19 Deriving Reduplicative Templates in a Modular Fashion

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19.1 Introduction

This chapter argues that reduplicative templates can be straightforwardly derived from general principles regarding the modular organization of grammar, computation in phonology, and language acquisition. These three areas act as organic constraints on all proposed formal systems of reduplication. Once these organic restrictions are understood, it is clear that Precedence-Based Phonology (PBP; see, e.g., Raimy 1999, 2000a,b) provides an explanatorily adequate account of reduplicative templates. Comparing PBP with surface-prosody-based analyses such as Prosodic Morphology (PM; e.g., McCarthy and Prince 1996/1986, 2001/1993) demonstrates that the PBP model of reduplication naturally incorporates the advantages of the organic constraints identified in this chapter while PM-based models must be modified in incongruent ways that create redundancies.

Section 19.2 discusses the role that the formal representation of reduplication plays in accounting for reduplicative templates and illustrates the distinctions between a PM and a PBP approach. Section 19.3 demonstrates how a modular approach to morphology and phonology immediately derives the surface appearance of prosodic templates without positing prosodic templates as theoretical entities in their own right. Section 19.4 further shows that commonly held assumptions about possible (and impossible) computations in the phonology component further constrain possible reduplication patterns. Section 19.5 discusses the relevance of language acquisition to sharpening our understanding of common versus uncommon reduplication patterns. The result of these observations is that the minimalist theoretical machinery in PBP can economically and insightfully account for patterns of reduplication with little to no redundancy. On the other hand, each section highlights the redundancies in a PM account of reduplication. Consequently, currently popular surface-oriented, prosody-based accounts of reduplication should be abandoned.

19.2 Formal Underpinnings of a Theory of Reduplication

Any theory of reduplication must make specific claims about the formal nature of reduplication. For the purposes of this chapter, we need only to compare two distinct classes of formal proposals on this issue. The first is surface-oriented, prosody-based approaches; these assume that reduplication results from a phonologically underspecified affix whose full surface phonological specification results from the interaction of prosodic demands on the surface representation. This view is best exemplified by contemporary Optimality Theory (OT; Prince and Smolensky 2004) approaches to reduplication, based on proposals in McCarthy and Prince 1995. This approach posits an abstract RED morpheme whose surface phonological content is determined through constraint interaction.

Early forms of this model, such as McCarthy and Prince's (2001/1993), posited direct templatic constraints on RED at the surface (e.g., RED = $\sigma_{\mu\mu}$ 'heavy syllable'). Most contemporary approaches (e.g., atemplatic reduplication (Spaelti 1997, Gafos 1998, Hendricks 1999) or generalized templates (Urbanczyk 1996, 2006)) derive the surface form of reduplicative templates primarily from constraint interaction. The common theme is that these approaches posit mechanisms that directly restrict the surface prosodic shape of the abstract morpheme RED. Templatic, atemplatic, and generalized template approaches differ in the content of this constraining mechanism; they vary in how explicitly the surface prosodic category of the reduplicant is specified. They all assume that possible reduplicative templates are constrained by the vocabulary of prosodic categories and by the constraints that encode the RED morpheme in a rather direct fashion. The creation and the interpretation of RED are conflated in this approach.

PBP separates the creation and interpretation of reduplicated structures. All PBP models of reduplication (Raimy 1999, 2000a,b, Halle 2001, 2005, Frampton 2004) assume that the morphology builds the reduplicated structure, which the phonology then interprets. Although all these models benefit from this separation (despite their fundamental differences), in this chapter I will concentrate on explicating the model developed in Raimy 1999, 2000a,b.

(1) presents reduplication data from Pangasinan (all drawn from Benton 1971). The most important aspect of the data is the rich diversity of reduplication patterns found in this single language.

(1) *Reduplication in Pangasinan*

a. *Total reduplication – nominal affixation (p. 103)*

toó	'man'	tóo-tóo	'figure of a man'
ogáw	'child'	ogáw-ogáw	'figure of a child'
abóng	'house'	abóñg-áboñg	'toy house'

	man-bása	'(will) read'	man-bása-bása	'reading anything and everything'
	man-pasiár	'(will) go around'	man-pasiár-pasiár	'going around all over the place . . .'
b.	*Initial (C)VCV (p. 101)*			
	Noun plurals			
	tamuró	'forefinger'	tamu-tamuró	
	pañgánsi	'ring finger'	pañgá-pañgánsi	
	lusór	'cup'	lusó-lusór	
	otót	'mouse, rat'	otó-otót	
c.	*Initial (C)VC reduplication*			
	Noun plurals (pp. 100–101)			
	báley	'town'	bal-báley	
	balíta	'news'	bal-balíta	
	paltóg	'gun'	pal-paltóg	
	lúpa	'face'	lup-lúpa	
	áteñg	'parent'	at-áteñg	
	Numerals of limitation (p. 151)			
	sakéy	'one'	sak-sakéy	'one only'
	taló	'three'	tal-taló-ra	'three only'
	+apát	'four'	a-pat-pátíra	'four only' INFIX
d.	*Initial (C)V reduplication*			
	Noun plurals (pp. 99–100)			
	kanáyon	'relative'	ka-kanáyon	'relatives'
	dalikán	'clay stove'	da-ralikán	'clay stoves'
	báso	'glass'	ba-báso	'glasses'
	+amígo	'friend'	a-mi-mígo	'friends' INFIX
	Verbs (p. 120)			
	likét	'be happy'	maí-li-likét	'always happy'
	ermén	'be sorrowful'	maí-e-ermén	'sentimental'
	akís	'cry'	maí-a-akís	'crybabyish'

Pangasinan has at least four distinct reduplication patterns: total reduplication (1a), (C)VCV reduplication (1b), initial (C)VC reduplication (1c), and initial (C)V reduplication (1d). I say "at least" because of the two additional subpatterns of reduplication indicated by the forms in (1c) and (1d) with a "+" symbol. These two patterns show the infixing of the repeated sequence of phonemes as opposed to the strictly prefixing pattern found in all the other examples.

(2) shows the phonological representations built by the morphology that will account for the four main reduplication patterns in Pangasinan. The representations

are based on proposals in Raimy 1999, 2000a,b. The arrows indicate precedence relations, and the different reduplication patterns result because in each case different phonemes are "inside" or "outside" of the "loop." See note 4 of Raimy, this volume, for the purely expository nature of loops.

(2) *Precedence-Based Phonology representations for Pangasinan*

a. *Total reduplication*

$\# \rightarrow o \rightarrow g \rightarrow a \rightarrow w \rightarrow \%$ > ogaw-ogaw

b. *(C)VCV reduplication*

$\# \rightarrow t \rightarrow a \rightarrow m \rightarrow u \rightarrow r \rightarrow o \rightarrow \%$ > tamu-tamuro

c. *(C)VC reduplication*

$\# \rightarrow b \rightarrow a \rightarrow l \rightarrow e \rightarrow y \rightarrow \%$ > bal-baley

d. *(C)V reduplication* > mai-a-akis

$m \rightarrow a \rightarrow i$

$\# \rightarrow a \rightarrow k \rightarrow i \rightarrow s \rightarrow \%$

The main thing to note about the examples in (2) is that segments that are inside the loop end up being reduplicated, while segments outside the loop do not. Thus, in (2a) total reduplication occurs because all the segments are "inside the loop," while in (2b) (C)VCV reduplication occurs because only the first CVCV of the root is "inside the loop." Reduplication occurs when there is a loop in a phonological representation because of a linearization process that ensures that phonological representations are interpretable by the phonetics-phonology interface. (See Raimy 1999, 2000a for discussion of the nature of linearization.) Linearization is not a reduplication-specific device, because all phonological forms are linearized.

The representations in (2) also demonstrate how different reduplication patterns are encoded in PBP. Different loops are created depending on how the begin and end points of the precedence link that creates a given loop are described. (3) specifies the begin and end points for the reduplication patterns in (2).

(3) *Descriptions of Pangasinan reduplication patterns*

	Pattern	*Begin*	*End*
a.	total	"last segment"	"first segment"
b.	(C)VCV	"second vowel"	"first segment"
c.	(C)VC	"after first vowel"	"first segment"
d.	(C)V	"first vowel"	"first segment"

(3a) provides the general description for total reduplication. It specifies the begin point of the precedence link (the tail of an arrow) as "last segment" and the end of the precedence link (the head of the arrow) as "first segment." The combination of these two anchor points defines a new precedence link that causes an entire word to be within a loop, resulting in the surface effect of total reduplication. The descriptions of the anchor points are specific and deterministic (e.g., every word has a first segment) but variable (e.g., the distance between the first and last segment varies, depending on specific lexical items), thereby succinctly encoding the surface-variable total reduplication pattern. One noteworthy aspect of the descriptions in (3) is that the end setting for all the precedence links is the same. This uniformity in the end settings in (3) captures the generalization that all of these reduplication patterns are prefixing. Any partial repetition will appear before the entire lexical item because of this anchor point setting. The differences between the reduplication patterns are then encoded as differences in the begin anchor point. (3b) is distinct from (3a) in that the added precedence relation anchors to the "second vowel" which produces the surface effect of repeating the lexical item up to the second vowel. (3c) encodes an even smaller region of repetition, creating a loop from the segment "after the first vowel" to the "first segment." Finally, (3d) creates the smallest loop by anchoring to the "first vowel."

The fundamental difference between the PBP and PM models of reduplicative templates lies in the description of reduplication patterns. In PBP, there is no formal, necessary connection between the specifications for the begin and end anchor points that describe a reduplicative template. PM models describe reduplication patterns primarily through units of prosody such as mora, syllable, foot, or prosodic word. PBP does not deny the existence of any of these prosodic categories; it merely denies the primacy of their utility in describing reduplication patterns.

The PBP approach to reduplicative templates has two important consequences. First, the PBP approach can be considered truly atemplatic (McCarthy and Prince 1994) in that it involves no matching to a prosodic target. Second, this truly atemplatic aspect of PBP has the apparent liability that there is no constraint on the formal system to produce only reduplication patterns that coincide with a prosodic pattern. This disconnect between the anchor point system and prosody has been criticized by Downing (2001), Nevins (2002), and Lieber (2004). As the following sections demonstrate, however, this concern is unfounded.

To summarize this section: The fundamental formal distinction between the PM and PBP approaches to reduplicative templates is based on how different reduplication patterns are described. PM describes reduplication patterns either explicitly by using prosodic templates or implicitly by deriving a particular prosodic template from the interaction of surface-based prosodic constraints in language-specific configurations.

In contrast, PBP describes reduplication patterns by specifying how a precedence link is attached in terms of its anchor points. The PM approach appears more constrained than the PBP approach because of PM's limitation to only "legitimate prosodic categories"; we will see, however, that this restriction is actually a redundancy that can be eliminated.

19.3 Organic Constraint I: Grammatical Architecture

One question that must be answered when developing a model of reduplication is, What is the relationship between morphology and phonology?—more generally, What is the overall architecture of the grammar? Although examples where a morphological process is sensitive to a phonological distinction (e.g., expletive infixation and stress; McCarthy 1982) are easy to find, they do not require the conclusion that morphology and phonology are equally mixed. Answering the question about the relationship between morphology and phonology is another place where PM and PBP differ.

The PBP model generally adopts Distributed Morphology (Halle and Marantz 1993, 1994) as the model of grammatical architecture. Distributed Morphology is a modular approach to grammar in which the morphological and phonological modules are distinct. Furthermore, the phonology module follows the morphology module; this arrangement constrains the surface effects of any morphological operation to be in line with the general prosody of the language in question. In other words, the modular organization of Distributed Morphology ensures that the phonology acts as a filter on morphological processes. This is important because it derives the connection between occurring reduplication patterns and language-specific prosodic structures.

Let us consider the import of adopting this architecture by investigating some aspects of reduplication in Pangasinan. As the data in (1) show, Pangasinan has a (C)VC reduplication pattern. The fact that Pangasinan allows codas licenses the existence of this reduplication pattern. If word-internal codas were not licensed in Pangasinan, it would not be possible for a model of reduplication that assumed a modular relationship between morphology and phonology to force a CVC reduplication pattern. Consider the example derivation in (4).

(4) *Impossible CVC reduplication*

a. *Morphophonology*

$$\# \to t \to a \to b \to u \to \%$$

b. *Linearization and resyllabification*

$$\begin{array}{l} \quad\ \sigma \qquad\qquad\quad \sigma \qquad\ \ \sigma \\ \# \rightarrow t \rightarrow a \rightarrow b \rightarrow t \rightarrow a \rightarrow b \rightarrow u \rightarrow \% \end{array}$$

c. *Deletion*

$$\begin{array}{l} \quad\ \ \sigma \qquad\qquad\quad \sigma \qquad\ \ \sigma \qquad\quad > \qquad\quad \sigma \qquad\ \ \sigma \qquad\ \ \sigma \\ {*}\# \rightarrow t \rightarrow a \rightarrow b \rightarrow t \rightarrow a \rightarrow b \rightarrow u \rightarrow \% \quad \# \rightarrow t \rightarrow a \rightarrow t \rightarrow a \rightarrow b \rightarrow u \rightarrow \% \end{array}$$

The constraint on CVC reduplication in a strictly CV language is derived from this organization of grammar. If we allow the morphology to create a CVC reduplication structure as in (4a), it will be linearized and resyllabified as in (4b). The potential coda consonant in (4b) will be targeted for repair because it is not syllabified according to the general syllabification of the language in question. Consequently, as indicated in (4c), the offending coda consonant will be deleted. The point to note here is that the morphology can potentially generate structures that do not follow the surface prosodic patterns of the language and yet still not overgenerate because the phonology will repair and constrain this type of overgeneration. No match need be stipulated between the structures that the morphology generates and the surface prosody. This result is predicted by and obtained from the derivationally ordered modular structure of Distributed Morphology.

PBP combined with Distributed Morphology predicts a stronger connection between reduplication patterns and syllable structure than do PM approaches to reduplication. To see this, consider a variety of PM instantiated within an OT model of grammar that adopts a strictly templatic approach to reduplicative templates, which are evaluated at the surface. Within such a model, a CVC reduplication pattern could be specified and, depending on where the constraint that specifies the CVC template is ranked, the templatic requirement could override the general prosodic pattern of the language in question. Consider the tableau in (6) with the constraints listed in (5).

(5) *Constraints for pathological templates*

a. *Max-Stem*
All segments of the stem in the input must appear in the output.

b. *Max-BR*
All segments in the base must occur in the reduplicant.

c. *NoCoda*
Don't have codas.

d. *Red* $= \sigma_{\mu\mu}$
The reduplicant must have a branching rhyme.

e. **LongV*
Don't have long vowels.

(6) *Pathological templates*

/RED + tabu/	RED = $\sigma_{\mu\mu}$	MAX-BR	NOCODA	*LONGV	MAX-STEM
☞ a. tab-tabu		*	*		
b. taa-tabu		**!		*	
c. ta-tabu	*!	**			
d. tabu-tabu	*!				

The constraints in (5) are generic versions of commonly used constraints and are only informally defined. If we rank these constraints as shown in tableau (6), we can see that a CVC reduplicant, (6a), can be produced in a language that does not allow for codas. Note that the constraint requiring a branching coda (RED = $\sigma_{\mu\mu}$) is undominated, while MAX-STEM is dominated by NOCODA. This encodes the necessity that the reduplicant have a coda (the presence of the coda as opposed to vowel lengthening can also be derived from a MAX-BR effect) but that codas are not allowed in stems. We thus derive the emergence of the marked. The candidates in (6b–d) are all less harmonic because they violate undominated RED = $\sigma_{\mu\mu}$.

OT approaches to reduplicative templates do not necessarily produce the pathological effect in (6), and readers familiar with contemporary OT analyses of reduplication will immediately see the flaw—namely, the constraints that determine the size of the reduplicant, RED = $\sigma_{\mu\mu}$ and MAX-BR, are ranked above the general MAX-STEM constraint. This type of constraint ranking is generally eschewed for the simple reason that it can produce the types of pathological effects demonstrated in (6). Rejecting (6) as a possible grammar is a reasonable move, and it produces the correct type of constraint on reduplicative templates. However, this result has nothing to do with whether the reduplication pattern is specified via prosodic units or not. Rather, it is produced by a stipulated metaranking that prevents RED-specific constraints from dominating general Faithfulness constraints. In other words, it is a brute force prediction and does not flow organically from the architecture of the theory as it does in PBP approaches.

At first blush, atemplatic approaches to reduplication in OT would appear not to need the metaconstraint approach to rule out an analysis similar to (6) because the offending RED = $\sigma_{\mu\mu}$ is not available. This is not the case, though, at least for atemplatic approaches to reduplication based on proposals by Spaelti (1997) and Hendricks (1999). Both of these approaches use constraint interaction to derive limits on the size of reduplicants. Tableau (7) demonstrates an approach in this spirit where a heavy syllable is the target for reduplication. The constraints in (7) are the same as those in (6) except that the templatic constraint RED = $\sigma_{\mu\mu}$ has been removed. Instead, total reduplication is limited to a single syllable by the constraint *σ ("Don't have syllables"), in that if we assume that the RED morpheme must have some sort of surface exponent (see Gafos 1998 and Walker 2000 for proposals along these lines), then ranking MAX-BR beneath *σ will produce a reduplicant one syllable in size.

(7) *Pathological atemplatic approaches*

/RED + tabu/	*σ	MAX-BR	NOCODA	*LONGV	MAX-STEM
☞ a. tab-tabu	***	*	*		
b. taa-tabu	***	**!		*	
c. ta-tabu	***	**!			
d. tabu-tabu	****!				

Candidate (7a) is the most harmonic because it copies as much material from the base into the reduplicant as is allowed in a single syllable. The fact that MAX-BR is ranked above NOCODA (just as in (6)) causes the reduplicant to have a coda. Although some might object to the ranking in (7) because the general MAX-STEM constraint is dominated by *σ—a ranking that may be interpreted as suggesting that there are no syllables in the language, this objection is based on assuming the containment model of OT (Prince and Smolensky 2004) where segments occurred at the surface only if they were prosodically licensed (e.g., parsed into syllables; Ito 1986). The correspondence theory model of OT (McCarthy and Prince 1995) supplanted the containment model, and this has had the effect of dissociating the insertion and deletion of segments from whether they are prosodically licensed or not. Raimy and Idsardi (1997) use this aspect of syllabification in correspondence theory in analyzing reduplication in Bella Coola, which is notorious for its unsyllabified segments (Bagemihl 1991). Consequently, we must come to the same conclusion for atemplatic models as we did for templatic models: a metaconstraint that prevents RED-specific constraints from being ranked above general Faithfulness constraints is the source of the isomorphy between a language's prosodic structures and possible reduplication patterns.

The presence of this very useful metaconstraint on possible rankings makes any additional formal mechanisms constraining reduplicative templates completely redundant. This is where the PBP and PM approaches converge in the analysis of reduplication. It is the general architecture of particular theories that serves as a constraint on the shape of possible reduplication patterns; PBP invokes a modular approach of morphology first, whereas PM invokes a metaranking on reduplication-specific constraints. Neither theoretical approach requires additional restrictions on reduplication based on authentic units of prosody. Consequently, the PBP approach to reduplicative templates is not less constrained on this particular front even though there is no necessary connection between a prosodic category and the definition of a precedence link.

To summarize this section, the observation that reduplicative templates never violate language-specific surface prosody is the result of the architecture of grammar in both the PBP and PM approaches. In the PBP approach, modularity—with the morphology preceding the phonology—derives this effect. In the PM approach, a metaconstraint prevents constraint rankings that would produce pathological grammars. Neither theory requires any other mechanism to capture this generalization about the relationship between surface prosody and possible reduplicative templates. It follows that the additional constraints on reduplicative templates assumed in the PM approach are superfluous. In turn, it follows that PBP approaches show more promise of achieving explanatory adequacy than do PM approaches.

19.4 Organic Constraint II: Phonological Computation

The constraint on reduplication patterns derived from general grammatical architecture developed in section 19.3 does not fully constrain possible reduplication patterns. There are other conceivable patterns that would have legitimate prosodic structure but are nevertheless unattested in natural human language and are considered to be impossible. Downing (2001:448–449) suggests that PBP reduplication is unconstrained on this front because it could express the generalization ‘‘Copy up to the first three vowels,’’ among others. Downing’s question here is actually a recycled version of a question that McCarthy and Prince (1996/1986:2) asked: why there aren’t any reduplication patterns of the type ‘‘Reduplicate the first three segments.’’

The general answer to this question is that phonology is only capable of certain calculations and has a limited stock of representations. All theories are equally constrained (or unconstrained) on this front. One way of demonstrating this point is to modify the above question and ask it about moras and syllables instead of segments or vowels. Why aren’t there reduplication patterns that reduplicate the first three moras? Why aren’t there reduplication patterns that reduplicate the first three syllables? The answer has nothing to do with whether the target of counting (moras vs. syllables vs. segments vs. vowels) is an authentic unit of prosody. The answer is based on the nature of the counting involved. Phonology only robustly supports binary counting (see Idsardi, this volume, for a different view; but note that admitting ternary counting to phonology does not help any particular model of reduplication), so any pattern that requires counting beyond two will be ruled out. Note that invoking the prosodic category ‘‘foot’’ or ‘‘syllable’’ to derive the counting-to-two restriction does not adequately explain why phonology doesn’t count to three. This type of response only shifts the question to a different domain: why do feet not consist of three syllables, or syllables of three moras? PM and PBP have the same source of constraints on possible reduplication patterns: that is, they are based on our general knowledge of the "counting abilities" of phonology. This constraint on counting ability is an organic property of both approaches, and in neither approach is it inherently connected to the notion "authentic units of prosody." So PM still faces the question, how does the constraint that restricts reduplicative templates to authentic units of prosody add to our understanding of reduplication? PBP faces an analogous question: what constrains how precedence links can be defined?

Although in many cases different theories are equivalent when provided identical resources, there are still questions about what patterns a theory can and cannot produce. In Raimy 1999, 2000a,b, the set of anchor points that describe possible reduplication patterns is not explicitly delineated, and this is a major source of confusion with respect to PBP. Anchor point theory (Raimy 2005) remedies this omission and subsumes proposals by Yu (2003) about where infixation can occur. The set of anchor points that describe where a precedence relation can be concatenated to a representation is delimited by the parameters in (8).

(8) *Parameters for an anchor point*

Placement:	{at/before/after}
Edge:	{first/last}
Plane:	{x-tier/metrical/syllable/consonantal}
Target:	{plain/stressed(head)/consonant}

Each parameter expresses a variable regarding how phonological representations can be searched. Phonology must search (Reiss 2007) each representation as part of any process or constraint evaluation because representations are directed graphs (Raimy 2004). The placement parameter, (8a), refers to whether the element that is being searched for is the target of the process, or whether the element immediately before or after it is. The edge parameter, (8b), indicates whether the search is, informally speaking, left to right (first) or right to left (last). More formally, the edge parameter indicates whether a strictly left-to-right search terminates as soon as a target is found (first) or whether the search continues all the way to the end of the representation and the last target found is used. The plane parameter, (8c), indicates which representation in 3-D phonology (Halle 1985) is the locus of the calculation. Finally, the target parameter, (8d), can narrow the locus of the search to subcategories of stressed elements or consonants, creating cross-planar calculations (Archangeli and Pulleyblank 1994) such as "the onset of the stressed syllable" or (as we'll see in a moment) "the segment after the first vowel."

In Raimy 2005, I argue that the parameters in (8) are sufficient to capture all documented reduplication and infixation patterns, but demonstrating the validity of these claims is beyond the scope of this chapter. Instead, I will illustrate my proposals by formalizing the informal descriptions of the anchor points for the patterns of reduplication in Pangasinan proposed in (3). These generalizations have the formal parameter settings shown in (9).

(9) *Formal settings of the anchor point descriptions in (3)*
  a. "first segment" = {at, first, x-tier, plain}
  b. "last segment" = {at, last, x-tier, plain}
  c. "first vowel" = {at, first, metrical, plain}
  d. "second vowel" = {after, first, metrical, plain}
  e. "after first vowel" = {after, first, metrical, consonant}

The parameter settings for "first segment" and "last segment," (9a) and (9b), respectively, are straightforward in that the search operates on the x-tier. It thus scans every segment and ends when either the first or the last segment is reached. The "first vowel" anchor point, (9c), is produced by limiting the search to elements on the metrical tier alone (i.e., vowels) via the plane parameter and thus differs from the "first segment" anchor point in (9a) by only one parameter setting. The "second vowel" anchor point, (9d), is derived by again changing a single parameter, but this time it is the placement parameter. Changing the placement parameter setting from "at" in (9c) to "after" in (9d) allows the second vowel to be identified and produces the surface appearance of a foot being reduplicated. Finally, the "after first vowel" anchor point, (9e), differs from the "second vowel" anchor point, (9d), only in that if the target parameter is changed to "consonant," the search on the metrical tier to find the first vowel switches to the x-tier and selects the following segment (a consonant). See Raimy 2005 for a full discussion of the empirical adequacy of anchor point theory.

While the parameters in (8) are capable of producing all documented reduplication patterns, they are still restricted in that they cannot produce all hypothetical patterns. Consider the hypothetical XXX pattern presented in (10), discussed by McCarthy and Prince (1996/1986:2).

(10) *Hypothetical XXX reduplication*
  a. badupi > bad-badupi
  b. bladupi > bla-bladupi
  c. adupi > adu-adupi

The PBP model cannot produce all three forms in (10) from a single generalization, because the surface patterns of reduplication for each of the three examples are distinct. If we view the three patterns in (10) in light of the analysis of Pangasinan in (3) and (9), then (10a) is (C)VC reduplication as in (3c), (10b) is (C)V reduplication as in (3d), and (10c) is (C)VCV reduplication as in (3b). Each of these reduplication patterns has a distinct begin setting as listed in (3) and formalized in (9). Therefore, PBP correctly predicts that the three forms in (10) do not create a coherent reduplication pattern.

The main point to take away from this demonstration is that the PBP model of reduplication is distinct from previous derivational models of reduplication (e.g., Marantz 1982, Mester 1988, Steriade 1988). It follows that arguments that have been lodged against these specific models of reduplication do not hold against the PBP approach. This observation does not give the PBP and PM models of reduplication a free pass, though, because both models have new sources of potential overgeneration that must be confronted. A specific example is Lieber's (2004) question about how the PBP model rules out the hypothetical last-vowel-to-first-vowel (LVTFV) reduplication pattern in (11).

(11) *Last-vowel-to-first-vowel reduplication pattern (Lieber 2004:199)*

babab	babaabab
dait	daiait
balabat	balabaalabat

Lieber is correct in suggesting that the frequent occurrence of the anchor points "first vowel" and "last vowel" raises the question why we don't find them paired to create a "no coda and no onset" reduplication pattern. However, Lieber's discussion misses two points. The first is that this particular aberrant overgeneration is shared by all existing models of reduplication, as the following data from Korean onomatopoeic and mimetic reduplication illustrate:

(12) *Onomatopoeic and mimetic reduplication in Korean (Jun 2006)*

	Base	*Total reduplication*	*V-initial reduplication*
a.	pulkɨt	pulkɨt-pulkɨt	ulkɨt-pulkɨt
b.	pollok	pollok-pollok	ollok-pollok
c.	pulluk	pulluk-pulluk	ulluk-pulluk
d.	pult^{h}uŋ	pult^{h}uŋ-pult^{h}uŋ	ult^{h}uŋ-pult^{h}uŋ
e.	təmpəŋ	təmpəŋ-təmpəŋ	əmpəŋ-təmpəŋ
f.	c'ukɨl	c'ukɨl-c'ukɨl	ukɨl-c'ukɨl

These data present a total reduplication pattern and a V-initial reduplication pattern. The importance of the V-initial reduplication pattern is twofold: first, how would a PM-based model of reduplication account for a reduplicant that must delete an initial onset, and second, once we have a mechanism that can produce this "no onset" effect, why doesn't it occur with a "no coda" ranking? Again, we can see that there are more parallels between PM and PBP once we begin to investigate where and how reduplicative templates are constrained.

It is also incorrect to suggest, as Lieber (2004:199) does, that the formal mechanisms of a theory are the only source of constraints. The inaccuracy of this view is clear from the current discussion and section 19.3. Lieber's question cannot be rejected, though, because it can be generalized to one that asks why all possible operations in reduplication (i.e., onset effects, no coda effects, no onset effects, complex onset effects, etc.) do not appear in all possible combinations and in all templatic patterns. Answers already exist for some parts of this question (see Raimy 2000a:163–177 for discussion), but not for the LVTFV pattern in (11). Another way of posing Lieber's question is to ask what other sources of organic constraints there can be beyond architectural and computational aspects.

19.5 Organic Constraint III: Language Acquisition

The final organic constraint on reduplicative templates that we will investigate is language acquisition. The general view of language acquisition that will be adopted here is presented in Yang 2002. Yang argues that language acquisition is the result of both Universal Grammar (UG; Chomsky 1980) and statistical learning. UG's role is to constrain the hypothesis space within which statistical learning occurs. For the purposes of reduplication, UG provides the formalisms of a particular theory. For our purposes, UG is a PBP-based model of reduplication along with anchor point theory (see section 19.4). Under this view, the formal system described by PBP delimits the hypothesis space and nothing more. The explanation for how a child arrives at particular places in the hypothesis space should result from a combination of particular proposals about statistical learning and the environment.

At this point, we must recognize that there is a distinction between the lack of a particular pattern and children's inability to learn the pattern. Lieber (2004) conflates these two options when she suggests that because LVTFV reduplication is not attested, it must therefore be impossible in UG, and thus unlearnable. I suggest that this is too hasty a conclusion. We first must determine whether children can or cannot learn this pattern if presented with appropriate data. One way of investigating this question is experimental. Marcus et al. (1999) have demonstrated that 7-month-olds can learn reduplication patterns sufficiently to distinguish between ABA (e.g., *wo-fe-wo*) and ABB (e.g., *wo-fe-fe*) patterns and between AAB (e.g., *wo-wo-fe*) and ABB (e.g., *wo-fe-fe*) patterns. The particular relevance of this finding is that 7-month-old infants with very limited exposure (2-minute speech sample) can process reduplication patterns well enough to distinguish between two reduplication patterns. While Marcus et al.'s results do not answer our particular question, they do provide the template for experiments that would potentially determine whether we should treat the LVTFV reduplication pattern as a gap or an impossible pattern.

Another useful avenue of inquiry into LVTFV reduplication is formal in nature. What is the starting state of the learner? Exactly what pattern of forms is needed to induce a LVTFV generalization? Both of these questions have been investigated by Iba and Nevins (2004), who developed a computational model of a selectionist learner (Yang 2002) for reduplication, called the *reduplicator*, based on general PBP proposals. As part of the selectionist learner implementation, the reduplicator returns multiple working solutions for reduplication patterns that are ambiguous with respect to description via anchor points. Given the possibility of ambiguous patterns, it is very likely that UG provides biases toward particular solutions over others. These biases can be encoded as the likelihood of when particular anchor point pairings are selected as hypotheses to compare input data with in a selectionist learner. (13) presents two general biases that will guide learning of reduplication patterns.

(13) *Biases for reduplicative learning*

a. *Be conservative:* favor anchor points with more general parameter settings.

Placement:	at	>	before/after
Plane:	x-tier	>	metrical/syllable/consonantal
Target:	plain	>	stressed(head)/consonant

b. *Be different:* if the anchor points, X and Y, that define a precedence link are not identical (X = Y), then favor pairs of anchor points that are distinct with respect to (a).

The biases in (13) reflect general aspects of language acquisition and do not appear to be unique to reduplication. (13a), ‘‘Be conservative,’’ is the general idea that learners move to more specific hypotheses only when positive evidence forces them to. For each parameter in (8), there is a most general setting that contains the others. Consequently, (13a) can also be viewed as the application of the Elsewhere Condition (Kiparsky 1973) as a metric over parameter settings. Note that there is no representational way to determine whether ‘‘first’’ or ‘‘last’’ is more general for the placement parameter of an anchor point, so it has been omitted from (13a). The ‘‘Be different’’ bias in (13b) can be understood as some sort of knowledge similar to the Obligatory Contour Principle, where the learner knows that sequences of extremely similar but not identical elements are generally disfavored.

The interaction of the biases in (13) creates a dynamic ranking of hypotheses that depends on the particular reduplicated form being considered. For reasons of space, I cannot fully investigate these ideas here, but the general shape of their impact is clear from (14).

(14) *Acquisition biases for total reduplication pattern*

a. $\# \rightarrow t \rightarrow a \rightarrow g \rightarrow o \rightarrow \%$

Anchor point descriptors for /t/
‘‘first segment’’
‘‘first consonant’’
‘‘before first vowel’’
Anchor point descriptors for /o/
‘‘last segment’’
‘‘last vowel’’
‘‘after last consonant’’

b. *Hypotheses*

i. "last segment" → "first segment" — Least marked hypothesis

Next level of markedness

ii. "last segment" → "first consonant"
iii. "last vowel" → "first segment"

Next level of markedness

iv. "last vowel" → "first consonant"
v. "last segment" → "before first vowel"
vi. "after last consonant" → "first segment"

Most marked hypotheses

vii. "last vowel" → "before first vowel"
viii. "after last consonant" → "first consonant"
ix. "after last consonant" → "before first vowel"

(14a) presents the hypothetical reduplicated form *tago-tago*, which in a vacuum would generally be interpreted as a case of total reduplication. The point of (14) is to demonstrate that this form is actually multiply ambiguous. The ambiguity can be seen by considering the anchor points that can describe the reduplicative precedence link. The /t/ at the head of the precedence link can be described as "first segment," "first consonant," or "before the first vowel," and the /o/ at the foot of the precedence link can be described as "last segment," "last vowel," or "after the last consonant." When these two sets of anchor points are freely combined, we get the nine hypotheses about what this reduplication pattern could be.

The biases in (13) allow us to rank these nine hypotheses as in (14b). The least marked hypothesis about the pattern in (14a) is (14bi): "the last segment precedes the first segment." This is the least marked hypothesis because when we interpret the element informally called "segment" in terms of specific anchor point parameter settings from (8), it results from the least marked setting for placement ("at"), plane ("x-tier"), and target ("plain"). Because "segment" is the most general hypothesis that works for both anchor points, this analysis will be favored by the learner. All the other solutions that also work are more specific along some dimension of (13a) and are thus less favored by the learner. (14bii) and (14biii) each take one step toward the more specific by altering the setting for the plane parameter. (14bii), "first consonant," changes the plane setting to "consonantal," and (14biii), "last vowel," changes the plane setting to "metrical" (producing "vowel"). The remaining hypotheses about the reduplication pattern in (14a) are all more specific than the one in (14bi).

The biases in (13) do not eliminate more specific hypotheses from consideration, but they do make their adoption less likely for the learner. This view of the biases has two immediate benefits. The first is that this type of bias can be modeled very easily in selectionist learning (Yang 2002) by adding probabilities to particular hypotheses based on the biases instead of selecting a hypothesis purely at random to test against the data. Hypotheses favored by the biases in (13) will be chosen to test at a higher frequency than disfavored hypotheses. The result is that some learners will adopt a surface-ambiguous but disfavored hypothesis (see Lightner 1972:50–51 for discussion of this idea) as their solution to a particular reduplication pattern. This possibility might provide insight into language change or variation.

Fitzpatrick and Nevins (2004) demonstrate the usefulness of surface-form ambiguity in their discussion of a dialectal difference in Tigrinya, based on two reduplication patterns for quadriliteral forms documented by Rose (2003). Fitzpatrick and Nevins argue that the two distinct patterns for quadriliteral forms are directly explained by the ambiguity of how to describe the reduplication pattern on triliteral forms. Consider the data in (15).

(15) *Tigrinya frequentive forms*

a. Triliteral: $\sqrt{}$grf 'whip' grarf > gərarəf

b. "First reduplicate C_2 to achieve quadriliteral status, then infix /a/ between C_2 and C_3."

$\# \rightarrow g \rightarrow r \rightarrow f \rightarrow \%$ *linearize*

$\# \rightarrow g \rightarrow r \rightarrow r \rightarrow f \rightarrow \%$ *linearize* $\# \rightarrow g \rightarrow r \rightarrow a \rightarrow r \rightarrow f \rightarrow \%$

a

c. "C*a* reduplication on penult C"

$\# \rightarrow g \rightarrow r \rightarrow f \rightarrow \%$ *linearize* $\# \rightarrow g \rightarrow r \rightarrow a \rightarrow r \rightarrow f \rightarrow \%$

a

d. Quadriliteral: $\sqrt{}$glbt 'turn over'

$\# \rightarrow g \rightarrow l \rightarrow b \rightarrow t \rightarrow \%$

i. glabt > gəlabət

ii. glbabt > gələba:bət

(15a) presents the triliteral root $\sqrt{}$*grf* 'whip' and its frequentive form [gərarəf] (note that all schwas in (15) are epenthetic and thus have been left out in some representations). (15b) and (15c) demonstrate that there are at least two distinct ways of producing the intermediate form /grarf/. (15b) reduplicates the medial consonant in order to produce a quadriliteral form of the base through linearization, and then infixes /a/ between C_2 ("consonant after the first consonant") and C_3 ("consonant before the last consonant") in the now quadriliteral form. (15c) shows that the same surface form can be created through what Fitzpatrick and Nevins call C*a* reduplication, where the infix /a/ uses the same anchor point, "consonant before the last consonant," for beginning and end. (15d) then demonstrates that both analyses are attested as a dialectal difference in how the frequentive is formed on true quadriliteral forms in Tigrinya. (15di) is based on the derivation in (15b), and (15dii) is based on the derivation in (15c).

From an acquisition point of view, we must allow learners of Tigrinya to base their learning primarily on triliteral forms (presumably occurring much more frequently than quadriliteral forms) and then assume that they choose a specific hypothesis (either (15b) or (15c)) in the face of multiple possible solutions. Once learners make a decision based on the dominant triliteral forms, it can be the locus of language change (see Calabrese, this volume, and Kaisse, this volume, for discussion of this point) because the quadriliteral forms will now distinguish possible hypotheses for triliteral roots. For this particular case, learners must choose a single solution to the ambiguity of triliteral roots. This general theme of explaining variation through ambiguity is also found in Nevins and Vaux 2007.

To return to Lieber's challenge, we have now arrived at an explanation for the lack of attested LVTFV reduplication patterns. It is not that this pattern is ruled out by UG; instead, the acquisition aspect of reduplication very much disfavors it. In essence, the LVTFV generalization violates both biases in (13): the informal "vowel" anchor point requires the more specific plane parameter (i.e., metrical) setting, which violates (13a), and then reuses this marked identical anchor point setting, now violating (13b). Other surface-ambiguous hypotheses that fare better on the biases in (13) will serve as better acquisition targets, thus hindering the learner from settling on the LVTFV pattern. Consider the forms in (16), which add likely bases and corresponding LVTFV reduplication patterns to the ones suggested by Lieber.

(16) *Additional last-vowel-to-first-vowel forms*

	Base	*Reduplicated*	*Favored hypothesis*
a.	abo	abo-abo	"last segment to first segment"
b.	abot	abo-abot	"last vowel to first segment"
c.	dabo	dabo-abo	"last segment to first vowel"
d.	ba	ba-a	"first vowel to first vowel"

These forms are all implied by the forms that Lieber chose and are based primarily on what is known about the typology of syllables. First, in order for the LVTFV pattern to exist at all, vowel hiatus must be tolerated by the language, which implies that there can be onsetless syllables. Consequently, forms like (16a) and (16b) should occur in the language, with (16a) suggesting to the learner that total reduplication is an option and (16b) suggesting that total reduplication with a "no coda" effect is an option. Second, since syllables without codas are universal, (16c) and (16d) should appear in the language. Both of these forms obscure the identification of the "last vowel" anchor point. (16c) will pull the learner toward a "last segment" hypothesis, and (16d) suggests a "first vowel lengthening" process. When these forms are added to the learning environment, it becomes clear that the LVTFV hypothesis is a very difficult one for a learner to grab onto. This observation is sufficient to explain why the LVTFV pattern is not attested, yet it leaves the question of whether humans can learn this pattern an empirical matter. This is the most appropriate state of affairs regarding this pattern.

To summarize this section, the final constraining mechanism on reduplicative templates is a theory of language acquisition. A theory of language acquisition cannot be viewed as an ad hoc mechanism that exists only to artificially constrain an overly powerful formal mechanism. Instead, a theory of language acquisition should be considered a core component of any formal proposal. Consequently, contrary to Lieber's (2004:199) suggestion that the PBP model is not constrained enough to further our understanding of reduplication, the model in fact provides the right amount of constrained formalism in that it creates a hypothesis space in which a learner could use proposed acquisition devices such as selectionist learning (Yang 2002) or other statistical models of language acquisition (see the 2006 *Trends in Cognitive Science* special issue on probabilistic learning). The hypothesis space for reduplication patterns created by PBP is empirically adequate in that it contains all attested reduplication patterns. Because this hypothesis space is not "flat," not all patterns of reduplication are equally likely. The remaining question for the PBP approach is how much of the warping of the hypothesis space can be derived from general linguistic resources and/or general cognitive resources.

19.6 Conclusions

The purpose of this chapter has been to demonstrate that independently needed theories of grammatical architecture, computation, and acquisition all serve as organic constraints on possible reduplication patterns. All formal theories of reduplication are obliged to explain how these components of human cognition interact with the proposed formal system accounting for reduplication. The main claim of this chapter has been that once the role of these other components of human cognition is fleshed out with respect to reduplication, the claim that reduplicative templates are constrained by surface prosodic considerations as suggested by Prosodic Morphology becomes vacuous. The strongest aspect of the arguments in this chapter against PM approaches to reduplication is that all of the advances and insights provided by the Precedence-Based Phonology model require the PM model to be modified in ad hoc ways to mimic the PBP model. The fact that the insights from the PBP model of reduplication can be used to improve the PM model clearly suggests that these insights are not theory-internal to PBP but instead are actual improvements in our understanding of the nature of reduplication. Because the prosodic constraints proposed by PM add no explanatory force to analyses of reduplication, and because it appears that all other things are equal between PM and PBP models of reduplication (e.g., weak generative capacity appears to be the same), Occam's razor suggests that the PBP model of reduplication patterns should replace the PM approach.

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