Reduplication in Stratal OT

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1 Stratal OT

In Stratal OT, morphology and phonology are stratified and interleaved, as in traditional Lexical Phonology (Mohanan 1986), but the strata (Stem, Word, Postlexical) are characterized by systems of parallel constraints. The output of each morphological operation is submitted to the phonological constraints on its stratum: stems must satisfy the stem phonology, words must satisfy the word phonology, and Phrase must satisfy the phrasal phonology.[1] For example, an affix which is added to stems to form words would enter into the derivation in the following fashion.

(1)

$[\ A\ ]_{\text{Stem}}$	
$\downarrow$	(phonological constraints on stems are enforced)
$[\ A'\ ]_{\text{Stem}}$	
$\downarrow$	(B affixed to A′, selectional requirements of B checked here)
$[\ A' + B\ ]_{\text{Word}}$	
$\downarrow$	(phonological constraints on words are enforced)
$[\ A'' + B'\ ]_{\text{Word}}$	
$\downarrow$	
$\vdots$	
$\downarrow$	
$output$	

On the phonological side, Stratal OT accounts for opacity and paradigmatic transfer phenomena (Kiparsky 2000, Bermúdez-Otero 1997, 2007). Although constraint interaction is locally parallel and transparent, the interleaving of phonology and morphology and the intrinsic seriality of strata gives rise to "derivational" effects. On the morphological side, the assumption that the selectional restrictions of an affix are checked at the point of affixation has two important consequences. First, if an affix (such as B in (1)) selects a base with some phonological property, this requirement must crucially be satisfied at an intermediate representation (A′ in (1)); it need *not* be satisfied in the underlying form A (which does not show the derived phonology of the base) nor in the output form (which shows an overlay of phonological effects, triggered by B and by any later layers of derivation). Secondly, checking selectional restrictions at the point of affixation correctly predicts a range of morphological locality effects, among them notably the generalization of Carstairs 1987

[1] As in Lexical Phonology, roots are not themselves directly subject to phonological constraints, though they are indirectly constrained via the stems and words that they enter into. This idea has been taken over in OT, except that under parallelism it is has to be the entire phonology that constrains underlying representations, not just the stem level phonology, with very different empirical consequences.

that morphological selection is not "outwardly sensitive", i.e. that in the configuration (2), A and B cannot be morphologically dependent on (selected by) the presence of the morpheme C, or by the particular shape of C.

(2) [[A + B] C]

One of the things that makes prosodic morphology interesting is the rich additional phonology/morphology interactions that it gives rise to. With respect to selection, reduplication is more revealing than other kinds of morphology, for the copying operation mirrors the phonological shape of the base, thereby providing some of the clearest evidence that when a base undergoes affixation, it has already undergone the lexical phonology applicable at that point, but not yet any phonology triggered by later morphology or by postlexical processes.

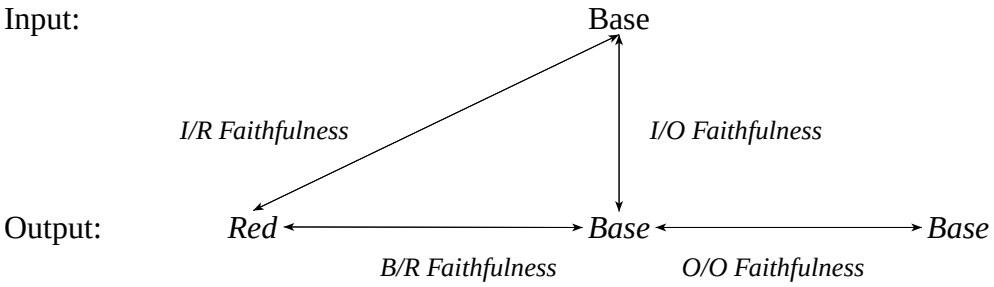
Furthermore, prosodic morphology is a massive source of opacity, for two reasons. First, prosodic morphology can involve operations that mask phonological conditioning. For example, a phonological process may seem to "overapply" in a reduplicant or truncatum when a superimposed prosodic template wipes out its trigger. (Although the traditional term "overapplication" is a misnomer from our point of view, it will serve as a descriptive term for the effect that such constraint masking creates.) Importantly, our view of the morphology/phonology interface says not just that phonological processes *can* "overapply" under these conditions, it says that they *must*. Here Stratal OT makes a stronger claim about overapplication than theories which treat it an exceptional situation that requires special stipulations or special mechanisms of some kind.

The second predicted new type of opacity associated with prosodic morphology is just the opposite: phonology masks morphology. This arises specifically with reduplication. Because Stratal OT requires the output of prosodic morphology to satisfy the phonological constraint systems at any subsequent layer of derivation, the application of phonological processes may disturb the prosodic template or obscure the melodic parallelism between base and reduplicant.

2 Parallel OT

For these reasons, the complex phonology/morphology interactions in reduplication provide an ideal testing ground for assessing the relative merits of Stratal and parallel OT. The parallel OT approach to reduplication relies on special correspondence relations between a reduplicant and two representations of the base, its *output* form, and its *input* form (McCarthy and Prince 1995). These correspondence relations are independent of those which hold between the input and output representations of the base itself, but they are formally parallel to it. For every MAX-I/O, DEP-I/O, and IDENT-I/O constraint this theory posits a corresponding B/R constraint, and a corresponding I/R constraint. Thus, a reduplicated output participates simultaneously in four faithfulness relations (not counting Sympathy and whatever other faithfulness relations are invoked for opacity):

(3)



Parallel OT treats reduplication as a separate type of phenomenon governed by Base/Reduplication (B/R) and Input/Reduplication (I/R) correspondence constraints, and allocates truncation with paradigmatic effects to Output/Output (O/O) correspondence constraints.

In Stratal OT, there are no reduplication-specific correspondence constraints, i.e. no B/R or I/R constraints, and no O/O constraints either. The shape of a reduplicated or truncated element — the REDUPLICANT or TRUNCATUM — is determined by the interaction of normal Input/Output (I/O) faithfulness constraints with markedness constraints in a morphologically selected constraint ranking (a co-phonology, along the lines of Inkelas & Zoll 2005). Overapplication phenomena and other apparent anomalies associated with prosodic morphology are no different in principle from any other so-called cyclic effects. They are just more spectacular. The reduplicant+base combination obeys the general phonology of the category to which it belongs (allowing for lexical exceptions and morpheme-specific idiosyncratic behavior, as with any morphology). There is nothing morphologically special about prosodic morphology; phonologically its outputs behave like ordinary affixed forms and compounds. Truncation and reduplication do not differ in the constraint families they are subject to, but in the form of the template (represented by a ranking of prosodic markedness constraints) and in whether it is imposed on the base itself, or on a copy of the base.

I shall argue that the phonology/morphology interface phenomena, far from motivating B/R and I/R constraints, tell decisively *against* them, and support Stratal OT. They predict unattested base/reduplication phonological interactions of at least two types, BACK-COPYING and RECOPYING. Furthermore, some reduplication systems are intractable in parallel OT; this is shown for Sanskrit below. In each case, Stratal OT not only accommodates the correct phonology/morphology interaction, but predicts it. In short, the parallelist theory of reduplication is too weak in some respects and too strong in others, and both failings are traceable to the parallelist architecture. The Stratal OT approach provides a superior treatment of the actually occurring cases and generates a reasonable typology.

3 Back-copying and recopying: the excess richness of parallel OT

Back-copying is the putative phenomenon of overapplication in the reduplicant of a process triggered by the reduplicant in the base. McCarthy and Prince 1995 support their claim that back-copying exists with an example from Malay which they cite from Kenstowicz 1981, who has it from Farid Onn 1980, apparently the original source of the datum. In Malay, nasality spreads postlexically rightwards over vowels, glides, and laryngeal consonants, and is blocked by obstruents and liquids. This spreading process crosses a reduplication boundary, and — this is the back-copying — nasality which spreads from the first member of a reduplicated compound onto the second is then said to be copied from the second member back onto the first. In consequence, the nasalization appears in a context where it is not phonologically licensed.

(4) [w̃ãŋ̃ĩ-w̃ãŋ̃ĩ] ‘very fragrant’ (from [waŋ̃ĩ] ‘fragrant’)

In the model proposed here, such cases would actually be impossible to deal with.

In Farid Onn’s examples, the extra nasalization abuts a nasal consonant, as in the first syllable of (4). So it is important to rule out the possibility that the putative back-copying nasalization is just a coarticulation effect due to the fact that the entire rest of the word is nasal. The crucial evidence will have to come from longer examples, which allow a bit more separation between the nasal and oral spans. During a delightful visit to the Mohanans in Singapore, I tried to verify the

back-copy phenomenon with such data. I interviewed four (non-linguist) native speakers of the dialect of Malay described by Farid Onn, using examples like (5). Here I would like to express my thanks to Lian Hee and his colleagues at the National University of Singapore, who helped me construct the examples and graciously answered my questions.

(5) a. *(warna bajunya) ke-hitam-hitam-an*
'(the color of the dress) is blackish'

b. *(taman bunganya terasa) ke-harum-harum-an*
'(the garden terrace) is full of fragrance'

In (5), back-copying would predict *three* nasal spans interleaved with three oral spans. The crucial prediction is the first, boldfaced little island of nasality:

(6) a. *[kə-**h̃ĩ**tam-h̃ĩtamãn]
b. *[kə-**h̃ã**rum-h̃ãrumãn]

I heard no nasality in this part of the words in the speech of any of the informants, however. Therefore, until solid phonetic evidence is produced I will assume that the report of back-copying in Malay is erroneous, conceivably due to the interpretation of phonetic coarticulation as phonological back-copying, as suggested above.

Inkelas and Zoll 2005 examine a number of other putative back-copy examples and conclude that none of them stand up to scrutiny. So at this point it is reasonable to doubt whether the whole phenomenon even exists.

The second kind of global base-reduplication interaction predicted by B/R constraints is RECOPYING, the overapplication in the base of a process in the reduplicant (whether the application in the reduplicant is itself conditioned by the base or not). Not even an apparent example of this pattern has ever been exhibited as far as I know, but here is what it would look like. In Sanskrit, the intensive is formed with a reduplicating prefix of the form CVC-. The coda of the reduplicating prefix is subject to regular process of Sanskrit phonology, including coda neutralization and place assimilation. For example, a medial *-mn-* created by reduplication shows up as *-nn-*, as in the intensive 3.Sg. *nan-namīti* 'bends' (from *nam-*, *namati*). Base-Reduplicant identity would cause the assimilated *-n* of the reduplicant to be recopied into the root, giving **nan-nanīti*. This is not merely the wrong Sanskrit form, it represents a typologically undocumented phenomenon. It is not derivable in Stratal OT, since this theory has no mechanism for enforcing stem-reduplicant identity other than copying itself, which, as explained above, accesses the melody of the base at the point of affixation. OT with B/R constraints, on the other hand, straightforwardly predicts that recopying should emerge simply when the relevant B/R constraint is ranked high enough:[2]

(7)

Sanskrit	AGREE	IDENT-B/R(Lab)	IDENT-I/O(Lab)	IDENT-I/R(Lab)
Input: /R-namīti/, Base: *-namīti*				
a. nan-namīti		*		*
b. nam-namīti	*			
c. ☛ nan-nanīti			*	*

[2]Theoretically, I/O, B/R, and I/R faithfulness constraints should be able to rank anywhere with respect to each other and with respect to markedness constraints, to yield a complete factorial typology. But McCarthy and Prince show that allowing I/R constraints to outrank I/O constraints would badly compromise the typology of reduplication, and propose that I/R constraints are universally ranked below I/O constraints because of a "metaconstraint" that ranks root faithfulness over affix faithfulness. The tableau in (7) respects this stricture.

Since Stratal has neither I/R constraints nor B/R constraints, nor of course sympathy constraints or O/O constraints, these overgeneration problems simply do not arise.

I now turn to a case of the opposite type, where even this rich machinery is descriptively insufficient, while Stratal OT still gives the right results.

4 Where parallel OT is too weak

In this section I turn to the phonology of reduplication in classical Sanskrit. The forms in (8) are perfect stems of classical Sanskrit, marked by a well-defined type of reduplication unique to this particular morphological category. (8a,c) have simple roots, and (8b,d) have prefixed root. We are interested in the initial consonant of the root and its reduplicant.

(8)	a.	/sic/	*si-ṣec-*	'pour'
	b.	/ni-sic/	*ni-ṣi-ṣec-*	'pour down'
	c.	/sañj/	*sa-sañj-*	'stick to'
	d.	/pari-ṣañj/	*pari-ṣa-ṣañj-*	'be attached to'
	e.	/ḍhauk/	*ḍu-ḍhauk-*	'approach'

In (8a,b,c), *s* is retroflexed to *ṣ* by a phonological process that applies after *r*, a nonlow vowel, or a velar,[3] a process known mnemonically after its context as *ruki*. (The retroflex *ḍh* in (8e) is underlying, and contrastive.) So the *s* ∼ *ṣ* alternation is phonologically transparent. But the phonological parallelism between reduplicant and stem is not: in (8a), the reduplicant's *i* triggers retroflexion of the root-initial *s*, whereas the reduplicant itself has plain *s*. In other words, there is no recopying, just as Stratal OT predicts. How can these data be dealt with in parallel OT?

First let us introduce the phonologic al constraints required in any OT analysis, stratal or parallel. Retroflexion is driven by a context-sensitive constraint — call it **Is* — which prohibits *s* in the *ruki* context, symbolized here by *I*. **Is* dominates a context-free markedness constraint *[+R] that bars retroflex consonants, including *ṣ* (where [R] is just a placeholder for the feature or features that define retroflexion).[4] *[+R] is also dominated by IDENT-I/O(R), since /ṣ/ and the retroflex stops a are distinct phonemes of Sanskrit.

(9) a. **Is*: [s] cannot occur after a nonlow vowel, after /r/, or after velars.

b. *[+R]: No retroflex [ṣ] (i.e., elsewhere).

Uncontroversially, the specific CV- template of perfect reduplication is defined by a set of prosodic constraints (such as NOCODA). The neutralization of certain features such as aspiration is general for prefixes in Sanskrit, and is accounted for by ranking the relevant markedness constraints (such as *ASPIRATED) highly for that class of morphemes. Setting the things aside, let us focus on how retroflexion works in reduplicated forms.

On the parallel theory, reduplication-specific faithfulness constraints require identity between the reduplicant and the base. One such constraint is IDENT-B/R(R): "corresponding segments in the base and the reduplicant have the same value with respect to retroflexion". IDENT-B/R(R) is

[3] Palatals cannot precede [s] for other reasons. It should also be said that, in what seems to be an OCP effect, *ruki* is normally blocked by an immediately following *r* (e.g. *su-sruv-úḥ* 'they flowed', *si-srev-iṣa-ti* 'wants to fail')

[4] I set aside the question what the context *I* and the affected feature or feature bundle [R] are phonologically; [+High] is very likely one feature that they share..

not surface-true in *si-ṣvid-*, for the retroflexion triggered by the reduplicant in the root is not "back-copied" into the reduplicant itself. Some higher-ranking constraint or constraints must dominate IDENT-B/R(R) to compel its violation in such forms. It must be either a markedness constraint, namely (9b) *[+R], or a faithfulness constraints, namely ID-I/O(R).[5] The first alternative can be immediately rejected on the basis of *ḍu-ḍhauk-*, which shows that retroflexion *is* retained in reduplicants. So the data cannot be accounted for by a markedness constraint, as shown by the tableau in (10) (where the solid hand marks the wrong output that is derived, and a checkmark the desired output that is not derived).

(10)

Sanskrit		ID-B/R(Lab)	**Is*	ID-I/O(R)	*[+R]	ID-B/R(R)
1. Input: /sic-sic/						
1a.	si-sic-		*			
1b. ☞	si-ṣic-			*	*	*
1c.	ṣi-ṣic-			*	**	
1d.	ba-sic-	*				
2. Input: /sañj-sañj/						
2a. ☞	sa-sañj-					
2b.	ṣa-sañj-				*	*
2c.	ṣa-ṣvaj-			*	**	
2d.	sa-ṣvaj-			*	*	*
2e.	pari-ba-sañj-	*				
3. Input: /ḍhauk-ḍhauk/						
3a.	du-dhauk-			*		
3b.	ḍu-dhauk-			*	*	*
3c. ✓	ḍu-ḍhauk-				**	
3d. ☛	du-ḍhauk-				*	*
3e.	ba-ḍhauk-	*			*	*

The dominant template-defining constraints, and the candidates that violate them, are omitted in the tableau. Other IDENT-B/R constraints than ID-B/R(R) must dominate the corresponding markedness constraints, in order to block candidates with unmarked reduplicants from ousting the more marked but faithful candidates. In (10), *ba-* represents all these party-crashers, and IDENT-B/R(Labial) represents the IDENT-B/R constraints needed to keep them out.

The other way to defeat ID-B/R(R) would be through domination by the faithfulness constraint IDENT-I/R(R) (see (3)), which would have to be crucially ranked between **Is* and *[+R].[6] Tableau (11) shows that it yields the right results for the data considered so far.

[5] Actually it could also be a Sympathy constraint ❁IDENT-B/R(R) (with ✭ID-I/O(R) as the selector). I will ignore this possibility because of the by now familiar general objections to sympathy theory, and because of the specific objection that, in early stages of Sanskrit, /ṣ/:/s/ is not contrastive in roots. Sympathy to noncontrastive features should be precluded, for otherwise sympathetic reduplication could indeed result in the impossible *[ṣa-svaj-], or for that matter in *[s̃a-svaj-] or what have you.

[6] Thanks to Stephen Anderson for pointing this out. The tableau respects the stipulation that IDENT-I/O constraints universally outrank IDENT-I/R constraints (McCarthy and Prince 1995.

(11)

Sanskrit	ID-B/R(Lab)	**Is*	ID-I/O(R)	ID-I/R(R)	*[+R]	ID-B/R(R)
1. Input: /R-sic/, Base: *sic-*						
1a. si-sic-		*				
1b. ☞ si-ṣic-			*		*	*
1c. ṣi-ṣic-			*	*	**	
1d. ba-sic-	*			*		
2. Input: /sañj-sañj/						
2a. ☞ sa-sañj-						
2b. ṣa-sañj-				*	*	*
2c. ṣa-ṣañj-			*	**	**	
2d. sa-ṣañj-			*	*	*	*
2e. pari-ba-sañj-	*					*
3. Input: /R-ḍhauk/, Base: *ḍhauk-*						
3a. du-dhauk-			*	*		
3b. ḍu-dhauk-			*		*	*
3c. ☞ ḍu-ḍhauk-					**	
3d. du-ḍhauk-				*	*	*
3e. ba-ḍhauk-	*		*		*	*

But this analysis also fails, albeit in a less obvious way. What it claims is that retroflex consonants appear in reduplicants only under two conditions: (1) in an overt *ruki* environment (i.e. after a high vowel, *r,* or *ṣ*), where retroflexion is forced by **Is*, and (2) if they correspond to an *underlying* retroflex consonant, in which case ID-I/O(R) takes effect regardless of the overt environment. A clear prediction for Sanskrit follows: *retroflexion overapplies in reduplicants if and only if it is specified in the underlying form of the base*.

This prediction is false, as shown by (8d) *pari-ṣa-ṣañj-* (which represents the regular classical Sanskrit outcome in such cases).[7] Here *derived* retroflex *ṣ* appears in an environment where it is *not* overtly licensed by a surface *ruki* context. ID-B/R(R) would select the desired (4c) *pari-ṣa-ṣañj-*, but because it must be ranked below ID-I/R(R) (see (11)), it is effectively invisible.

(12)

Sanskrit	ID-B/R(Lab)	**Is*	ID-I/O(R)	ID-I/R(R)	*[+R]	ID-B/R(R)
4. Input: /pari-sañj/						
4a. pari-sa-sañj-		*				
4b. ☛ pari-ṣa-sañj-				*	*	*
4c. ✓ pari-ṣa-ṣañj-			*	*	**	
4d. pari-sa-ṣañj-		*	*		*	*
4e. pari-ba-sañj-	*		*			

We have arrived at a ranking paradox: no single ranking of the available constraints can derive all the forms in (11) and (12).

[7]There is a set of Prefix+Root combinations that show transparent retroflexion (e.g. *pari-ṣasvaj-e* 'embraced' (Wackernagel 1957: 235). These are remnants of the older Vedic system where *ruki* was restricted to the word-level. Secondly, there are Prefix+Root combinations that are compound-like and do not undergo *ruki* at all, *a fortiori* whether the root is plain, reduplicated, or augmented (Wackernagel 1957: 234).

Stratal OT's phonology/morphology interleaving does predict the correct outputs, provided we make one crucial assumption about the morphological derivation: that the verb combines lexically with its prefix prior to suffixation. The theory then dictates that the prefix triggers retroflexion of the root-initial *s*- prior to reduplication.

The assumption that the verb combines lexically with its prefix prior to inflectional affixation is plausible because the prefix+verb combination often has an unpredictable meaning and unpredictable grammatical properties (such as active vs. middle voice). Prefixation is thus derivational: it forms new lexemes, which are then inflected. More compellingly, the priority of derivational prefixation over inflection is required by the selectional restrictions on affixes, which distinguish between bare and prefixed roots. The strongest selectional evidence that the prefix+root combination is the constituent to which inflectional affixes are added comes from suffix allomorphy. Several suffixes vary in form depending on whether the root is prefixed or not. The gerund (absolutive) suffix, which makes temporal adverbials with the meaning 'having V-ed', 'after V-ing', has two basic allomorphs: *-tvā*, which occurs after simple roots, and *-ya*, which occurs after prefixed roots. The latter allomorph gets a a *t* added before it if the root is light, in order to make the one-mora root syllable into a minimal foot. The allomorphy is illustrated by the simple form and a compounded form of the root /bhr/ 'carry' in (13).

(13)	a.	*bhr-tvā́*	'having brought'	(*-tvā* after a simple root)
	b.	*saṃ-bhṛ́-tya*	'having brought together'	(*-t-ya* after a light prefixed root)

In *bhr-tvā́*, the root, being simple, selects the allomorph *-tvā́*. In (13b) *saṃ-bhṛ́-tya*, the prefixed root selects the gerund allomorph *-(t)ya*. This shows that the gerund is formed off the prefixed root.[8]

Additional evidence is the special behavior of the negative prefix *a*-. Unlike verbal prefixes, such as *sam*- in (13b), *a*- has no effect on the choice of gerund allomorph. For example, *á-bhr-tvā* 'not having carried' has the gerund allomorph that is otherwise selected by simple roots. Why does *a*- differ from the verbal prefixes in this way? The solution to this puzzle is that *a*- is prefixed not to roots but to gerunds, so the gerunds are formed from simple roots, hence with the allomorph *-tvā*. The evidence that *a*- prefixed to gerunds and not to roots is that *a*- selects nominal and adverbial stems, and it is only in virtue of the gerund suffix *-tvā* that the verbs become adverbs eligible for *a*- prefixation. Conversely, verbal prefixes select verbal stems, and hence must be added to roots before they become adverbs. The allomorphy reflects this derivational history.

(14)	a.	saṃ-bhr̥ → (saṃ)$_{\text{Stem}}$(bhŕ̥-tya)$_{\text{Stem}}$	(suffixation to a prefixed root)
	b.	bhr-tvā́ → (á)$_{\text{stem}}$(bhr̥-tvā)$_{\text{Stem}}$	(prefixation to a suffixed stem)

The prosodic structure of the words is the same, as far as we can tell, as indicated in (14). Specifically, phonology shows that there is a compound boundary between the prefix and the root in both words. Examples like this show that level ordering cannot be simply reduced to the domains defined by prosodic structure. Rather, the morphophonology reveals that the order of prefixation and suffixation is determined by the different selectional requirements of the prefixes and suffixes, even for what (as far as we can tell) surfaces as the same prosodic structure.

[8]More precisely, it shows it provided we agree that that the right allomorph is selected at the point at which the morphological operation introducing the affix takes place, and in particular that there are no "allomorphy processes" that could, for example, replace *-tvā́* by *-tya* after the prefix has been added.

Therefore the derivation of *pari-ṣa-ṣañj-* proceeds from the prefixed root, after retroflexion has been triggered by the prefix-final vowel *i-*.

(15)

sañj-	Root
pari-ṣañj-	Prefixation, *ruki*-retroflexion
pari-ṣa-ṣañj-	Reduplication

A second class of opaque retroflexion contexts that follows from this morphology/phonology interleaving involves the augment *a-* which is prefixed to the root to mark past tense. In roots whose initial *s-* is retroflexed to *ṣ-* by a prefix, the *ṣ-* appears also when the *a-* is prefixed to the root, even though it interrupts the conditioning *ruki* context.

(16) a. *abhy-a-ṣiñc-a-n* 'poured on' (from *abhi* + *siñc-* → *abhi-siñc-*)

b. *adhy-a-ṣṭhā-m* 'stood on' (from *adhi* + *sthā* → *adhi-ṣṭhā*[9])

In sum: when verbs receive inflectional suffixes or the augment, their prefix (if they have one) with any phonological effects that it may trigger on the root, are already in place. In the case of augmentation, they make the *ruki* context opaque. This morphological derivation also explains the phonology of reduplication under discussion. The Stratal OT account works as follows.

Morphologically, the input is a full copy of the stem. The stem-level constraint system includes the template-defining constraints (again omitted here, with the candidates that violate them), and the general phonological constraints in their normal Sanskrit ranking:

[9]Glide formation takes effect at the word level. Coronal assimilation applies there also, as described below: *adhi-a-ṣthā-m* → *adhyaṣṭhām*.

(17)

Sanskrit	IDENT-I/O(Lab)	**Is*	IDENT-I/O(R)	*[+R]
1. Input: /sic-sic/				
1a. si-sic-		*		
1b. ☞ si-ṣic-			*	*
1c. ṣi-ṣic-			**	**
1d. ba-sic-	*		*	
2. Input: /sañj-sañj/				
2a. ☞ sa-sañj-				
2b. sa-ṣañj-			*	*
2c. ba-sañj-	*			
3. Input: /pari-sañj/				
3a. pari-sañj-		*		
3b. ☞ pari-ṣañj-			*	*
4. Input: /pari-ṣañj-ṣañj/ (by reduplication from 3b)				
4a. pari-sa-sañj-		*	*	
4b. pari-ṣa-sañj-			*	*
4c. ☞ pari-ṣa-ṣañj-				**
4d. pari-sa-ṣañj-		*	*	*
4e. pari-ba-ṣañj-	*		*	*
5. Input: /ḍhauk-ḍhauk/				
5a. du-dhauk-			*	
5b. ḍu-dhauk-			*	*
5c. ☞ ḍu-ḍhauk-				**
5d. du-ḍhauk-			*	*
5e. ba-ḍhauk-	*		*	*

Perfect reduplication doubles the root, after prefixation, and therefore with the stem-level phonology triggered by the prefix in place. Where consistent with the dominant templatic constraints (such as *ASPIRATED), IDENT-I/O(R), its ranking independently motivated by the rest of the phonology, keeps the output faithful to the copy. In this setup IDENT-I/O(R) does the job of the parallel theory's IDENT-B/R(R), with the important benefit that back-copying and recopying becomes impossible.

Augment forms like those in (16) are unproblematically derived by insertion of past-marking *a-*, followed by glide formation. The retroflex *ṣ* persists in spite of the intervening augment *-a-*.

(18)

siñc-	Root
abhi-ṣiñc-	Prefixation, *ruki*
abhi-a-ṣiñc-	Augmentation
abhy-a-ṣiñc-	Glide formation (Word level)

The observational generalization is that reduplication and the augment are "transparent" to *ruki*. The descriptive generalization behind it seems to be that they are added to prefixed roots after it undergoes *ruki*.[10] Stratal OT is a theoretical framework that accommodates that descriptive generalization.

[10] A similar account is needed for other inflections, such as the nasal infix in case forms like /havis/ → *haviṣ* → *hav-ṃ̄ṇ̣-i* 'oblations' (Neuter Nom.-Acc. Plural).

A final point of interest is that stops which are adjacent to *ṣ* (whether derived or underlying) assimilate to it in retroflexion. In contrast to *ruki* retroflexion, this process is automatic, and applies obligatorily across word boundaries. Interestingly, the retroflex stops derived by this process reduplicate as plain stops, never as retroflexes. This can be seen in initial *s*+stop clusters, which reduplicate with the stop (and not with the *s*).

(19) *vi-ta-ṣṭh-e* (not **vi-ṭa-ṣṭh-e*) 'stood apart'

We now have a good explanation for the behavior of these clusters: *ruki* enforces *ṣ* at the stem level, and this process consequently is rendered opaque by subsequent inflection and phonology. Assimilation of retroflexion in coronal clusters (such as *ṣt* → *ṣṭ*) applies at the word level, and consequently is not visible to, and not made opaque by, stem-level inflection and phonology.

The behavior of *derived* retroflex stops contrasts with that of *underlying* retroflex stops, which do enter into reduplication, as predicted, e.g. *ḍu-ḍhauk-*. A particularly interesting case is root-initial *ṣṭh-* in *ṣṭhīv-* 'spew'. In Classical Sanskrit, as prescribed by Pāṇini's grammar, it has the perfect *ṭi-ṣṭhev-a*.[11]

This intricate web of connections should not be surprising from the traditional prespective on reduplication, for since Marantz 1982 and Clements 1985 it has been known that contrastive features tend to be transferred from the base to the reduplicant. This insight is captured in Stratal OT. What it means for a feature F to be contrastive is to be protected by a sufficiently high-ranked IDENT-I/O(F) faithfulness constraint, and precisely this ranking guarantees also faithfulness to the copy of F in the reduplicant. For the global B/R correspondence approach, distinctiveness should be irrelevant to transfer. Distinctiveness is a matter of whether I/O faithfulness constraints dominate markedness constraints, and transfer is a matter of whether B/R constraints and I/R faithfulness constraints dominate markedness constraints. Parallel OT provides no principled reason why these rankings should be correlated at all. For Stratal OT, a corollary of the generalization that distinctive features are transferred from base to reduplicant in virtue of high-ranked IDENT-I/O(F) faithfulness is that the rise of a contrast in a language might entail changes in its reduplication patterns. This is exactly what we have seen.

5 Derivational alternatives

The putative existence of global phonology/morphology interactions in reduplication has prompted several novel proposals. Raimy (2000) incorporates an arrow symbol "→" into phonological representations to denote the precedence relation between segments. In order to represent reduplication, the arrow is allowed to loop back, so that a segment can in effect precede itself (p. 12). For example, *sañj-* and its reduplicated form *sa-sañj-* look like this:

(20) a. # → s → a → ñ → j → %

b. # → s → a → ñ → j → %

[11] In contrast, Vedic has *ti-ṣṭhev-a* (ŚB. 1.2.3.1). This can be explained directly from our assumptions. Unlike Classical Sanskrit, Vedic has no distinctive retroflex stops in verb roots. The root's lexical representation at that stage is therefore /ṣthīv/. Since the assimilatory retroflexion of stops next to *ṣ* is not registered in reduplicants — because it is not present at the stem level — the Vedic data follow. In Classical Sanskrit, retroflex stops become admissible in the lexical representations of verb roots (e.g. *ḍhauk* 'approach', *ghaṭ* 'strive', *aṭ* 'wander', *raṭ* 'howl'). At this point, *ṣṭhīv-* is restructured from /ṣthīv/ to /ṣṭhīv/ (lexicon optimization), and *ṭ* starts being copied in reduplicants.

Raimy proposes that looped representations such as (20b) provide insight into the phonology of reduplication. He introduces a UNIFORMITY PARAMETER with two settings, which "determines whether a rule requires all environments that a segment appears in to satisfy the structural description of the rule or if only a single environment is sufficient to trigger the rule" (p. 20). To illustrate, let us consider the reduplication of *siñc* to *si-ṣiñc*. A Raimy-style phonological representation of the reduplicated form looks like this:

(21) # → s → i → ñ → c → %

How does *ruki* apply to this structure? It depends on the setting of the Uniformity Parameter. When it is *off*, the fact that *s* appears is a *ruki* environment (namely *i* → *s*) suffices to trigger the *ruki*. This corresponds to overapplication: *siñc* → **ṣi-ṣiñc*. When it is *on*, the rule is blocked, because *s* also appears in a non-*ruki* environment (namely # → s). This corresponds to a type of underapplication: *sic* → **si-siñc*.

The correct output is neither **ṣiṣiñc* nor **sisiñc*; it is *siṣiñc*. The forms **ṣiṣiñc* and **sisiñc* are not only wrong, their derivation instatiates nonexistent types of global phonology/morphology interactions — back-copying, and a type of globality that even parallel OT does not allow, where a process fails to apply in the base just in case its reduplicated copy is not subject to it.[12] These forms could not be generated in Sanskrit under Stratal OT assumptions. Stratal OT has no mechanism for blocking *ruki* through a requirement of phonological parallelism between reduplication and base. Of course, if (contrary to what is the case in Sanskrit) the *ruki* rule were inapplicable across prefix boundaries, or at least between reduplication prefixes and their bases, and the grammar were otherwise the same, then **sisiñc* would not only be derivable, it would be the only possible output. On other words, if Sanskrit had **ti-stha-ti* 'stands', rather than *ti-ṣṭha-ti* (from *sthā*), and so on across the board, then Stratal OT would predict **si-siñc*; as it is, the actual form *ti-ṣṭha-ti* entails the actual form *si-ṣiñc-*.

Could the actual forms *ti-ṣṭha-ti, si-ṣiñc-* be derived in the looping theory? Raimy posits that phonological representations are linearized at some point in the derivation, so that loops between segments are translated into multiple copies of those segments in the phonetics. Raimy suggests that this linearization process takes place *before* the phonetics-phonology interface, between the cyclic and postcyclic rules (p. 50). From that point on, phonological rules take effect on each copy independently of the others. So, to derive *si-ṣiñc-*, the *ruki* rule would have to be postcyclic. But *ruki* in classical Sanskrit is clearly cyclic, for it interacts cyclically with morphology in cases such as (16).

The upshot is that Raimy's theory predicts two impossible patterns of *ruki* application in Sanskrit reduplication (depending on how the Uniformity Parameter is set), and fails to provide a coherent descriptive account of the actual observed pattern.

Frampton (2004) develops another descriptively rich derivational theory of reduplication which makes provision for some of the unwanted types of morphology/phonology interactions discusssed here.

[12]The early literature on reduplication sometimes analyzed Luiseño as having a process that fails to apply in the base just in case its reduplicated copy is not subject to it, but as noted by Marantz 1982 the 'underapplication' can also be located in the reduplication.

6 Conclusion

In sum: the parallel approach both overgenerates and undergenerates. Stratal OT, where the only phonological correspondence relation is I/O correspondence, gives better results.

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