McCarthy 1993: 179, Tuinman et al. 2007: 1905-6) than word-initial [ɹ]; see further Knight and Jones (2009). Thus, dialects with intrusive *r* afford minimal pairs such as the following (McCarthy 1993: 179):

(35) a. *saw eels* [sɔː.ɻiːɬz]
b. *saw reels* [sɔː.ɹiːɬz]

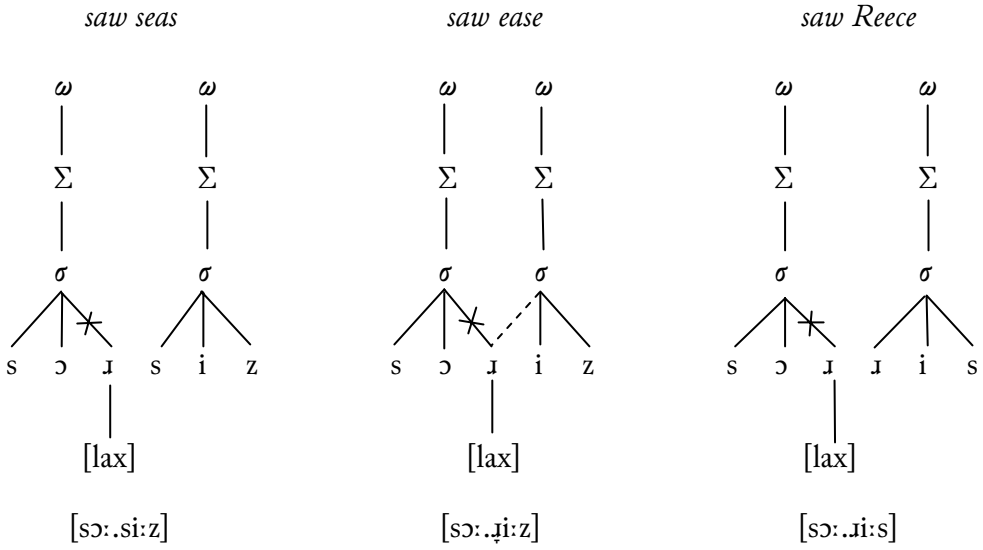
If, as I have suggested, linking and intrusive [ɻ] escapes the phonotactic restriction in (33c) because it surfaces in onset position, just like word-initial [ɹ], then the reasons why the former undergoes lenition and the latter does not are not apparent on the surface: thus, *r*-lenition overapplies. However, this opaque pattern is easy to explain in stratal-cyclic terms (Kiparsky 1979: 437ff; McCarthy 1991: 203-4). Intrusive *r* is inserted at the word level after *ω*-final nonhigh vowels in order to satisfy the constraint FINALC, i.e. *V_{ω}] (McCarthy 1991: 203, 1993: 176), which outranks *CODA[ɹ] at the word level.[26] In the same cycle, the inserted *r* is targeted by coda lenition and undergoes a corresponding featural change: say, it acquires the feature [lax]. At the phrase level, however, the relative ranking of FINALC and *CODA[ɹ] is reversed: in consequence, word-final *r* undergoes deletion in preconsonantal and prepausal environments, but in prevocalic position it escapes into the onset, carrying with it the feature [lax].

[26] The idea that *r*-intrusion is driven by FINALC receives independent support from the absence of intrusive *r* after reduced function words (which do not project an *ω*-node) in the nonrhotic dialect of Eastern Massachusetts (McCarthy 1991: 200ff, 1993: 173ff). In the case of words ending with high vowels or closing diphthongs, we assume that *r*-intrusion is blocked by the final offglide, which suffices to satisfy FINALC; alternatively, FINALC can be replaced with *$V_{[-hi]\ \omega}$].

If *r*-intrusion applies *ω*-finally, then stem-level applications may be needed to generate forms like *draw*[ɹ]-*ing*, for there is evidence that word-level suffixes like *-ing* are incorporated into the prosodic word of the stem, and not adjoined: i.e. [$_{\omega}$*draw*]→[$_{\omega}$*drawing*], not [$_{\omega}$*draw*]→*[$_{\omega}$[$_{\omega}$*draw*]*ing*]. Notably, the increased duration normally associated with *ω*-boundaries is absent before *-ing*: see Sproat (1993: 178), reporting measurements from Sproat and Fujimura (1993); cf. (18) above. If so, we may assume that listed allomorphy preëmpts stem-level *r*-intrusion in cases like *algebr*[ə]-*algebr*[eɪ]*ic* (McCarthy 1991: 196): see the references in note 10 above.

(36) a. $\mathcal{P}_{WL}$: FINALC ≫ *CODA[ɹ]

b. $\mathcal{P}_{PL}$: *CODA[ɹ] ≫ FINALC



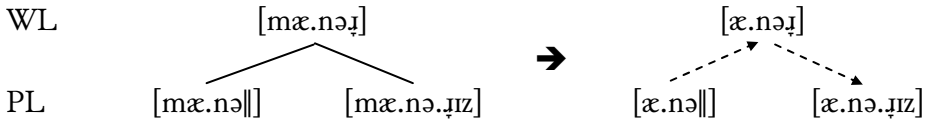
As in the case of Quito Spanish /s/-voicing (§4), this synchronic system can easily be understood as the product of a straightforward series of ordinary phonological changes:

(37)

	level	processes	*manner*	*manner is*	*Anna*	*Anna is*
a. *Initial stage.*						
	$\mathcal{P}_{WL}$		[mæ.nəɹ]	[mæ.nəɹ][ɪz]	[æ.nə]	[æ.nə][ɪz]
	$\mathcal{P}_{PL}$		[mæ.nəɹ]	[mæ.nə.ɹɪz]	[æ.nə]	[æ.nə.ɪz]
b. *Phonologization and stabilization (I): lenition of* [ɹ] *in codas enters the phrase level.*						
	$\mathcal{P}_{WL}$		[mæ.nəɹ]	[mæ.nəɹ][ɪz]	[æ.nə]	[æ.nə][ɪz]
	$\mathcal{P}_{PL}$	lenition	[mæ.nə̝]	[mæ.nə.ɹɪz]	[æ.nə]	[æ.nə.ɪz]
c. *Analogical input restructuring (I): lenition of* [ɹ] *in codas climbs up to the word level.*						
	$\mathcal{P}_{WL}$	lenition	[mæ.nə̝]	[mæ.nə̝][ɪz]	[æ.nə]	[æ.nə][ɪz]
	$\mathcal{P}_{PL}$	lenition (vacuous)	[mæ.nə̝]	[mæ.nə.ɹ̝ɪz]	[æ.nə]	[æ.nə.ɪz]
d. *Phonologization and stabilization (II): deletion of* [ɹ] *in codas enters the phrase level.*						
	$\mathcal{P}_{WL}$	lenition	[mæ.nə̝]	[mæ.nə̝][ɪz]	[æ.nə]	[æ.nə][ɪz]
	$\mathcal{P}_{PL}$	deletion	[mæ.nə]	[mæ.nə.ɹ̝ɪz]	[æ.nə]	[æ.nə.ɪz]
e. *Analogical input restructuring (II): analogical extension of word-level final* [ɹ̝].						
	$\mathcal{P}_{WL}$	insertion, lenition	[mæ.nə̝]	[mæ.nə̝][ɪz]	[æ.nə̝]	[æ.nə̝][ɪz]
	$\mathcal{P}_{PL}$	deletion	[mæ.nə]	[mæ.nə.ɹ̝ɪz]	[æ.nə]	[æ.nə.ɹ̝ɪz]

The path for (37e) was smoothed by a general process of schwa apocope in Middle English (Minkova 1991). As a result of this, Early Modern English had relatively few words like *Anna*, with an underlying final /ə/. Thus, the rise of *r*-deletion brought about a situation in which most tokens of preconsonantal or prepausal [ə] alternated with prevocalic [ə̝]. In these circumstances, learners reanalysed phrase-level representations like [æ.nə‖] as derived by *r*-deletion from word-level [æ.nə̝].

(38)



In turn, this analogical extension of final [ɹ̝] across word-level outputs resulted in a word-level ban of *ω*-final [ə], enforced where necessary by [ɹ̝]-insertion.

This stratal-cyclic account of the diachronic rise and synchronic operation of *r*-intrusion avoids the pitfalls of its best known competitors. Rule-inversion scenarios resulting in a phrase-level hiatus-breaking rule of [ɹ]-epenthesis in onsets (e.g. Vennemann 1972: 216, McMahon 2000: ch. 6, Bermúdez-Otero and Hogg 2003: 99ff) cannot make sense of the lenited realization of intrusive *r*. In turn, restructuring scenarios in which /ə/ is replaced by /əɹ/

in underlying representations (e.g. Donegan 1993) fail to account for the regular and productive nature of *r*-intrusion (see the references in Heselwood 2009: 86). A regular process of [ɹ]-epenthesis in *ω*-final position at the word level incurs neither problem.

Furthermore, the diachronic scenario outlined in (37) fulfils well-grounded expectations concerning the life cycle of phonological processes: see e.g. Bermúdez-Otero (1999: 99-103, 239-40; 2006a: 504; 2007e: 503), Garrett and Blevins (2009: 527-28), John Harris (1989), Kiparsky (1988: 389ff, 1995: 657ff, 1998: 66ff), McMahon (1991, 2000: ch. 4), Zec (1993).[27] First, phonetically driven innovations enter the grammar from below as gradient phonetic rules, which later become stabilized (note 22) as phrase-level categorical processes (37b,d).[28] Secondly, analogical change proceeds by input restructuring: typically, as in (37c), learners reanalyse structures introduced in the output of level *l* as being already present in the input to *l* (Bermúdez-Otero 2006a: 501ff, Bermúdez-Otero and Hogg 2003: 105ff), and phonological processes concomitantly climb from lower to higher levels and come to apply in smaller cyclic domains (Dressler 1985: 149); see §6 below. Thirdly, older phonological rules are generally more advanced in their life cycle than younger rules. In this connection, observe that lenited [ɻ̞] constitutes an intermediate stage in a diachronic pathway from [ɹ] to [∅]: i.e. [ɹ] > [ɻ̞] > [∅]. This implies that *r*-lenition entered the grammar earlier than *r*-deletion and has been exposed to analogical pressures for longer. It is therefore unsurprising that *r*-lenition should have already reached the word level, whereas *r*-deletion remains at the phrase level.

In addition, the synchronic markedness reversal illustrated in (36) arose from a clash between disparate diachronic forces: the high ranking of *CODA[ɹ] at the phrase level reflects the phonologization of phonetic effects; in contrast, the high ranking of FINALC at the word level reflects the analogical restructuring of phrase-level inputs. In this light, McCarthy's (1993: 181-82) complaint of arbitrariness against his own previous stratal analysis (McCarthy 1991: 203-4) betrays a failure to strike a proper balance between synchronic and diachronic explanation (cf. Bermúdez-Otero 1999: 98-107).

It should now be clear that English linking and intrusive *r* provides a direct counterexample to OO-correspondence. The segment's lenited realization is opaque because there is no *r*-lenition in onsets. To explain the facts, OO-correspondence would need to find a surface base in which [ɻ̞] occurred transparently. Yet this is obviously impossible, for the defining property of nonrhotic dialects is precisely that they do not allow *r* to surface outside the onset.

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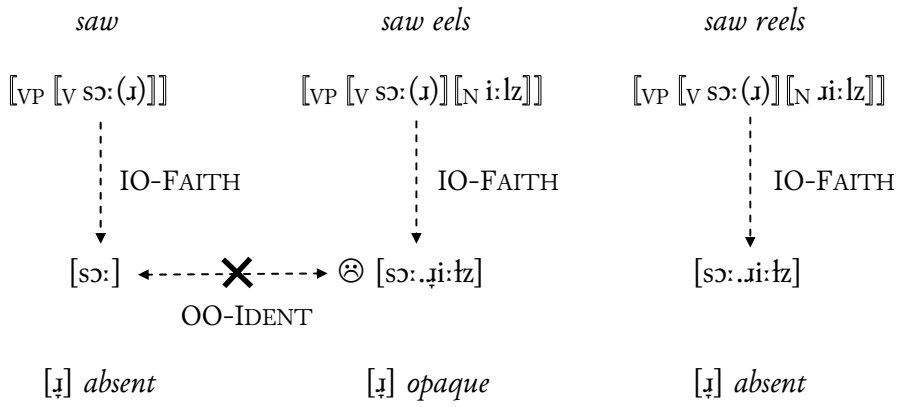
[27] Awareness of the diachronic life cycle of phonological processes goes back at least to Baudouin de Courtenay (1895[1972]): see Anderson (1981: 512ff, 1985: 78).

[28] An early incarnation of this idea was the generative concept of 'rule addition' (Halle 1962: 68, Kiparsky 1970: 309).

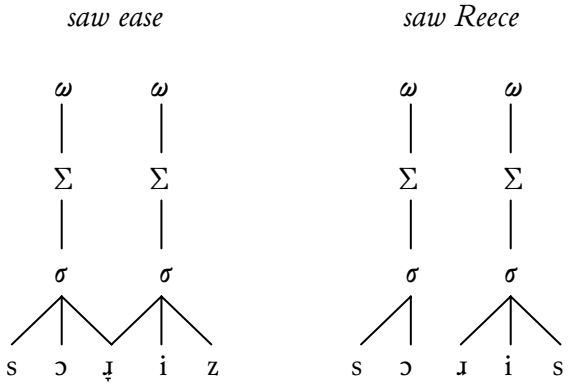
(39)



In this light, it is best to abandon all talk of 'surface bases'. If the phrase *saw eels* has bases at all, they can only be the representations that the grammar assigns to its two immediate cyclic subdomains: i.e. the word-level representations of the verb *saw*, namely [WL sɔːɻ], and of the noun *eels*. In [WL sɔːɻ], the final [ɻ] occupies the coda and so undergoes lenition transparently; but, as we have seen, this base never surfaces unmasked: at the phrase-level, [ɻ] either undergoes resyllabification into the onset or deletes altogether.

It remains only to show that the proponents of OO-correspondence cannot deflect this argument by putting forward a transparent analysis of linking and intrusive [ɻ]. McCarthy (1993: 178-81) attempts to do so by means of ambisyllabicity (e.g. Kahn 1976, Gussenhoven 1986, Rubach 1996a). In this account, linking and intrusive [ɻ] is permitted to surface because it has an onset attachment, but it is lenited because it has a link to the coda too: cf. (36b) and (40).

(40)



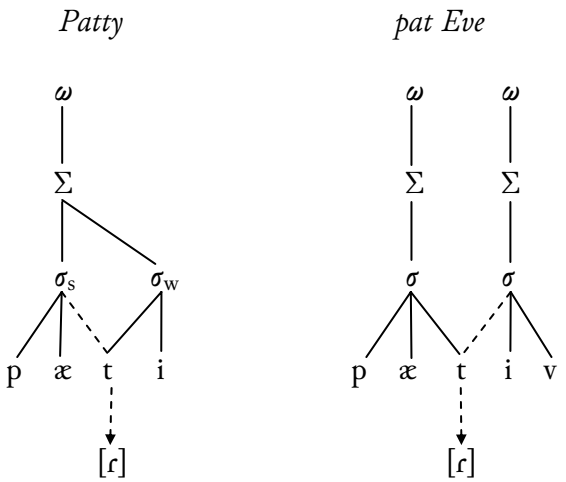
However, ambisyllabicity provides a flawed and contradictory account of English segmental allophony (e.g. Kiparsky 1979: 437ff, Jensen 2000, John Harris 2003). Bermúdez-Otero (2007d: §14-§24) proves this by exhibiting two ambisyllabicity paradoxes. Since Kahn (1976), the standard diagnostic for ambisyllabification in English is /t/-flapping. In most North American dialects, /t/ undergoes flapping in two environments: foot-medially between a vowel or /ɹ/ and another vowel (41a), and word-finally between a vowel or /ɹ/ and another vowel (43b).

(41) a. $[_{\Sigma} \ldots \begin{Bmatrix} V \\ \text{ɹ} \end{Bmatrix}$ __ V ...] e.g. [ɾ] in *Patty, party, parity*

b. $\begin{Bmatrix} V \\ \text{ɹ} \end{Bmatrix}$ __ GWord]] V e.g. [ɾ] in *pat it, pat Eve, at it, at ease*

Since the segmental conditions in these two environments are exactly identical, formulating two separate rules of flapping would miss a generalization. Accordingly, Kahn proposed that the two environments could be unified prosodically: in (41a) /t/ becomes ambisyllabic by Coda Capture, and in (41b) /t/ becomes ambisyllabic by Onset Capture.

(42) a. Coda Capture b. Onset Capture



Thus, Kahn's strategy was to use syllabification to channel the allophonic effects of both stress and word-boundaries. Unfortunately, this solution does not generalize to other English consonants. Consider, for example, /l/-darkening in the Midwestern American dialect studied by Sproat and Fujimura (1993). This dialect exhibits Kahn's canonical pattern of /t/-flapping. By implication, /l/ too should display the same allophone, either clear [l] or dark [ɬ], in foot-medial intervocalic position (e.g. *Bee*/l/*ik*) and word-final intervocalic position (e.g. *Bee*/l/ *equates*): /l/ should be ambisyllabic in the former by Coda Capture and in the latter by Onset Capture. As Sproat and Fujimura (1993) themselves note in passing, however, this prediction proves false: X-ray microbeam cinematography revealed that their subjects produced clear [l], with the coronal gesture phased before the dorsal gesture, in *Bee*/l/*ik*, whereas they produced dark [ɬ], with the dorsal gesture phased before the coronal gesture, in *Bee*/l/ *equates*.

(43)	form	/l/ allegedly ambisyllabic by...	/l/ allophone	the coronal gesture...
	Beelik	Coda Capture	clear [l]	leads
	Beel equates	Onset Capture	dark [ɬ]	lags

In this dialect, therefore, Kahn's ambisyllabification rules work for /t/, but not for /l/. And this is not the only problem: Bermúdez-Otero (2007d: §21-§24) adduces a second ambisyllabicity paradox involving /t/-flapping and prefortis clipping; Kiparsky (1979: 440) observed a third, further discussed by Nespor and Vogel (1986: 93-94). I conclude that ambisyllabicity does not exist in English and, more generally, that it is forbidden by the theory of phonological representations.

Incidentally, the dialect described by Sproat and Fujimura poses no difficulties for a stratal-cyclic model with onset-maximal stem-level syllabification and resyllabification of prevocalic consonants in word-level and phrase-level cycles (Bermúdez-Otero 2007d: §18-§20). The right results follow from the operation of two word-level processes: one laxes /t/ in non-foot-initial position (Kiparsky 1979: 437ff, Jensen 2000, John Harris 2003, Davis and Cho 2003); the other darkens /l/ in the coda.[29] A full typology of English dialects corroborates the need to allow individual allophonic processes to target either weak positions in the syllable (i.e. the coda) or weak positions in the foot (i.e., in a trochaic system, anywhere outside foot-initial onsets). Notably, an innovative pattern of foot-based /l/-darkening (e.g. *ye*[ɬ]*ow, vi*[ɬ]*age*) is attested alongside the conservative syllable-based pattern: see e.g. Olive et al. (1993: 366) and Hayes (2000: 95-96) for American dialects, and Carter and Local (2003, 2007) for British dialects.[30]

In sum: like Quito Spanish /s/-voicing, English linking and intrusive *r* shows that OO-correspondence founders upon simple patterns of external sandhi in which word-final prevocalic consonants display opaquely derived properties that are absent from citation forms. Yet these external sandhi patterns fall unequivocally within the province of the theory of procedural morphosyntactic conditioning in phonology (§3): the burden can be shifted neither to phonetic implementation (§4) nor to the theory of representations.

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[29] Sproat and Fujimura (1993) suggest that /l/-darkening is a purely gradient phonetic process conditioned by duration. Nonetheless, their data are entirely consistent with a two-step derivation: first, a word-level rule conditioned by syllable structure introduces a categorical distinction between clear [l] and dark [ɬ]; later, in the phonetic implementation module, a gradient rule adjusts the delay of the tongue-tip gesture in [ɬ] according to duration (Hayes 2000: 93, Bermúdez-Otero 2007e: note 6). This two-step derivation is necessary because /l/-darkening shows sensitivity to morphosyntactic structure: see (18) above. See Bermúdez-Otero (2007e: 506) on the diachronic emergence of this type of two-rule system.

[30] Similarly, alongside the conservative pattern of syllable-based *r*-deletion in nonrhotic dialects, an innovative foot-based pattern has been detected in the South of the USA: see note 23 above. This enlargement of the prosodic span of /l/-darkening and *r*-deletion falls under the classic concept of 'phonetic analogy' or 'rule generalization' (Kiparsky 1988: 393-94).

6. Interlude: the life cycle of phonological processes and the Russian Doll Theorem

Before I present one last example of missing surface bases (§7), I should like to make a further point about the relationship between the architecture of grammar, language acquisition, and the life cycle of phonological processes. When we considered the diachronic origins of Quito Spanish /s/-voicing (§4) and of English linking and intrusive *r* (§5), we saw that, once an innovative phonological phenomenon has become stabilized as a categorical phrase-level process (note 22), it tends to percolate upwards to the word and stem levels by analogical change. The history of English provides several other instances of this life cycle.

For example, Garrett and Blevins (2009: 527-28) discuss the case of /ŋg/-simplification, which deletes /g/ in the coda after a homorganic nasal:

(44)
$$g \rightarrow \varnothing \;/\; ŋ \underline{\quad}\,\overset{\text{Coda}}{|}$$

In the 'solemn' (i.e. formal) speech of the eighteenth-century orthoepist James Elphinston, rule (44) was confined to phrase-level cycles; in Elphinston's 'familiar' (i.e. casual) register, it applied in word-level domains. In present-day RP, it has climbed up to the stem level (see Bermúdez-Otero 2008 for detailed discussion of this stage).

(45)	level	(44) applies?	*elongate*	*prolonging* ‖	*prolong it*	*prolong* ‖
a.	*Early Modern English*					
	$\mathcal{P}_{SL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋg][ɪŋg]	[prə.lɒŋg][ɪt]	[prə.lɒŋg]
	$\mathcal{P}_{WL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋg]	[prə.lɒŋg][ɪt]	[prə.lɒŋg]
	$\mathcal{P}_{PL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋg]	[prə.lɒŋ.gɪt]	[prə.lɒŋg]
b.	*Elphinston's formal register*					
	$\mathcal{P}_{SL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋg][ɪŋg]	[prə.lɒŋg][ɪt]	[prə.lɒŋg]
	$\mathcal{P}_{WL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋg]	[prə.lɒŋg][ɪt]	[prə.lɒŋg]
	$\mathcal{P}_{PL}$	yes	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ̸g̸]	[prə.lɒŋ.gɪt]	[prə.lɒŋ̸g̸]
c.	*Elphinston's casual register*					
	$\mathcal{P}_{SL}$		[iː.lɒŋ.geɪt]	[prə.lɒŋg][ɪŋg]	[prə.lɒŋg][ɪt]	[prə.lɒŋg]
	$\mathcal{P}_{WL}$	yes	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ̸g̸]	[prə.lɒŋ̸g̸][ɪt]	[prə.lɒŋ̸g̸]
	$\mathcal{P}_{PL}$	yes (vacuously)	[iː.lɒŋ.geɪt]	[prə.lɒŋ.gɪŋ]	[prə.lɒ.**ŋ**ɪt]	[prə.lɒŋ]
d.	*Present-day RP*					
	$\mathcal{P}_{SL}$	yes	[iː.lɒŋ.geɪt]	[prə.lɒŋ̸g̸][ɪŋ̸g̸]	[prə.lɒŋ̸g̸][ɪt]	[prə.lɒŋ̸g̸]
	$\mathcal{P}_{WL}$	yes (vacuously)	[iː.lɒŋ.geɪt]	[prə.lɒ.**ŋ**ɪŋ]	[prə.lɒŋ][ɪt]	[prə.lɒŋ]
	$\mathcal{P}_{PL}$	yes (vacuously)	[iː.lɒŋ.geɪt]	[prə.lɒ.**ŋ**ɪŋ]	[prə.lɒ.ŋɪt]	[prə.lɒŋ]

As suggested in §5 above, input restructuring was the engine of the analogical changes whereby system (45b) was succeeded by (45c), and (45c) by (45d): see Bermúdez-Otero (2006a: 504, Figure 4). In (45b), for example, surface [$_{PL}$ prə.lɒŋ‖] was derived unfaithfully from word-level [$_{WL}$ prə.lɒŋg] by a phrase-level application of /ŋg/-simplification. In (45c), however, [$_{PL}$ prə.lɒŋ‖] has been reanalysed as derived faithfully from an identical word-level representation [$_{WL}$ prə.lɒŋ]. This introduces /ŋg/-simplification into the word-level phonology and gives rise to innovative [$_{WL}$ prə.lɒŋ][$_{WL}$ ɪt]→[$_{PL}$ prə.lɒ.ŋɪt]. Bermúdez-Otero (1999: 100-3, 239-40; 2003: 4ff) outlines an approach to phonological learning that accounts straightforwardly for such patterns of recurrent input restructuring.

If we now consider the incidence of /l/-darkening in dialects where this process has not yet become foot-based (i.e. in dialects with [l] rather than [ɬ] in *village*: see §5), we can reliably infer a parallel pattern of diachronic evolution:[31]

[31] For RP, see Cruttenden (2001: 201). The dialect I have here labelled 'Am1' is the one described by Sproat and Fujimura (1993); see §5 above. For 'Am2', see Olive et al. (1993: 212-15). The implicational relationships implicit in (46) are confirmed by the rates of variation reported by Hayes (2000: 98).

(46)

dialect	RP	Am1	Am2
Healey	l	l	l
heal-ing	l	l	ɬ
heal it	l	ɬ	ɬ
heal ‖	ɬ	ɬ	ɬ
darkening of rhymal /l/ applies in...	$\mathcal{P}_{PL}$	$\mathcal{P}_{WL}$	$\mathcal{P}_{SL}$

conservative → innovative

Observe that, as /ŋg/-simplification and /l/-darkening traverse their life cycles, they create growing dialectal diversity. Strikingly, however, the newly created dialects inhabit a grammar space bounded by a remarkable restriction: no process that misapplies within words can apply transparently across word boundaries. Thus, if /ŋg/-simplification overapplies before a suffixal vowel, then it must also overapply before a vowel in a following word: [pɹə.lɒ.ŋɪŋ] entails [pɹə.lɒ.ŋɪt]. Similarly, if coda darkening overapplies to an /l/ syllabified in the onset before a suffixal vowel, then it must also overapply to an /l/ resyllabified across a word boundary: [hiː.ɬɪŋ] entails [hiː.ɬɪt]. In a cyclic framework, this restriction is just an instance of a wider generalization that follows as a theorem from the very definition of the cycle:

(47) *The Russian Doll Theorem*
Let there be the nested cyclic domains $[_{\gamma} \ldots[_{\beta} \ldots[_{\alpha} \ldots]\ldots]\ldots]$. If a phonological process $\mathcal{P}$ is opaque in β because its domain is α, then $\mathcal{P}$ is opaque in γ.

To my knowledge, the Russian Doll Theorem has not been formally enunciated before, probably because it has been considered so obviously true as to be entirely trivial. Yet, if we assume OO-correspondence, this generalization need not hold. For example, Hayes (2000: 102) proposes two separate OO-correspondence constraints to describe the dialectal facts in (46):

(48) a. hiːɬ ⟷ hiː.ɬɪŋ
OO-IDENT(MORPHOLOGICAL)

b. hiːɬ ⟷ hiː.ɬɪt
OO-IDENT(PHRASAL)

By factorial typology, however, these two constraints can generate an impossible dialect with [hiːɬ, hiː.ɬɪŋ, hiː.lɪt], in violation of the Russian Doll Theorem. All that is needed is a constraint hierarchy of the following type:

(49) *CODA[l] ≫ OO-IDENT(MORPHOLOGICAL) ≫ *[ɨ] ≫ OO-IDENT(PHRASAL).

To avoid this result, Hayes (2000: 102) resorts to stipulating an innate fixed ranking in Universal Grammar:

(50) OO-IDENT(PHRASAL) ≫ OO-IDENT(MORPHOLOGICAL).

The explanatory loss is plain to see: whereas (47) is a theorem, (50) is an axiom.

7. Nonsurfacing bases in noncanonical paradigms: Albanian stress

In the examples of morphosyntactically induced misapplication discussed in §4 and §5, the surface bases required by OO-correspondence are unavailable for phonological reasons: an opaque phonological process applies normally in a nonfinal cycle ☪, but the output of ☪ is always subsequently altered by the operation of other phonological processes in later cycles. However, the output of ☪ may also fail to surface unchanged for purely morphological reasons. This effect stands out with particular clarity in noncanonical inflectional paradigms, i.e. paradigms exhibiting phenomena such as deponency, defectiveness, suppletion, or heteroclisis (Corbett 2007, 2009). In such circumstances, the predictions of cyclicity and OO-correspondence diverge dramatically. Let two words *a* and *b* have identical syntagmatic structures in all relevant respects, but belong in paradigms with different sets of cells: one canonical, the other noncanonical. The theory of the cycle predicts that, in the phonology, *a* and *b* must exhibit the same procedural intervention effects (§3), since the course of cyclic derivations depends on syntagmatic structure alone (Bobaljik 2008: 32; Bailyn and Nevins 2008: 242). In contrast, OO-correspondence predicts the opposite, as transderivational identity effects depend on the availability of surface bases. As Trommer (2006, 2009) has brilliantly demonstrated with evidence from Albanian, the first prediction is true, the second false. In this section I briefly summarize Trommer's argument, omitting his detailed motivation of the morphological segmentations underpinning the analysis.

Trommer (2004) found that Albanian polysyllabic words bearing no overt inflection display end-stress in either of two cases:

(i) if the final syllable is headed by a nonmid vowel (i.e. by /i/, /u/, or /a/), as in (51a) and (51b),

or (ii) if the final syllable is both headed by a full vowel (i.e. by a vowel other than /ə/) and closed by a consonant, as in (51b) and (51c);

otherwise, stress falls on the penultima, as in (51d) and (51e).

(51)

a.	[ɟu.hə.ˈsi]	‘linguistics’	d.	[ˈho.le]	‘swing’
	[a.kə.ˈku]	‘here and there’		[ˈba.bo]	‘midwife’
	[ɾi.ˈʤa]	‘prayer’		[ˈhə.nə]	‘moon’
b.	[aɾ.ˈmik]	‘enemy’			
	[ʧi.ˈfut]	‘gipsy’			
	[ɾe.zul.ˈtat]	‘result’			
c.	[a.ˈdet]	‘habit’	e.	[ˈa.fəɾ]	‘near’
	[pa.ˈtok]	‘gander’			

In wordforms containing overt inflectional markers, however, stress assignment often misapplies. Consider, for example, the present indicative of a verb with a canonical paradigm: *formoj* ‘form’.[32]

(52)

			UR	SR	opaque stress?
ACT	SG	1	[GWord [Stem foɾmo-j]]	[foɾ.ˈmoj]	no
		2	[GWord [Stem foɾmo-n]]	[foɾ.ˈmon]	no
		3	[GWord [Stem foɾmo-n]]	[foɾ.ˈmon]	no
	PL	1	[GWord [Stem foɾmo-j] [Affix mə]]	[foɾ.ˈmoj.mə]	no
		2	[GWord [Stem foɾmo-n] [Affix ni]]	[foɾ.ˈmo.ni]	yes: *[foɾ.mo.ˈni]
		3	[GWord [Stem foɾmo-j] [Affix nə]]	[foɾ.ˈmoj.nə]	no
NACT	SG	1	[GWord [Stem foɾmo-j] [Affix he-m]]	[foɾ.ˈmo.hem]	yes: *[foɾ.mo.ˈhem]
		2	[GWord [Stem foɾmo-j] [Affix he-ʃ]]	[foɾ.ˈmo.heʃ]	yes: *[foɾ.mo.ˈheʃ]
		3	[GWord [Stem foɾmo-j] [Affix he-t]]	[foɾ.ˈmo.het]	yes: *[foɾ.mo.ˈhet]
	PL	1	[GWord [Stem foɾmo-j] [Affix he-mi]]	[foɾ.ˈmo.he.mi]	yes: *[foɾ.mo.he.ˈmi]
		2	[GWord [Stem foɾmo-j] [Affix he-ni]]	[foɾ.ˈmo.he.ni]	yes: *[foɾ.mo.he.ˈni]
		3	[GWord [Stem foɾmo-j] [Affix he-n]]	[foɾ.ˈmo.hen]	yes: *[foɾ.mo.ˈhen]

Metrical opacity arises in consequence of the fact that the domain of stress assignment is the stem, not the word: stress is assigned transparently in stem-level cycles, but is rendered opaque at the word level by the addition of inflectional suffixes and by regular internal sandhi at the stem-suffix juncture.

(53) a. *Internal sandhi processes*

(i) nn → n

(ii) j → ∅ / __h

[32] NACT denotes ‘nonactive’.

b. *Sample derivations*

		⟦WL ⟦SL foɾmo-j⟧⟧	⟦WL ⟦SL foɾmo-j⟧⟦SL he-m⟧ ⟧
$\mathcal{P}_{SL}$	(stress assignment)	[foɾ.'moj]	[foɾ.'moj] [hem]
$\mathcal{P}_{WL}$	(internal sandhi)	—	[foɾ.'mo.hem]
		'form[ACT.1SG]'	'form.NACT.1SG'

Let us now turn to verbs with noncanonical paradigms. The verb *pendohem* 'regret', for example, exhibits deponency: it lacks a voice alternation, and its fixed lexical meaning is expressed by a series of nonactive forms. Crucially, the absence of nonactive forms entails that the location of stress is opaque throughout the present indicative.

(54)

			UR	SR	opaque stress?
ACT			—	—	—
NACT	SG	1	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-m⟧⟧	[pen.'do.hem]	yes: *[pen.do.'hem]
		2	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-ʃ⟧⟧	[pen.'do.heʃ]	yes: *[pen.do.'heʃ]
		3	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-t⟧⟧	[pen.'do.het]	yes: *[pen.do.'het]
	PL	1	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-mi⟧⟧	[pen.'do.he.mi]	yes: *[pen.do.he.'mi]
		2	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-ni⟧⟧	[pen.'do.he.ni]	yes: *[pen.do.he.'ni]
		3	⟦GWord ⟦Stem pendo-j⟧⟦Affix he-n⟧⟧	[pen.'do.hen]	yes: *[pen.do.'hen]

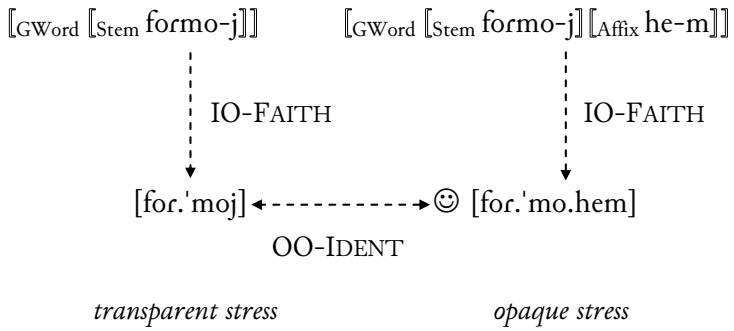
This corroborates the predictions of cyclicity: since the single series of forms of a deponent verb has the same syntagmatic structure as the nonactive series of a canonical verb, both must display the same pattern of metrical opacity; cf. (53b) and (55).

(55)

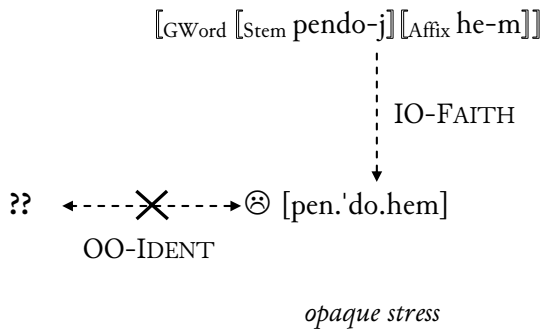
		⟦WL ⟦SL pendo-j⟧⟦SL he-m⟧ ⟧
$\mathcal{P}_{SL}$	(stress assignment)	[pen.'doj] [hem]
$\mathcal{P}_{WL}$	(internal sandhi)	[pen.'do.hem]
		'regret.1SG'

In contrast, OO-correspondence cannot account for the misapplication of stress assignment in the present indicative forms of Albanian deponent verbs: there are simply no suitable surface bases with transparent stress.

(56) a.



b.



In conclusion, morphologically induced misapplication depends on syntagmatic structure, not on the contents of paradigms.

8. Further problems for OO-correspondence

I regard the theory of OO-correspondence as conclusively falsified by the empirical evidence presented in §4, §5, and §7: in all three cases, the necessary surface bases are simply unavailable. For the sake of completeness, however, I shall also briefly mention here a few other problems for OO-correspondence that have been extensively discussed in the literature.

In a cyclic framework, the range of phonological domain structures that can possibly be attributed to a linguistic expression is very narrowly constrained by the expression's morphosyntactic constituency, many of whose aspects are independently verifiable on morphological, syntactic, and semantic criteria: see e.g. (20). In contrast, there are few *a priori* limits to the set of transderivational relationships that a linguistic expression could conceivably enter into. In consequence, the proponents of OO-correspondence have entertained an ever widening range of possible criteria for basehood, including morph containment (Benua 1997: 28-29), morphosyntactic feature containment (Kager 1999: 215ff), morphological markedness, phonological markedness (McCarthy's 2005 'attraction to the unmarked'), frequency, reliability (Albright 2002, 2008), and arbitrary stipulation (Kenstowicz 1996: 387, 391). The evidence surveyed in this chapter suggests that the search for the right criterion is ultimately doomed to failure: in many cases, no surface expression at all provides a suitable base. Nonetheless, some of this research has yielded important insights: for example, I regard Albright's (2002, 2008) work

as proving that the theory of the acquisition of underlying representations must incorporate measures of the reliability of the evidence provided by different surface forms.

Similarly, cyclic computation is inherently asymmetric and local: by the definition of cyclicity as $\mathcal{P}$-function composition (§2), the phonological representation assigned to a nonminimal cyclic domain is uniquely defined by a function from the phonological representation of its immediate subdomains. In contrast, transderivational correspondence relationships need not abide by any of these restrictions, except by express stipulation. In the absence of *ad hoc* provisions, for example, OO-correspondence is inherently—and incorrectly—symmetrical (Orgun (1996: §5.1, Bermúdez-Otero 1999: 113-25). All practitioners agree upon the need to inject some asymmetry into the theory, but they disagree on the precise measure: Kenstowicz (1996) mixes symmetrical and asymmetrical OO-correspondence *ad libitum*; McCarthy (2005) argues for asymmetry in derivation and symmetry in inflection (but cf. Hall and Scott 2007, Albright 2008); and Benua (1997) stipulates that all transderivational relationships must be asymmetrical. Moreover, the theory allows a surface form to engage in simultaneous OO-correspondence with several bases, including morphosyntactically remote expressions: for example, Burzio (1998) asserts that, in Italian, the agentive derivative *vincitore* 'winner' is transderivationally linked with the infinitive *vincere* 'to win' and the participle *vinto* 'won'; but the claim rests on a misconstrual of the synchronic morphosyntax of agentive nominals in Romance (Bachrach and Nevins 2008: 15-17, citing Tucker 2000 and Steriade 2002; see also Bermúdez-Otero 2007a: 293).

Finally, it has not often been noted that interface theories like Benua's (1997) imply a rather bizarre claim about acquisition. As we saw in Table 1, Benua's theory handles representational intervention by means of alignment constraints, and procedural intervention by means of OO-correspondence. The use of alignment constraints (e.g. ANCHOR(√,*σ*,final) in Benua 1997: 122) entails that learners refer to morphosyntactic constituency in the acquisition of representational intervention effects. Yet, *ex hypothesi*, the theory of OO-correspondence holds that children acquire procedural intervention effects on the evidence of paradigmatic surface information alone, ignoring syntagmatic structure. In cyclic frameworks, in contrast, both representational and procedural intervention are conditioned syntagmatically: paradigms have no ontological status in adult grammars (Bobaljik 2008), and the child's task is precisely to infer syntagmatic effects from paradigmatic information (Wunderlich 2003: 28ff.)

Figure 2 provides a synopsis of the various challenges to OO-correspondence that have been listed in this chapter.

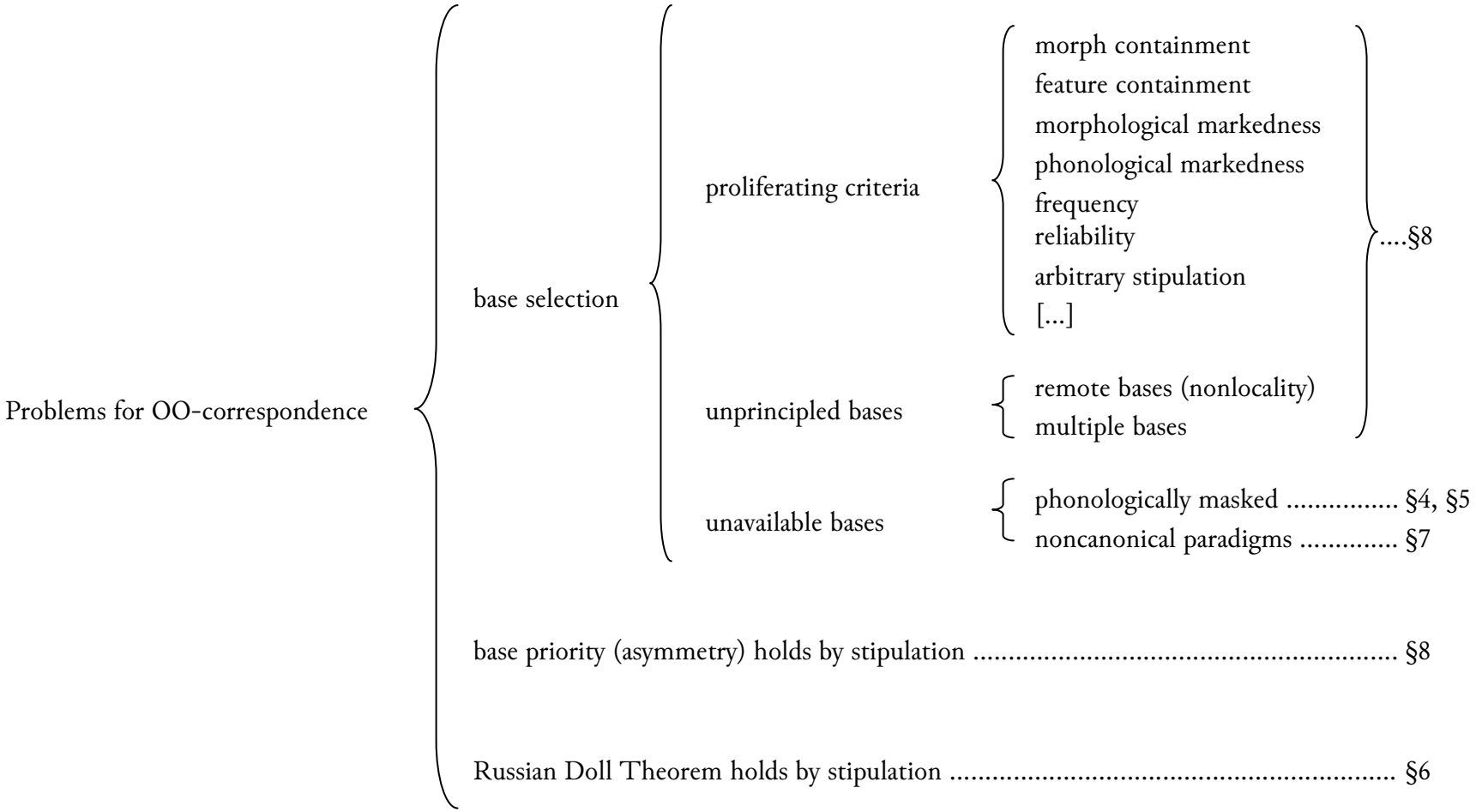


Figure 2. *Problems for OO-correspondence.*

9. A methodological moral

I should like to conclude with a methodological reflection upon the nature of the arguments formulated above. Analysing the interaction between morphosyntax and phonology in Ecuadorian Spanish /s/-voicing drew us deeply into a discussion of the relative rôles of categorical phonology and gradient phonetics in external sandhi (§4). Similarly, establishing the cause of the lenition of linking and intrusive *r* in English required us to consider whether the theory of representations should allow ambisyllabicity (§5). It could not have been otherwise: every phonological phenomenon engages the whole of phonological theory and adjacent linguistic disciplines. Every empirical puzzle forces us to ask: is this a morphological, phonological, or phonetic generalization, or a combination thereof? can I trade off a derivational step for a relatively richer or more covert representation, or vice versa? should I revise my assumptions about what lies on the other side of this or that interface? which aspects of the facts should be explained by synchronic grammatical theory, and which should be explained diachronically? For this reason, a research programme that regards the problem of phonological opacity (including morphosyntactically induced misapplication) merely as a question of adjudicating between the relative claims of parallelist and serialist computation is ultimately doomed to barrenness: the theory of phonological representations and the theory of phonology's interfaces are just as implicated in the problem of opacity as the theory of phonological computations, nor is there a neutral landscape of representational and architectural assumptions, or of explanatory goals, against which one can tackle the computational question.[33] Even further, it will simply not do to pursue our research by just considering the relative interactions of pairs or triplets of processes in particular languages: one cannot settle even such a plain question as the syllabic affiliation of linking and intrusive *r* without digesting a substantial fragment of the phonology of English.

This is why phonology is hard, but it does no good to pretend otherwise.

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[33] Scheer (forthcoming) expresses kindred views.

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