Non-Local Phonology by Morphological Movement

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1. Introduction

Morphological movement arises as an automatic consequence of the Merge-based approach to morphological exponence in harmonic serialism developed in Müller (2020), where competing outputs can be separated from the input by at most one operation: If a second-merged exponent obeys a lower-ranked competing alignment constraint, the derivation cannot respond by squeezing it in between the stem and the first-merged exponent, because of the Strict Cycle Condition, and consequently a new alignment constraint violation is triggered that is undone by movement in the following step.

This gives rise to a new approach to seemingly non-local phonological processes in words, which can now be analyzed as local reflexes of movement in the exponent's base position. We illustrate this with case studies of verb inflection in Homshetsma Armenian and diminutive formation in European and Brazilian Portuguese, thereby extending the approach in Gleim, Müller, Privizentseva, and Tebay (2021) to further phenomena.

2. Inflectional morphology in Harmonic Serialism

Harmonic serialism is a derivational variant of optimality theory where generation and evaluation are interspersed (McCarthy; 2016; Heck and Müller; 2007). The generator is restricted so that at most one operation can apply to the input. This produces a finite set of candidates that are evaluated by constraints. The candidate with the best profile becomes the input of the next generation step. The process repeats until further improvement of the constraint profile is impossible, and the winning candidate is identical to the input ('convergence'). Harmonic serialism has so far mainly been pursued for phonology and syntax; however, an approach to inflectional morphology is developed in Müller (2020). Here, a stem fully specified for morpho-syntactic features constitutes the initial input, and in the course of the morphological derivation features are realized by morphological exponents – thus, inflectional morphology is realizational and lexical (Stump; 2001). Exponents are combined with the stem via Merge (Alexiadou and Müller; 2008; Bruening; 2017). Merge is driven by structure-building features ([•α•]; notation from Heck and Müller (2007)) and Merge Conditions (MCs) that are satisfied by the discharge of these features. The relative ranking of MCs is universal and determined by the functional sequence (f-seq; Starke (2001)). Positional requirements of exponents are derived from linearization constraints, among them lower-ranked alignment constraints like $\alpha\Rightarrow$R(ight) or $\beta\Rightarrow$L(eft) (Trommer; 2001).

All Merge operations comply with the inviolable Strict Cycle Condition in (1) (Chomsky; 1973; 2013); thus, exponents can be merged only at the current root.

(1) *Strict Cycle Condition* (SCC): Within the current domain δ, no operation may affect solely a proper subdomain γ that is dominated by δ.

As a basic principle of linguistic computation, the SCC yields problems for a post-syntactic approach: Independently of whether morphological exponence is carried out by Merge (as assumed here) or by a substitution transformation like Vocabulary Insertion

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(Halle and Marantz; 1993), if it applies post-syntactically it exclusively affects a proper subpart of the structure. Following Müller (2020), we adopt a pre-syntactic, numeration-based (Chomsky; 2001) approach to morphology. Features realized by morphological exponents remain accessible in the syntax, and are available for operations like subject-verb agreement, via feature checking (see also Bruening (2017)).[1]

To see how this approach predicts movement of exponents, let us consider verb inflection in Berber. Here, tense and agreement exponents are prefixal, and agreement is closer to the stem: *ad-y-seg* 'FUT.3.MASC.SG-buy' (Ouhalla; 1991). Initially, the stem is equipped with two structure-building features ([•T•], [•Agr•]), and with fully specified morpho-syntactic features in need of morphological realization ([3], [SG], [MASC], [FUT], in the case at hand). $MC_{T(ense)}$ and $MC_{Agr(eement)}$ bring about structure-building. Given f-seq, their ranking is $MC_T \gg MC_{Agr}$. This order leads to an attachment of the T exponent prior to attachment of the Agr exponent, and thus ensures that the Mirror Principle (Baker; 1985) is respected at an early stage of the derivation (i.e., after basic structure-building). However, the final order of exponents is then reversed by exponent movement, via a ranking L⇐T ≫ L⇐Agr, which imposes conflicting left-alignment requirements on the two exponents; these can never be resolved by suffixation because of a high-ranked V⇒R. Thus, in the initial step in (2), candidate O_{14} (where the T exponent /ad/ is merged as a prefix) has the best constraint profile. O_{11} and O_{13} violate the high-ranked MC_T, and O_{12} violates V⇒R.

(2) *Berber verb inflection* (step 1):

I_1: [$_V$ seg]: [•T•], [•Agr•]; [3], [SG], [MASC], [FUT], {[$_T$ /ad/↔[FUT]], ... }, {[$_{Agr}$ /y/↔[3.SG.MASC]], ... }	MC_T	MC_{Agr}	V⇒R	L⇐T	L⇐Agr
O_{11}: [$_V$ seg]: [•T•], [•Agr•]	*!	*			
O_{12}: [$_V$ seg-ad]: [•Agr•]		*	*!	*	
O_{13}: [$_V$ y-seg]: [•T•]	*!				
☞O_{14}: [$_V$ ad-seg]: [•Agr•]		*			

In the next step (3), O_{14} is used as the new input, and the Agr exponent /y/ is merged as an outer prefix in the optimal output O_{143}, which gives rise to a new violation of L⇐T; /y/ cannot tuck-in between /ad/ and the stem (as might be expected given the lower ranking of L⇐Agr) due to the SCC (and V⇒R precludes suffixation in O_{142}).

(3) *Berber verb inflection* (step 2):

I_{14}: [$_V$ ad-seg]: [•Agr•]; [3], [SG], [MASC], [FUT], { ... }, {[$_{Agr}$ /y/↔[3.SG.MASC]], ... }	MC_T	MC_{Agr}	V⇒R	L⇐T	L⇐Agr
O_{141}: [$_V$ ad-seg]: [•Agr•]		*!			
O_{142}: [$_V$ [$_V$ ad-seg]-y]			*!		**
☞O_{143}: [$_V$ y-[$_V$ ad-seg]]				*	

Finally, the L⇐T violation of the new input I_{143} is removed by leftward movement (internal Merge) of the T exponent around the Agr exponent; cf. (4).

(4) *Berber verb inflection* (step 3):

I_{143}: [$_V$ y-[$_V$ ad-seg]]; [3], [SG], [MASC], [FUT], { ... }, { ... }	MC_T	MC_{Agr}	V⇒R	L⇐T	L⇐Agr
O_{1431}: [$_V$ y-[$_V$ ad-seg]]				*!	
☞O_{1432}: [$_V$ ad-[$_V$ y-[$_V$ seg]]]					*

[1] These considerations notwithstanding, it is worth emphasizing that the actual analyses we present below could easily be transferred to a post-syntactic approach.

Movement arises automatically here because the ranking of the MCs ($MC_T \gg MC_{Agr}$) is the same as the ranking of the corresponding alignment constraints (ACs; L⇐T ≫ L⇐Agr): The alignment constraint for the second-merged (i.e., outwardly-merged) exponent is ranked lower than the conflicting alignment constraint for the first-merged exponent, so the latter triggers movement of the first-merged exponent. This effect is illustrated abstractly in (5) vs. (6). MC_α and L⇐α demand Merge and left-alignment of exponent A, MC_β and L⇐β demand the same for B, and a higher-ranked S(tem)⇒R precludes all suffixation. In (5), the two rankings are parallel, so A eventually needs to move around B; (5a) becomes (5b). In contrast, no movement is triggered under a nested ranking, as in (6).

(5) $MC_\alpha \gg MC_\beta \gg$ S⇒R ≫ L⇐α ≫ L⇐β
a. [S B [S A Stem]]
b. [S A [S B [S Stem]]

(6) $MC_\alpha \gg MC_\beta \gg$ S⇒R ≫ L⇐β ≫ L⇐α
a. [S B [S A Stem]]
b. —

While the discussion above focuses on prefixes, the same holds for suffixes: A parallel ranking between MCs and ACs leads to movement, the reverse ranking does not. More generally, movement of exponents in the morphological component is thus inevitably predicted under parallel rankings as in (5) as a consequence of two fundamental features of the overall approach: first, the one-edit-away-from-the-input restriction on outputs in harmonic serialism, and second, strict cyclicity.[2]

Against this background, we argue in Gleim et al. (2021) that instances of seemingly non-local application of phonological processes in words should be re-analyzed as local processes rendered opaque by subsequent exponent movement, i.e., as reflexes of movement in morphology: On the surface, two exponents A, C are separated by an intervening exponent B as a result of A movement, but a local phonological process involving A and C took place at an earlier, intermediate stage in the derivation. More specifically, we propose in Gleim et al. (2021) that a first phonological cycle is started after all basic structure-building is complete; this stage of the derivation constitutes a morphological *phase* (Marvin; 2002; Embick; 2010; Bermúdez-Otero; 2011). After completing this phonological cycle, the morphological derivation continues, via movement and other operations, and it is finally followed by another phonological cycle. The phenomena discussed in Gleim et al. (2021) include despirantization apparently triggered by Agr exponents across a remote marker /wa/ in Barwar Aramaic; Saussurean accent shift apparently triggered by ϕ-exponents across a theme vowel in Lithuanian; *ni*-insertion apparently triggered by possessive markers across /lla/ ('just') in Quechua; *ruki* rule application across a past augment /a/ in Sanskrit; and vowel harmony applying with Q morphemes across an instrumental affix /men/ in Kazakh. In the present study, we turn to verb inflection in Homshetsma Armenian and diminutive formation in European and Brazilian Portuguese.

3. Vowel raising in Homshetsma Armenian verb inflection

Our first case study is from (Köprücü) Homshetsma, a Western Armenian language spoken in North-Eastern Turkey (Vaux; 1994; 2007). The relevant phonological process of Homshetsma is pre-nasal *e*-raising, where /e/ turns to [i] if it precedes a nasal consonant; see (7).[3]

[2] Note that it is ceteris paribus impossible for movement to arise in this simple way in parallel optimality theory (Prince and Smolensky; 2004): Exponent order will always be established directly.

[3] These forms are in the optative (not the indicative), the morphologically unmarked mood.

(7) a. [k^{h}alím] ⇐ /k^{h}al-e-m/
'may I walk' walk-TV-1SG

b. [k^{h}alín] ⇐ /k^{h}al-e-n/
'may they walk' walk-TV-3PL

The exponent /g(u)/ marks the indicative.[4] If it intervenes between the stem-final /e/ and the triggering nasal affix, however, raising applies opaquely; cf. (8).

(8) a. [k^{h}alígum] ⇐ /k^{h}al-e-gu-m/
'I walk' walk-TV-IND-1SG

b. [xarbígum] ⇐ /xarb-e-gu-m/
'I speak' speak-TV-IND-1SG

Seemingly non-local raising in (8) cannot be attributed to the /g(u)/ exponent itself: If the nasal is absent, raising fails to apply; cf. (9).

(9) [k^{h}alégus] ⇐ /k^{h}al-e-gu-s/
'you walk' walk-TV-IND-2SG

It is important to note that the intervening position of /g(u)/ is optional; /g(u)/ may also follow the agreement affixes; cf. (10). This position is in fact obligatory in other varieties of Homshetsma (Vaux; 2007).

(10) [k^{h}alímgu] ⇐ /k^{h}al-e-m-gu/
'I walk' walk-TV-1SG-IND

The gist of the analysis that we propose for this phenomenon is that the nasal suffix is local to the root at a first step of the phonology-morphology interface and moves out at a next iteration of morphology. However, before we can delve into the details, we have to establish some facts about /g(u)/ first, as is shows a quite peculiar distribution.

As we have seen, in forms like (8) /g(u)/ is a suffix that intervenes between the nasal (if present) and the stem. However, depending on the phonological shape of the root, it may also be realized as a prefix; cf. (11).

(11) a. [garnés] ⇐ /g-arn-e-s/
'you take' IND-take-TV-2SG

b. [gulás] ⇐ /gu-l-a-s/
'you cry' IND-cry-TV-2SG

The generalisation is that this exponent is realized (i) as a prefix /g-/ if the verb stem is vowel-initial; (ii) as a prefix /gu-/ if the root does not contain vowels (with three verbs, the only vowel is the theme vowel; see Bezrukov and Dolatian (2020)); and (iii) as a suffix /-gu/ in every other case. Phonologically determined alignment of affixes is rare but robustly attested (cf. Noyer (1994); Kim (2008; 2015); Jenks and Rose (2015)). Three approaches can be distinguished: subcatecorization (Kim; 2015), phonology-triggered variable positioning (Kim; 2008; Jenks and Rose; 2015), and movement in morphology. None of these approaches is entirely unproblematic because they all violate modularity, which is a recurring issue with approaches to phonologically conditioned allomorphy (Scheer; 2016). In the case of phonologically conditioned linearization, it is not the shape of the exponent that depends on the phonological structure of its context, but its position. These considerations notwithstanding, only the subcategorization approach is incompatible with our proposal – linearization is a consequence of constraint ordering and not of individual lexical items. In what follows, we will abstract away from the prefix/suffix issue and focus on the suffix occurrences of /g(u)/.

Recall from (7) and (8) that the mood/aspect exponent /g(u)/↔[IND.IMP] can intervene between the stem and an agreement exponent like /m/↔[1.SG] on the surface but does not

[4] Vaux (1994; 2007) glosses this affix as either 'present' or 'imperfect'; Bezrukov and Dolatian (2020) classify it as an indicative exponent. It is restricted to imperfect indicative contexts.

block *e*-raising of the theme vowel triggered by the nasal. Given the reasoning in section 2, this implies that /m/ is merged before /g(u)/, due to a ranking $\mathrm{MC}_{\mathrm{Agr}} \gg \mathrm{MC}_{\mathrm{Mood}}$; and that there is a parallel ranking Agr⇒R ≫ Mood⇒R. Note that the ranking of MCs is compatible with f-seq, as we follow Bezrukov and Dolatian (2020) and consider /g(u)/ (primarily) to be an exponent of the indicative (and not of tense). The tableau in (12) shows that at a first step of optimization, merging agreement morphology is optimal. A candidate that merges both /g(u)/ and /m/ in the order Mood-Agr would be optimal; however, such an output cannot be generated in harmonic serialism as it would be separated from its input by two Merge operations.

(12) *Vowel raising in Homshetsma verb inflection* (step 1):

I_1: [$_V$ k^{h}ale]: [●Agr●], [●Mood●], [1], [SG], [IND] {[$_{Agr}$ /m/↔[1.SG]], ... }, {[$_{Mood}$ /g(u)/↔[IND]], ... }	$\mathrm{MC}_{\mathrm{Agr}}$	$\mathrm{MC}_{\mathrm{mood}}$	L⇐V	Agr⇒R	Mood⇒R
O_{11}: [$_V$ k^{h}ale]: [●Agr●], [●Mood●]	*!	*			
☞O_{12}: [$_V$ [$_V$ k^{h}ale]-m]: [●Mood●]		*			
O_{13}: [$_V$ [$_V$ k^{h}ale]-gu]: [●Agr●]	*!				
O_{14}: [$_V$ m-[$_V$ k^{h}ale]]: [●Mood●]		*	*!	*	
O_{15}: [$_V$ gu-[$_V$ k^{h}ale]]: [●Agr●]	*!		*		*

In the next optimization step documented in (13), O_{122} is optimal: /g(u)/ is added, and it is also added as a suffix (because of the ranking L⇐V ≫ Agr⇒R). As before, placing /g(u)/ in a position between V and /m/ would in principle give rise to the best constraint profile, but this option is not available because of the SCC.

(13) *Vowel raising in Homshetsma verb inflection* (step 2):

I_{12}: [$_V$ [$_V$ k^{h}ale]-m]: [●Mood●], [1], [SG], [IND] {... }, {[$_{Mood}$ /g(u)/↔[IND]], ... }	$\mathrm{MC}_{\mathrm{Agr}}$	$\mathrm{MC}_{\mathrm{mood}}$	L⇐V	Agr⇒R	Mood⇒R
O_{121}: [$_V$ [$_V$ k^{h}ale]-m]: [●Adv:T●]		*!			
☞O_{122}: [$_V$ [$_V$ [$_V$ k^{h}ale]-m]-gu]				*	
O_{123}: [$_V$ gu-[$_V$ [$_V$ k^{h}ale]-m]]			*!		**

At this point, the V stem has discharged all its structure-building features, so a morphological cycle (phase) is completed, and phonological operations can be triggered. Thus, *e*-raising applies locally to O_{122}, turning /k^{h}ale-m-gu/ into /k^{h}ali-m-gu/. After this, the next morphological cycle starts; and, as shown in (14), the constraint profile can indeed be further improved by carrying out morphological movement of /m/ to the right edge: O_{1222} trades in the violation of higher-ranked Agr⇒R incurred by O_{1221} (which leaves the input intact) for a violation of lower-ranked Mood⇒R.

(14) *Vowel raising in Homshetsma verb inflection* (step 3):

I_{122}: [$_V$[$_V$ [$_V$ k^{h}ali]-m]-gu]: [●Mood●], [1], [SG], [IND] {... }, { ... }	$\mathrm{MC}_{\mathrm{Agr}}$	$\mathrm{MC}_{\mathrm{mood}}$	L⇐V	Agr⇒R	Mood⇒R
O_{1221}: [$_V$ [$_V$ [$_V$ k^{h}ali]-m]-gu]				*!	
☞O_{1222}: [$_V$ [$_V$ [$_V$ [$_V$ k^{h}ali]]-gu]-m]					*
O_{1223}: [$_V$ gu-[$_V$ [$_V$ k^{h}ali]-m]]			*!		**
O_{1224}: [$_V$ m-[$_V$ [$_V$ k^{h}ali]]-gu]			*!	**	

The next step yields convergence. A second phonological cycle starts which, however, does not affect *e*-raising anymore: Morphological movement counter-bleeds *e*-raising.

4. Stem changes in Portuguese diminutive formation

As noted in section 2, next to the case of vowel raising in Homshetsma Armenian there are many more cases of apparently non-local phonology that naturally lend themselves to the present approach of morphological movement in harmonic serialism, several of which are dicsussed in Gleim et al. (2021). In all these cases, the surface order of exponents deviates from the order predicted under f-seq (cf. Myler (2017)), and assuming that there is a first phonological cycle after satisfaction of all basic structure-building brought about by MCs (whose ranking obeys f-seq), before exponent movement triggered by alignment constraints, derives the phenomena as instances of counter-bleeding. In this section, we extend the approach to seemingly non-local phonological operations in European Portuguese (Rainer; 1996) and Brazilian Portuguese (Ferreira; 2004; Bachrach and Nevins; 2008) which arise in environments where a noun stem is accompanied both by a diminutive suffix and by a plural suffix. Here, the first process is derivational and the second one inflectional, and so one would expect that an f-seq-regulated order of the two MCs involved ($\mathrm{MC}_{\mathrm{Dim(inutive)}} \gg \mathrm{MC}_{\mathrm{Num(ber)}}$) results in N-Dim-Pl(ural) sequences, which might then be reversed on the surface as a consequence of identically ranked alignment constraints (Dim⇒R ≫ Num⇒R), with opaque phonological processes involving stem and the diminutive exponent. However, this is not what we find. Rather, the f-seq-respecting order shows up on the surface, and the initially surprising phonological processes involve the stem and the plural exponent; cf. the European Portuguese data in (15) (Rainer; 1996).

(15)

Sg.	Sg.Dim	Pl.	Pl.Dim
flor ‘flower’	flor-zinha	flor-es	flor-e-zinha-s
cã-o ‘dog’	cã-o-zinho	cã-es	cã-e-zinho-s
cord-a ‘rope’	cord-a-zinha	cord-a-s	cord-a-zinha-s
ólh-o ‘eye’	ólh-o-zinho	ólh-o-s	ólh-o-zinho-s

Rainer (1996) notes that a gender exponent (/o/, /a/, /e/) may show up closer to the stem than the diminutive exponent /zinho∼a/, which is unexpected if derivation precedes inflection. Even more importantly, Benua (1997) observes that these data reveal seemingly non-local phonological operations: The plural exponent /(e)s/ triggers assimilation or deletion of [o] in *cães*, in contrast to /zinho/ (cf. *cãozinho*); however, in diminutive plural contexts, the same phonological effect obtains, even though the triggering exponent is not adjacent (*cãezinhos*). In the same way, the occurrence of [e] in *florezinhas* cannot be attributed to /zinha/ (cf. *florzinha*), and must be due to the non-local plural exponent (cf. *flores*).

Similar effects are observed by Ferreira (2004) for Brazilian Portuguese; cf. (16).

(16)

Sg.	Sg.Dim	Pl.	Pl.Dim
jornal ‘newspaper’	jornal-zinho	jornai-s	jornai-zinho-s

As shown in (16), the plural exponent triggers a phonological process changing stem-final [l] to [i] (cf. *jornais*), which is not triggered by the diminutive exponent /zinho/ (cf. *jornalzinho*), but which reappears if the diminutive form is extended by a plural exponent (cf. *jornaizinhos*). This apparently non-local phonological effect does not show up with other pieces of derivational morphology (Bachrach and Nevins; 2008).

Two kinds of approaches have been suggested to deal with this phenomenon. First, Benua (1997) and Rolle (2018a) propose that output-output faithfulness constraints are responsible; cf. the next section. Second, Wolf (2008) assumes that /zinho∼a/ can be inserted countercyclically, thereby breaking up a N-Pl sequence formed earlier in which the phonological process is locally motivated. Such an approach has also been pursued for other seemingly

non-local phonological processes by Hyman (1994) and Kiparsky (1982); it implies abandoning the Strict Cycle Condition. In view of this situation, we develop a new analysis based on morphological movement in a harmonic serialist approach that adheres to f-seq and avoids non-locality in phonology.

Note first that there is a minimally different diminutive suffix /inho∼a/ which existing approaches treat as synchronically unrelated to /zinho∼a/, despite substantial partial syncretism, and despite the fact that /zinho∼a/ can diachronically be understood as a phonologically motivated form for some stems that was later generalized (Rainer; 1996). Ferreira (2004) treats /inho∼a/ as a stem-level exponent and /zinho∼a/ as a word-level exponent. In contrast, we suggest that there is only one exponent /inho∼a/; /z/ is an optional separate marker.

For concreteness, suppose that Portuguese noun stems (Ns) can initially be associated with four different structure-building features in the cases at hand: [•Gen(der)•], [•Num(ber)•] (both obligatory), as well as [•Dim•] (optional) and [•z•] (a purely morphomic feature that is optional in principle but can only be instantiated on N if [•Dim•] has been instantiated).[5] These structure-building features are regulated by MC_{Dim}, MC_{Gen}, MC_{Num}, and MC_{z}, in this order: Given f-seq, derivation comes before inflection, gender before number, and morphomic categories at the end. Next, the analysis relies on linearization constraints: (i) an undominated L⇐N ensuring that placement of the exponents under consideration can never involve prefixation, which we will tacitly presuppose in the tableaux below; (ii) an alignment constraint Num⇒R (with lower-ranked Gen⇒R, Dim⇒R that we can disregard); and (iii) the two higher-ranked precedence constraints Gen⇒Dim and z⇒Dim which require that a diminutive exponent follows both a gender exponent and morphomic *z*.[6] With these assumptions in place, consider the derivation of *cãezinhos* on the basis of the stem *cão*. In the first step, *inho* is merged, as required by MC_{Dim}, which is highest-ranked.

(17) *Stem changes in Portuguese diminutive plurals* (step 1):

I_1: [$_{N[masc,pl]}$ *cã*]: [•Gen•], [•Num•], [•Dim•], [•z•]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_{z}	z⇒ Dim	Num ⇒R
O_{11}: [$_{N}$ cã]: [•Gen•], [•Num•], [•Dim•], [•z•]	*!	*		*	*		
☞O_{12}: [$_{N}$ cã]-[$_{Dim}$ inho]: [•Gen•], [•Num•], [•z•]		*		*	*		
O_{13}: [$_{N}$ cã]-[$_{Gen}$ o]: [•Num•], [•Dim•], [•z•]	*!			*	*		
O_{14}: [$_{N}$ cã]-[$_{Num}$(e)s]: [•Gen•], [•Dim•], [•z•]	*!	*			*		

In (18), the gender exponent *o* is merged at the right edge (given the SCC), thereby producing a violation of Gen⇒Dim. This is rectified by *inho* movement in (19).

(18) *Stem changes in Portuguese diminutive plurals* (step 2):

I_{12}: [$_{N}$ cã]-[$_{Dim}$ inho]: [•Gen•], [•Num•], [•z•]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_{z}	z⇒ Dim	Num ⇒R
O_{121}: [$_{N}$ cã]-[$_{Dim}$ inho]: [•Gen•], [•Num•], [•z•]		*!		*	*		
☞O_{122}: [$_{N}$ cã]-[$_{Dim}$ inho]-[$_{Gen}$ o]: [•Num•], [•z•]			*	*	*		
O_{123}: [$_{N}$ cã]-[$_{Dim}$ inho]-[$_{Num}$(e)s]: [•Gen•], [•z•]		*!			*		

[5] The substantial lexical variation in this area can be addressed by modulating the status of [•z•] between (in-)compatibility and obligatoriness with any given N.

[6] These precedence constraints are reminiscent of bigram constraints (Ryan; 2010) but differ from the latter in not requiring an exponent to *immediately* follow the other one; see Müller (2020).

(19) *Stem changes in Portuguese diminutive plurals* (step 3):

I_{122}: [$_N$ cã]-[$_{Dim}$ inho]-[$_{Gen}$ o]: [•Num•], [•z•]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_z	z⇒ Dim	Num ⇒R
O_{1221}: [$_N$ cã]-[$_{Dim}$ inho]-[$_{Gen}$ o]: [•Num•], [•z•]			*!	*	*		
☞O_{1222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]: [•Num•], [•z•]				*	*		
O_{1223}: [$_N$ cã]-[$_{Dim}$ inho]-[$_{Gen}$ o]-[$_{Num}$(e)s]: [•z•]			*!		*		

After this, the plural exponent is merged in (20), followed by morphomic *z* in (21).

(20) *Stem changes in Portuguese diminutive plurals* (step 4):

I_{1222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]: [•Num•], [•z•]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_z	z⇒ Dim	Num ⇒R
O_{12221}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]: [•Num•], [•z•]				*!	*		
☞O_{12222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]: [•z•]					*		

(21) *Stem changes in Portuguese diminutive plurals* (step 5):

I_{12222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]: [•z•]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_z	z⇒ Dim	Num ⇒R
O_{122221}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]: [•z•]					*!		
☞O_{122222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]-[$_z$ z]						*	*

Since O_{122222} has a new violation of the precedence constraint z⇒Dim, movement of *inho* takes place again in (22); crucially, now the plural exponent is in a position where it can locally interact with the extended stem, giving rise to *o*-assimilation/deletion.

(22) *Stem changes in Portuguese diminutive plurals* (step 6):

I_{122222}: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]-[$_z$ z]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_z	z⇒ Dim	Num ⇒R
$O_{1222221}$: [$_N$ cã]-[$_{Gen}$ o]-[$_{Dim}$ inho]-[$_{Num}$(e)s]-[$_z$ z]						*!	*
☞$O_{1222222}$: [$_N$ cã]-[$_{Gen}$ o]-[$_{Num}$(e)s]-[$_z$ z]-[$_{Dim}$ inho]							*

Finally, the plural exponent moves around the diminutive exponent so as to satisfy Num⇒R, yielding convergence (with violations of lower-ranked Gen⇒R, Dim⇒R); see (23).

(23) *Stem changes in Portuguese diminutive plurals* (step 7):

$I_{1222222}$: [$_N$ cã]-[$_{Gen}$ e]-[$_{Num}$ (e)s]-[$_z$ z]-[$_{Dim}$ inho]	MC_{Dim}	MC_{Gen}	Gen ⇒Dim	MC_{Num}	MC_z	z⇒ Dim	Num ⇒R
$O_{12222221}$: [$_N$ cã]-[$_{Gen}$ e]-[$_{Num}$ (e)s]-[$_z$ z]-[$_{Dim}$ inho]							*!
☞$O_{12222222}$: [$_N$ cã]-[$_{Gen}$ e]-[$_z$ z]-[$_{Dim}$ inho]-[$_{Num}$ (e)s]							

Some final remarks. First, the present counter-bleeding analysis of *cãezinhos* directly extends to cases like *florezinhas* and *jornaizinhos*. Second, it is clear that the first phonological cycle giving rise to local plural-stem interaction must not take place directly after merging *z*, but only after *inho* is moved around it; this suggests that completeness of a word (first phase status) is understood in such a way that not only all MCs, but also all precedence constraints (but not alignment constraints) are satisfied. And third, step 4 above captures the endpoint of a derivation where bare *inho* is used (i.e., without [•z•] on N); this gives rise to a local phonological interaction of *inho* with the extended stem, accounting for stem-level properties (Ferreira; 2004).[7]

[7] Incidentally, (Ferreira; 2004) notes that *inho* can also lead to stem changes in plural environments, as in *pork-inho* ('little pig') vs. *pOrkinhos* ('little pigs'), with [±ATR] variation of the stem vowel. However, as Ferreira

5. An alternative account based on output-output correspondence

Rolle (2018a;b) sketches a phonological approach to the Brazilian Portuguese data in terms of an extended version of output-output-correspondence theory (OO-Corr), termed transparadigmatic output-output-correspondence. In this section we will point out some conceptual and empirical drawbacks of this approach and show that it cannot easily be extended to Homshetsma vowel raising.

The theory of base-derivative-correspondence (cf. Benua; 1997) assumes that correspondence relation exist not only between an input and an output, but also between morphologically related output forms. Crucially, the faithfulness relations based on these new correspondence relations are asymmetric, i.e., an output form can be forced to be faithful to its base, but not vice versa. In the scheme in (24) (Benua; 1997: 7), O_1 and O_2 can be faithful to their respective input via usual IO-correspondence. Additionally, in an OO-Corr framework, O_1 can be faithful to O_2 if O_2 is the designated base of O_1. This can derive overapplication patterns, where a process applies in a derived form even though the phonological context is only present in the base.

(24) *Correspondence relations and faithfulness in a base-derivative framework*

$$\begin{array}{ccccc} & \text{Input}_1 & & \text{Input}_2 & \\ \text{IO-Corr} & \uparrow & & \uparrow & \text{IO-Corr} \\ & \text{Output}_1 & \rightarrow & \text{Output}_2 & \\ & & \text{OO-Corr} & & \end{array}$$

The choice of correct and licit bases is a much debated topic in OO-Corr. In some approaches, the base is the base of affixation (Input: XY, Base: X), as in Benua (1997); in others it is an output of the base of affixation whereby the output base contains one unmarked inflectional affix (Input: X, Base: XY, cf. Albright (2002)). Yet other accounts have used the unmarked cell of an inflectional paradigm to which the output form also belongs (Input:XY′, Base: XY; cf. Albright (2011)) as the base. Rolle (2018a;b) adds a further option, where the output and its base share a root but not a stem. This allows for the exclusion of derivational affixes: Transparadigmatic correspondence can hold between outputs of the form [Root]-[Derivation]-[Inflection] and a base of the form [Root-Inflection]. The base is thus non-contiguous.

In Rolle's analysis, the correspondence relations in (25) are needed for Brazilian Portuguese.[8] The form *jornai*$_{i,k}$*-zinho-s* inherits the [l]-to-[i]-change from its base *jornai*$_{j,k}$*-s*, because the segments are in a correspondence relation and would otherwise violate a high-ranked OO-IDENT constraint. Since overgeneration problems with OO-Corr have been noted before (Bermúdez-Otero; 2011), it is fair to say that such an addition to OO-Corr makes the theory even more powerful and even less restrictive. The predictive power is severely weakened.

(25) *Correspondence relations needed for an OO-Corr analysis of Brazilian Portuguese*

$$\begin{array}{ccc} \text{jornal}_\text{i}\text{-zinho-s} & & \text{jornal}_\text{j}\text{-s} \\ \uparrow & & \uparrow \\ \text{jornai}_{\text{i,k}}\text{-zinho-s} & \rightarrow & \text{jornai}_{\text{j,k}}\text{-s} \end{array}$$

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argues, this is an instance of stem allomorphy that is not a consequence of a phonological rule applying before *(e)s*. In the present realizational approach, where all contextual morpho-syntactic features for morphological exponence are associated with the stem, stem allomorphy is conditioned by [+pl] here, not by the form (or features) of the actual plural exponent.

[8] Benua (1997) discusses the European Portuguese data, but she does not refer to non-contiguous bases and instead relegates the position of the plural marker to general morphological wellformedness.

Bachrach and Nevins (2008) note (with regard to Brazilian Portuguese) that it remains an open question which forms should be included in a paradigm and can enforce such identity effects. If other derivational exponents are used, the analysis introduced above would predict that overapplication persists. However, in the augmentative form *jornalzões* there is no overapplication: [l] does not undergo the change to [i], in contrast to what is the case with the underived plural form and the diminutive plural form. As shown in (26), OO-Corr would predict that this candidate does not become optimal, since it violates the high ranked OO-IDENT constraint.[9] This could either be solved by excluding the augmentative forms from the paradigm or by linking them to a separate base. Both solutions involve additional stipulations. OO-Corr thus faces empirical challenges for the Brazilian Portuguese data.

(26) *Overgeneration of OO-Corr for Brazilian Portuguese*

I: jornalzões Base: jornais	ID-OO	ID-IO
☆O_1:jornalzões	*!	
☛O_2:jornaizões		*

Rolle's prediction that non-contiguous bases should be restricted to sequences of derivational and inflectional affixes fails for the data from vowel raising in Homshetsma. In Rolle's approach, the base in Homshetsma would include a root and an inflectional suffix to the exclusion of another inflectional suffix: The form including only the root (with its theme vowel) and the agreement exponent would be the base for the form including an indicative marker /g(u)/ between the two. As shown in (27), the pre-nasal context for vowel raising is met in the base $k^h ali_{j,k}$-*m*, but the process overapplies in $k^h ali_{i,k}$-*gu-m*, where the inflectional exponent /g(u)/ intervenes. In order to establish a transparadigmatic correspondence relation, non-contiguous bases would need to be expanded to potentially exclude inflectional affixes.

(27) *Correspondence relations needed for an OO-Corr analysis of Homshetsma vowel raising*

$k^h ale_i$-gu-m		$k^h ale_j$-m
walk-IND-1SG		walk-1SG
↑		↑
$k^h ali_{i,k}$-gu-m	→	$k^h ali_{j,k}$-m

This further weakens the restrictivity of the approach: Non-contiguous bases can now exclude any inflectional or derivational exponent. Thus, the choice of the base is much less clear and potentially involves choosing between a higher number of options. In an output Root-$Affix_1$-$Affix_2$-$Affix_3$-$Affix_4$ there are 11 possible non-contiguous bases, yet only three possible contiguous bases.[10] We take this proliferation of potential bases to be conceptually undesirable. In sum, there are both empirical and conceptual problems with an approach based on transparadigmatic output-output correspondence.

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[9] ☛ indicates the wrong winner; ☆ accompanies the intended winner that emerges as suboptimal.

[10] Under the assumption that any base includes the root and at least one affix, contiguous bases are Root-$Affix_1$, Root-$Affix_1$-$Affix_2$ and Root-$Affix_1$-$Affix_2$-$Affix_3$. Non-contiguous bases are any single affix (=4) and any combination of two (=6) or three (=4) affixes minus the contiguous bases.

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