5

Reduplicative Economy[1]

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5.1 Introduction

The unexpected interactions between reduplication and phonological processes were the direct motivation for the invention of Correspondence Theory (CT; McCarthy and Prince 1993, 1995*a*, etc.) as a component of Optimality Theory (OT; Prince and Smolensky 2004, McCarthy and Prince 1993, etc.). As uncovered in the pioneering study of reduplication, Wilbur (1973), phonological processes frequently do not apply normally when combined with reduplication. Rather, what is observed is surface over- or underapplication of the phonological processes. McCarthy and Prince analyze these departures from normal process application as instances of identity (faithfulness) between Base and Reduplicant. Extending such analyses to other areas of phonology, McCarthy and Prince (1995*a*) expand Correspondence Theory to cover input-output relations generally. As Correspondence Theory has evolved, it has gained a whole panoply of additional uses, such as: Input-Reduplicant relations (McCarthy and Prince 1995*a*), Output-Output relations within a paradigm (Benua 1995) and Base-Epenthesis relations (Kitto and de Lacy 1999).

The advent of Correspondence Theory introduces new constraint families (Max, Dep, Ident) but also significantly enriches the representations allowed within the theory. The original Containment model of Prince and Smolensky (2004) handled deletion through underparsing, and epenthesis through empty prosodic positions (symbolized there by an empty box), which were to be filled in at phonetic interpretation. For a variety of empirical and conceptual reasons, the Containment model was superseded by Correspondence Theory, which allows a much richer conception of deviation from

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input-output identity. The difference in the two theories lies in the output of Gen, as in (1).

(1) Containment: Gen(input) → {outputs}
Correspondence: Gen(input) → {<input, output, relation>}

In the Containment model Gen produces a set of candidate output forms, each of which is an elaboration of the input form. Nothing of substance is removed, rather items which will ultimately remain unpronounced are included in the "output" so that they may still condition phonological processes. In contrast, the Correspondence model allows for arbitrarily different output forms, but includes a function within each "output form" indicating the correspondence relation between input and output.

In both theories there is an equivocation on what "output" means. Hale (2001) identifies the core of this issue as whether the "output" of an OT grammar is a purely phonetic representation that has already been transduced (transformed from discrete abstract phonological features to less abstract more continuous phonetic features) or is a phonological representation that has to be transduced at a later point in the derivation. While this issue is not crucial to the issues discussed in this chapter, it is one that must be addressed before a definitive evaluation of the success and merits of OT can be accomplished. For the purposes of this article, we will assume that the "output" of an OT grammar is a phonological one that must be further converted to a phonetic representation later in the derivation. Hale (2001) provides interesting discussion of the ramifications of this position.

The purpose of this chapter is to examine some of the consequences of Correspondence Theory. We believe that Correspondence Theory is far too powerful, and as a result it is analytically uninsightful and computationally implausible (see Idsardi 2006 for discussion). We offer as an alternative the representations for reduplication proposed in Raimy (2000*a*). These representations have a greater affinity with the original Containment model of Prince and Smolensky. In Raimy's model, an abstract phonological representation is calculated which is then submitted to the phonetic implementation component.

Specifically, Raimy (2000*a*) clarifies how the information about temporal precedence is represented phonologically. Temporal relations are best encoded in phonological representations with a particular data structure, namely a linked list. The simplest temporal patterns can be represented with "linear" linked lists, those in which each segment leads to exactly one other segment. Once we identify this data structure as appropriate for simple cases, we can then ask a more sophisticated question: What could we represent by relaxing the linearity condition? That is, what if some non-linear temporal precedence relations were allowed? What if some segments were specified as having two or more possible continuations? Could we capture over- and underapplication more insightfully with these slightly enriched representations?

To illustrate the difference between these approaches, let us consider how a hypothetical[2] reduplicated form *ta-tema* would be represented in the two approaches. In CT, there will be an input, an output, and two correspondence relations, CORRESPONDENCE-IO and CORRESPONDENCE-BR, as in (2).

(2) Input: Ø + t e m a

CORRESPONDENCE-IO (IR)

Output: [$_{\text{Red}}$ t a][$_{\text{Base}}$ t e m a]

CORRESPONDENCE-BR

The [ta] portion in the output has a separate representation from the [tema] portion, but the two are related by Correspondence relations. First, they have correspondence relations to each other, CORRESPONDENCE-BR. Second they share correspondence with segments in the input, CORRESPONDENCE-IO.

In contrast, we show Raimy's representation in (3).

(3) # → t → e → m → a → %

In (3) there is no separation of [ta] from [tema], they use the same pieces of phonological structure. The portion [ta] simply repeats certain portions of [tema]. There are two continuations from the /t/, one to /a/ and one to /e/, and there are two continuations from /a/, one back to /t/ and one to the end of the word. Once this structure is linearized, we will obtain the surface form [tatema].

In the rest of this chapter we will briefly show how the Raimy model of reduplication works. In particular we will show how this system analyzes over- and underapplication facts and relates these to other phenomena in an insightful fashion. But, most importantly, we will show that Raimy's system is representationally economical. By this we mean that there is a natural evaluation metric for the complexity of representations in Raimy's system, and the right results come out when the simplest representation for reduplication

[2] This is basically the pattern of reduplication in Semai (Diffloth 1976).

through "looping" is chosen. In contrast, CT is too powerful because it allows arbitrary deviation between Base and Reduplicant, and it allows arbitrarily complicated correspondence relations among several representations. Simply put, CT allows too large a space of possible analyses for reduplication. Since the child must settle on the right analysis, CT requires too much data inspection on the part of the child. Consequently CT analyses are much less learnable than Raimy-style analyses.

5.2 Representing reduplication in Temiar

To illustrate the differences between the two approaches, we will consider some facts about reduplication in Temiar (Benjamin 1976 and most recently Gafos 1998, see references in Gafos for previous analyses). The continuative is formed in Temiar by repeating a portion of the word, as in (4).

(4) /Continuative + slɔg/ >>> [sglɔg]

If our job is to relate /slɔg/ to [sglɔg] as perspicuously and parsimoniously as possible with the resources in the Raimy model, we are forced to the analysis in (5).

(5) # → s → l → ɔ → g → %

We start at the /s/, jump to the /g/, come back to the /l/ and finish off the word as normal. The continuative morphology does not add any new segments but does condition the addition of two new temporal relations, the jump from /s/ to /g/ and the loop back from /g/ to /l/. Raimy (2000*a*) explains that the added temporal relations take precedence over those that are already present (this is a principle of Universal Grammar). The structures created in this way are also interpreted as economically as possible, so that the smallest output consistent with the maximum number of consistent temporal relations is chosen as the output, in this case [sglɔg]. Notice that the link [s → l] present in the underlying form is not used during linearization. Omissions of precedence information like this arise when two paths emanate from a segment, but only one path leads into the segment. In that case one of the paths must be sacrificed in pronunciation, and it is always the underlying path that is sacrificed in order to use the newly created path. In general the interpretation of the phonological structures optimizes for the following considerations: (1) the output must be asymmetric (this is inviolable), (2) no new precedence links are added (also inviolable), (3) morphologically added information is used first, and (4) the shortest possible output is generated (Raimy 2000*a*).

Raimy demonstrates that the Continuative morphology of Temiar is accomplished by the processes informally stated in (6).

(6) a. Add a link from the *last* segment to the *first onset* segment.

b. Add a link from the *first* segment to the *last* segment.

The representation that results from the addition of the precedence links indicated in (6) to a base compactly and explicitly stores the information necessary to pronounce both forms. The continuative is built out of the basic form by adding new information to it, and segments are reused whenever possible.

This new understanding of the phonological representation of temporal information has two major advantages: (1) it is not tied to particular surface properties or constructions and (2) it has an obvious and natural evaluation of markedness in the size of the structures required for representations and process statements. That is, the representation is both abstract and economical. It is these two properties that make this an excellent structure from which we can learn more about the way in which phonological relations are represented and manipulated mentally.

5.3 Economy of representation

Raimy's analysis of reduplication offers the beginnings of an explanation of how reduplication can be recognized and processed by the child, and why reduplication is a word-formation strategy favored by many languages. The child can recognize repeated chunks in short-term memory and build up an expectation of how the form will continue. When the child hears [sglɔg], there are two possible analyses available to him; shown in (7).

(7) [sglɔg] is heard, child constructs:

a. # → s → g → l → ɔ → g → %

b. # → s → g → l → ɔ %

The reduplicated representation in (7b) is more economical than the non-reduplicated one in (7a) because it has one fewer segments and the same amount of precedence links. If this hypothesized representation holds up under further data it will be maintained by the child. This suggests that words with common subsequences may be represented as reduplicative even in languages without reduplication (such as English 'banana', (8)).

(8) $\# \rightarrow b \rightarrow a \rightarrow n \rightarrow a \rightarrow \%$

Whether the representation in (8) is the one a child adopts while learning English will be affected by other considerations such as how the representation relates to metrical information (for example, the surface difference of stress between the last two syllables may prevent the child from adopting this representation). This seems to be attested in Manam, see Buckley (1998) for the relevant facts and Fitzpatrick and Nevins (2004) for an analysis along the lines suggested here.

5.4 Economy of computation

Both the Raimy model of reduplication and the Correspondence model of reduplication require computations to be performed on "input" forms to produce correct "output" forms. The Raimy model presents a case where there is only a small difference between the input and output representations. This difference between input and output is minimized because linearization only produces output forms that consist of links present in the input form. No new precedence relations are ever added during linearization, and only rarely are precedence links lost in the output (as in the above Temiar case). This economy of computation is what makes the Raimy model similar to the Containment model of Prince and Smolensky. Both of these models limit the amount of potential computation because the possible output representations that are produced are directly constrained by what information the input representations already contain. Correspondence models do not constrain the possible outputs that can be produced by a process. Outputs that freely add or delete any kind of structure are considered in Correspondence models and this increases the cost of computation dramatically.

Another aspect of computational economy present in the Raimy model is the statements that are required to add the links that produce reduplicative loops. These statements simply consist of specifications of what two segments stand in the relationship of precedence. Consider again the informal statement of Temiar reduplication in (6), presented below in the formal representation proposed in Raimy (2000*a*) (9).

(9) a. Add a link from the *last* segment to the *first onset* segment

begin → *end* *begin*: _ → %

end: #. . . X
|
onset

b. Add a link from the *first* segment to the *last* segment

begin → *end* *begin*: # → _

end: _ → %

The formalism in Raimy (2000*a*) specifies that each precedence link has a *begin* and *end* specification. These specifications indicate how the added precedence link will concatenate with the base. All forms have a beginning and an ending and, presumably, these positions are the two easiest locations to identify. All positions of segments in a formative are in ultimate reference to the beginning or ending of a form, thus all *begin* and *end* specifications of a precedence link will have the notion either "first" or "last" inherently present in them.

Total reduplication results from a precedence link that states "the last segment precedes the first segment." This can be considered the least complicated specification of a precedence link since it only requires reference to the first and last segment of a form. Support for this conclusion is the fact that total reduplication is the most prevalent type of reduplication (Moravcsik 1978). The coincidence between the formal simplicity of the statement of total reduplication and its prevalence in the world's languages creates the basis of a natural markedness metric. As more information is added to the link statements, the resulting reduplication pattern should be less prevalent. This appears to be true since less frequent but common reduplication patterns, such as prefixing CV/CVC, require the additional specification of some sort of prosodic position (nucleus, onset, C, etc.) in the statement of one part of the precedence link. Infixing reduplication which appears to be still rarer requires additional prosodic information in both parts of the statement. The claimed rarity of suffixing reduplication in comparison to prefixing reduplication can be explained by the fact that prefixing reduplication will always include some reference to "first" (more generally the beginning of the form) while suffixing reduplication will always include some reference to "last" (more generally the end of the form). If the scan through a phonological representation starts at the beginning of the form, precedence links that can be concatenated without having to scan through the entire form will be favored over links that must reach the end of the form before they can be discharged—another computational economy. Patterns of reduplication like Temiar require two distinct links to be added and thus are more marked than other patterns that require only the addition of a single link.

We can understand how over—and underapplication effects are produced by considering how segments with multiple temporal relations are viewed by processes. Consider a hypothetical case: Temiar with word-final devoicing (WFD). How does the structure in (5), repeated in (10), react to the application of WFD?

(10) # → s → l → ɔ → g → %

There are three possibilities to consider. First, WFD could be delayed until after linearization, for example if WFD were a postlexical rule. In this case WFD applies normally: [sglɔk]. Second, the fact that /g/ is at the end of the word according to one of its precedence links could be sufficient to allow WFD to apply (a "contamination" view of the word-final environment); this produces overapplication as /g/ → [k], [sklɔk]. Finally, the fact that /g/ is not consistently word-final (the two precedence links differ on this point) could block the application of WFD, yielding underapplication [sglɔg]. It is the representational discovery of the ambiguous status of /g/ that allows for a unified explanation of both under-and overapplication. See Raimy (2000*a,b*) for analyses of various actual over-and underapplication effects and discussion of how backcopying effects are accounted for within this system.

5.5 Extensions

A natural consequence of the addition of a new device to a theory is the possible utility of it in other situations. There are two immediately possible extensions[3] of the Raimy model that do not relate to reduplication.

The first possible extension of Raimy (2000*a*) is to reanalyze deletion in phonological representations not as the actual removal of a segment but instead as the addition of a jump link. This approach to deletion can mimic underparsing analyses from Prince and Smolensky. (11) presents a possible approach to deletion in Tiberian Hebrew where instead of deleting the vowel in question, a link that skips over it is added (11b), which then allows

[3] Both of the following extensions are utilized in the analysis of reduplication in Tohono O'odham and Indonesian in Raimy (2000*a*).

spirantization (11c) to apply without ordering restrictions. In essence the extra representational power can stand in for derivational opacity in this instance.

(11) a. # → k → a → t → a → b → u → %

b. Deletion (Jump)

→ k → a → t → a → b → u → %

c. Spirantization

→ k → a → θ → a → v → u → %

d. Linearization

→ k → a → *θ* → v → u → %

This potential analysis preserves the opacity effects in that the vowel is present in the representation long enough to trigger spirantization and it is removed only when the form is linearized. This approach to deletion can also handle base-truncation effects (Benua 1995) and provides an explicit account of what truncation morphology is. The connection between reduplication and truncation as argued for by Benua is preserved in this model because over— and underapplication effects are both derived as cases of phonological opacity involving segments with multiple links.

Another possible area of extension is the representation of geminates. A natural representation of geminates would be to have a segment "loop back" onto itself as in (12).

(12) # → t → a → k → i → % Agta takki 'leg'

This approach to the representation would immediately connect geminate blockage effects (Schein and Steriade 1986) with over- and underapplication effects. Both of these phenomena would be united under the understanding that it is the environmental ambiguity that a single segment appears in that is the source of their unusual behavior. It must be noted that the present representation of gemination as the multilinking of a single melody to multiple x slots is not ruled out in the Raimy model and only future research will indicate whether both types of geminate representations are required or if one type can explain all geminate behavior.

FIGURE 5.1. Hot Cross Buns[4]

5.6 Repetition in musical cognition

Precedence is a basic notion in phonology and if the Raimy model of precedence is correct we should hope to find converging evidence from other similar areas of cognition. A discussion of the learning of a musical tune by Bamberger (1991) provides strong supporting evidence for the representation of repeated material as proposed in the Raimy model.

Bamberger (1991) discusses an experiment where a child is asked to build the melody for "Hot Cross Buns" using what are called Montessori Bells. The melody for "Hot Cross Buns" is presented in Figure 5.1.

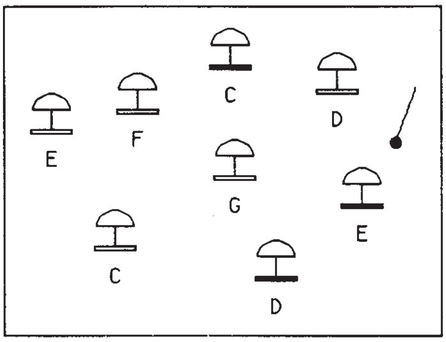
Montessori Bells are an important aspect of this experiment because of their ingenious design. Most musical instruments give some indication of what pitch they can produce through physical attributes. For example, we expect a smaller shorter instrument such as a piccolo to have a higher pitch than the larger and longer flute. A correspondence between pitch and size is something that we learn very quickly and it is a connection that the Montessori Bells deliberately avoid. Montessori Bells are built specifically to be identical in appearance but to still have different pitches. Thus, a C bell and a D bell can only be distinguished by striking and listening to them and cannot be distinguished by looking at them.

The particular Montessori Bells used in this experiment covered the C-major scale starting at middle C (eight bells) and the entire chromatic scale starting at middle C (thirteen bells).[5] This provides the child enough resources to build the tune for "Hot Cross Buns" which is found in Figure 5.1. The "search space" for the child in the experiment discussed by Bamberger is presented in (13). (13) is considered the search space because all of the notes needed to construct "Hot Cross Buns" are present in (13).

[4] It is unclear for percussive instruments such as the Montessori Bells whether the duration of the notes (quarter notes for this example) is relevant because it is the timing of the striking of the bells that is important and not how long the bells actually ring.

[5] There is another dimension of color to the bells provided to the children in this experiment. The chromatic bells had brown bases while the C-major bells had white bases. Bamberger discusses the special use of color in the learning task but this aspect is irrelevant to the point at hand and will not be discussed.

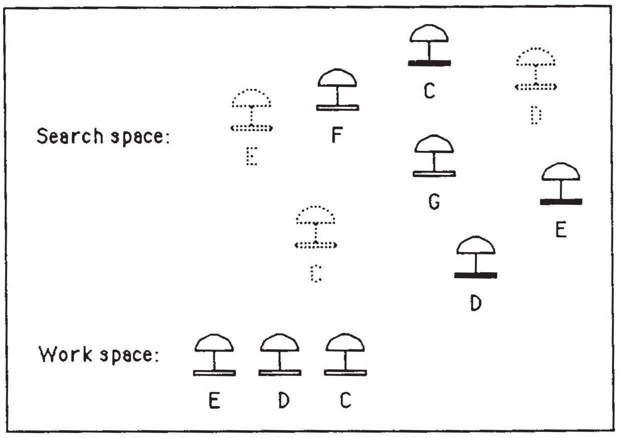
(13)



Bamberger (1991: 132, figure 7-2)

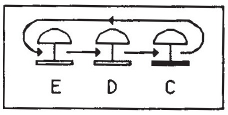
The interesting and relevant part of this experiment is how the child built the tune in Figure 5.1 out of the bells given in (13). The subject was given an E bell to begin and was allowed to proceed in building the tune from there (the child already knew the tune from a previous experiment). The child built the first measure by randomly choosing bells and striking them, listening to see if it matched the tune. Once a matching bell was found it was placed next to the previous note. The first measure of the tune was completed and the child had three bells sitting in front of him separated from the search space as seen in (14).

(14)



Bamberger (1991: 134, figure 7-5)

Now the interesting thing is what happens next. Instead of searching for another E bell to continue the tune, the child immediately used the three bells present in the "work space" to produce the second measure. The child recognized that the first and second measures of HCB are identical and recycled the present resources to reflect this fact. Most striking about this behavior is that a previous experiment where the child used a computer program to build HCB did not allow the child this possibility. There was no way to tell the computer to repeat a sequence. It appears that given the opportunity to use the notion of "repeat" in a representation, the child does. Bamberger (1991) provides the representation in (15) for the present state of HCB in the experiment. The similarity between Bamberger's informal representation in (15a) and a representation of this behavior in the representations proposed by Raimy (2000*a*) is striking.

(15) a.


b. # → E → D → C → %

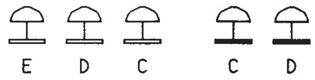
Bamberger (1991: 135, figure 7-6)

The behavior of the child after these first two measures are constructed indicates that more than surface similarity between two entities is required for them to be equated as the same in a representation. Consider (15): this representation contains all of the bells that are required to play HCB. From (15) we only need to add the four repetitions of C, the four repetitions of D, and then return to the beginning. All of these notes are contained in (15). Interestingly, the child does not recognize that the final C note in measure two of HCB is the same note as the one that begins measure three. The child discussed by Bamberger actually explicitly says that the final C note in measure two is not the same note that begins measure three when asked about it.

At this point in the child's construction of HCB, the child is searching for the first note of measure three by playing through the first two measures and then striking a single bell four times to see if it "fits" the melody. This indicates that rhythmic information plays a role in the determination of "identity" in a representation and explains why the child does not recognize the single note of C in the first and second measure as the same note as the repeated C note in measure three.[6] Eventually, the child finds another C bell and another D bell and creates the sequence of Montessori bells in (16a).

[6] That more than simple surface resemblance is considered when building representations will allow languages to build reduplicative structures into representations in an "intelligent" way that allows Manam to build reduplication into forms that repeat the final syllable (i.e. ragogo is ragoRED) as claimed by Buckley (1998) and Fitzpatrick and Nevins (2004) but to not build a reduplicative structure in a form like *banana* in English. Whether repetition is adopted in a representation is affected by the language-specific information based on criteria such as segmental rules, metrical considerations, morphology, etc.

(16)

a. 

b. $\# \rightarrow E \rightarrow D \rightarrow C \rightarrow \overset{4}{C} \rightarrow \overset{4}{D} \rightarrow \%$

Bamberger (1991: 138, figure 7-9)

The organization of bells in (16a) is sufficient to produce HCB. The child first runs through the EDC group two times and then plays four repetitions of C and D. To complete the tune, the child now immediately goes back to the first set of bells and runs through the EDC sequence with no hesitation. This is important because it indicates that while rhythm may prevent two identical notes from being recognized as identical, temporal distance may not interfere with this type of judgement in a representation. The final representation of the tune constructed by the child within using the representations in Raimy (2000*a*) is in (16b). Note that the numbers above the second C and D note are shorthand for four loops back to the note itself.[7] This representation is completely in line with the Raimy model of reduplication, and consequently the discussion by Bamberger (1991) of children learning melodies with Montessori Bells supports the representational proposals of Raimy (2000*a*). This further supports Lerdahl and Jackendoff's (1983) parallels between music and language.

5.7 Representational profligacy in Correspondence Theory

As discussed in the introduction, Correspondence Theory analyzes reduplication by establishing a Base (B) and a Reduplicant (R) in the output string, along with separate Correspondence relations between B and R and input and output. The whole information structure—input, output, where B is, where R is, Correspondence-IO, Correspondence-BR—constitutes the phonological structure produced by Gen and submitted to Eval. For convenience, let us call this the GenOUTPUT. There is no requirement that a given surface form has a unique GenOUTPUT and in fact it may be the case that there is never a unique GenOUTPUT for any reduplicative structure. To illustrate this point, we will consider GenOUTPUT structures for the previously discussed Temiar form in (4) that have either been proposed in the literature or must be considered by Gen based on other existing OT analyses of reduplication.

[7] Some indication of "rest" should probably be added to (16b).

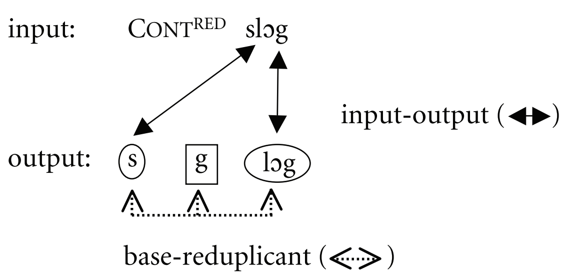
We can begin by considering the analysis of Temiar offered by Gafos (1998). Although Gafos does not explicitly discuss what the base is or how it is calculated, we can determine what his assumptions are by looking at the tableau in (17) (Gafos 1998: 520).

(17)

	CONT^{RED}, slɔg	*PREFINAL-V	MARKEDNESS	MAX-BR
	a. sɔ.lɔg	*!	*****	***
	b. s.**1g**.lɔg		******!	**
☞	c. s.**g**.lɔg		*****	***

The important aspect of the tableau in (17) is how the violations of MAX-BR are calculated. Since the winning candidate (17c) only reduplicates a single consonant (/g/ in bold) and there are three violations of MAX-BR we can conclude that Gafos considers the stem in the input to be coextensive with the base in the output. This produces the GENOUTPUT structure in (18) as the winning candidate.

(18)



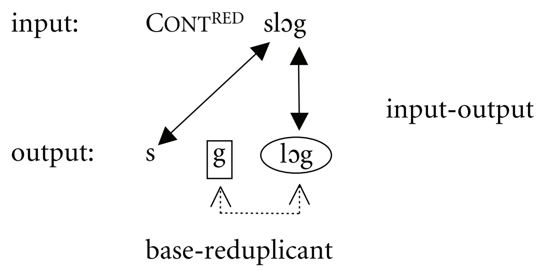
The GENOUTPUT structure in (18) presents the relevant correspondence relationships that are used to calculate input-output Faithfulness and base-reduplicant Faithfulness. The input level indicates that a stem /slɔg/ and an abstract reduplicative morpheme associated with Continuative Aspect are present. The output level contains the phonological string /sglɔg/. The base structure is indicated by enclosing all segments considered to be the base in ovals. There are two regions of base in (18), /s/ at the beginning of the output and /lɔg/ which is at the end. Splitting the base is the /g/ which is the reduplicant. The reduplicant in (18) is marked by being enclosed in a rectangle. The correspondence relations of input-output and base-reduplicant are indicated by the arrowed lines. The solid lines with solid arrow heads indicate input-output correspondence and the dotted lines with simple arrow heads indicate base-reduplicant correspondence. Input-reduplicant faithfulness is suppressed in this example because it is not relevant to Gafos's analysis.

The GenOutput structure in (18) is not the only possible one for the particular Temiar example. In fact, the analysis proposed by Gafos (1998) violates claims made by Urbanczyk (1996, 2001, 2006) about what possible relationships between base and reduplicant can occur in Gen. Urbanczyk (1996: 272, 2001) proposes the *adjacent string hypothesis* which states that the "B[ase] is the string adjacent to R[eduplicant] such that it begins at the tropic edge." The *tropic edge* is defined as "...immediately follow[ing] R if R = prefix or immediately preced[ing] R if R = suffix" (1996: 272, 2001). Following from these points, Urbanczyk (1996: 273, 2001) states that:

> An implicit feature of A[djacent] S[tring] H[ypothesis] is that there is a direct relationship between the placement of RED and the segments which constitute the base. So, as Gen may freely place the reduplicant anywhere in the word, the tropic edge, and hence the base will be determined accordingly.

Urbanczyk's restrictions on how the base is calculated by Gen rules out the GenOutput structure in (18) because the base cannot be on both sides of the reduplicant. Accordingly, a different GenOutput, based on (18), that follows Urbanczyk's restrictions on the base is presented in (19).

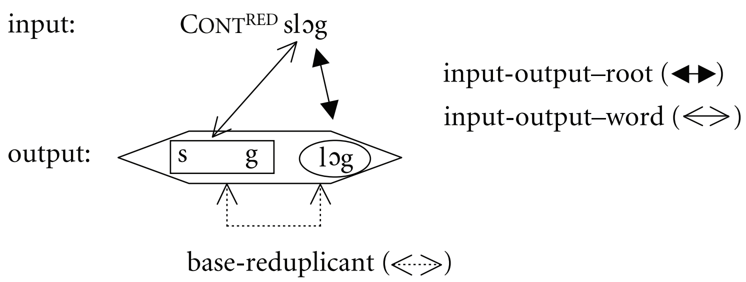
(19)



The difference in GenOutput structures between (18) and (19) is that in (19) the /s/ in the output is not part of the base. We must also assume that reduplication in Temiar must be prefixation in order for the base to be to the right of the reduplicated /g/. This ensures that there is a Faithfulness relationship between the reduplicant and base which can determine the correct segmental content of the reduplicant.

A yet different GenOutput structure is consistent with Urbanczyk's restrictions on the calculation of the base if proposals in Struijke (2000, 2002) are considered. Struijke (2000, 2002) modifies McCarthy and Prince's (1995*a*) extended model of reduplication by replacing the notion of input-reduplicant faithfulness with *word faithfulness*. Word faithfulness calculates input-output Faithfulness on the entire output string of segments regardless of base-reduplicant association. Given this modification, the /s/ in the GenOUTPUT structure in (19) can be associated with the reduplicant producing a new GenOUTPUT structure in (20). The additional input-output–word Faithfulness calculation is included in (20) by the additional hexagon which indicates the domain of Word Faithfulness. The input-output–word correspondence is indicated by the plain double-arrowed line.

(20)



The novel aspect of the GenOUTPUT structure in (20) is that although /s/ is part of the reduplicant, it is faithful to the input structure (and not the base in the output) through word faithfulness. All input-output-based MAX constraints are thus satisfied since all segmental content in the input appears in the output as the model of Struijke (2000, 2002) outlines. Two possible advantages of this approach are that (1) the output is completely parsed into either a base region or a reduplicant region and (2) the reduplicant region for a triconsonantal form like /slɔg/ is now coextensive with the reduplicated region in a biconsonantal form /kɔ̄w/ >> /kwkɔ̄w/.

The theories of the base considered so far all assume that there is a universal static generalization as to what the base is for a reduplicant in a GenOUTPUT structure. However, Kitto and de Lacy (1999) propose a model of epenthesis which claims that there is a correspondence relation between an epenthetic segment and a segment present in the input. The segment that corresponds with the epenthetic segment is thus the base in this correspondence relationship. Most relevant to the present discussion is the claim that the base for epenthetic consonants is not determined by a static function but instead is determined *dynamically* via constraint interaction. Directional effects in epenthesis patterns where an epenthetic segment derives some or all of its features from segment in the input are produced through constraints that indicate whether the base for epenthesis may occur to the left or the right of the epenthetic segment in the output. Since direction of epenthetic copying is now determined by constraint interaction, patterns where epenthesis copies from the right in some circumstances but the left in others can be described. Consider the Faroese example discussed in Kitto and de Lacy (1999) presented below in (21). (21a) presents the generalization of the pattern and (21b, c) show tableaux that indicate how the appropriate constraints interact to encode the generalization in (21a).

(21) a. (1) Copy from the left if [i] or [u] precedes:
e.g. [si:$\underline{j}$ur] 'custom', [hyu$\underline{w}$ir] 'skins'
otherwise
(2) Copy from the right if [i] or [u] follows:
e.g. [so:$\underline{j}$in] 'boiled', [mæa$\underline{w}$ur] 'man'
otherwise
(3) Do not epenthesize

b.

	/o_i/	BE-IDENT-F	COPY-LEFT	COPY-RIGHT
	$o_1\underline{w}_1i$	*!		*
☞	$o\underline{j}_1i_1$		*	

c.

	/i_u/	BE-IDENT-F	COPY-LEFT	COPY-RIGHT
☞	$i_1\underline{j}_1u$			*
	$i\underline{w}_1u_1$		*!	

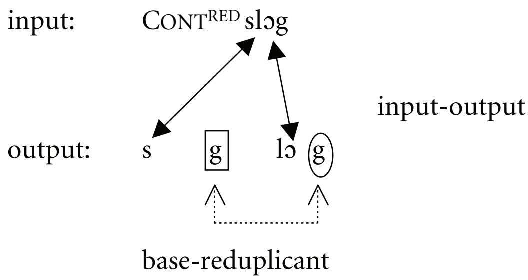
The BE-IDENT-F constraint in (21b) enforces featural similarity (specifically [high] for this case) between the epenthetic segment and its base. This is seen in the first candidate in (21b) where the epenthetic segment /w/ has been inserted but there is no feature [high] in the base (/o/ in this case). Since the candidate that copies from the right violates the IDENT constraint, the secondary pattern of copying from the left may emerge. The tableau in (21c) shows that copying from the right takes precedence when the IDENT constraint is satisfied by both candidates.

While Kitto and de Lacy (1999) only explicitly discuss base-epenthetic relations, they are clear on the wider ramifications of their proposal which affect possible GENOUTPUT structures. In their conclusion they state:

> … the Base cannot be identified by a "static" mechanism, but is instead "dynamic"—the location of the Base can change in different environments. In effect, the identification of the Base reduces to constraint interaction. This opens up the possibility that the Base of reduplication is similarly determined. (Kitto and de Lacy 1999: 22)

Following this proposal leads to yet another possible GENOUTPUT structure that must be considered for the Temiar reduplication pattern. This structure is presented in (22).

(22)



(22) presents a GENOUTPUT structure where the base for the reduplicant is the single segment /g/. This base-reduplicant parsing minimizes the violation of MAX-BR so this parsing is presumably optimal under some high ranking of that constraint. Determining which base-reduplicant mapping is desired for particular reduplication patterns in specific languages requires the addition of input-base constraints that evaluate particular base-input mappings. Presumably this set of constraints would interact to determine whether the base should be to the left or the right of the reduplicant and what size the base should be (minimize base, maximize the similarity between base and input, base should be a minimal prosodic word, etc.). This dynamic approach to determining what the base is in reduplication increases the number of candidates produced by Gen that must be evaluated. The unlikely but possible reduplicant-base mappings where /g/ is the reduplicant (as above in 22) but the base is /s/ or /l/ or /ɔg/, etc. or any other number of regions of the base must now be added to the candidates produced by Gen.

Excursus: The value of dynamic bases

While the dynamic theory of the base for reduplication appears to only complicate the analysis of reduplication patterns, the strict static interpretation of the base in reduplication as espoused by Urbanczyk (2001, 2006) runs into empirical problems when certain cases of reduplication are considered. (23) presents a case of reduplication from Indonesian discussed by McCarthy and Prince (1995*a*) with data from Uhrbach (1987).

(23)	pukul	pukul-məm-ukul	'to hit (reciprocal)'
	tari	tari-mən-ari	'to dance (reciprocal)'
	hormat	hormat-məŋ-hormat-i	'to respect (reciprocal)'

The importance and relevance of this pattern of 'interposing' reduplication is that the base and reduplicant are separated by the prefix /məŋ/. The separation of the base and reduplicant violates the *adjacent string hypothesis* as proposed by Urbanczyk (2001, 2006). Importantly, reduplication in Indonesian appears to be a case of total reduplication of the root[8] and this fact indicates that Gen must be able to somehow restrict copying to the input root in this pattern. This effect follows naturally if we assume that the base is calculated in the output via constraint interaction. The relevant question is what constraints determine the base. By considering other constraints already present in the literature on OT, we find extremely likely and useful candidates for relevant constraints. For the Indonesian example in (23), the relevant constraint is Base = Root[9] which will exclude affixes from participating in base-reduplicant correspondence if ranked high enough. Consider the tableau in (24) which provides an analysis of the interposed reduplication pattern in Indonesian.

(24)

	RED + məŋ + hormat + i	Faith-BR	Base = Root	Base = Stem	Alignment	ASH
☞	a. **hormat**-məŋ-hormat-i			****		*
	b. **hormat**-məŋ-hormat-i	*!**	***	*		
	c. məŋ-**hormat**-hormat-i			****	*!	
	d. **məŋ-hormat**-məŋ-hormat-i		*!**	*	*	

[8] We will ignore the interaction of nasal substitution and reduplication which complicates the first two examples in (23). See Raimy (2000*a*) for the analysis of the nasal substitution facts and the general interposing pattern of reduplication in Indonesian.

[9] The form of this constraint is based on Kager's (1999: 220) use of RED = STEM as part of the analysis of Diyari.

The function of each cover constraint in (24) is fairly intuitive. FAITH-BR covers both MAX-BR and DEP-BR and other possible deviance from perfect copying. BASE = ROOT is one of the "base-specific" constraints that interacts to determine what the base should be in an output string and indicates that the base in the output should consist solely of the root. For this pattern of reduplication, BASE = ROOT is undominated with respect to other "base-specific" constraints. BASE = STEM is another "base-specific" constraint that indicates that the base should be the root plus any and all affixes associated with the root. Crucially, BASE = ROOT dominates BASE = STEM. ALIGNMENT is a cover constraint for the multiple constraints that determine the linear order between the root, affixes, and RED. Since /məŋ/ is a prefix, part of ALIGNMENT is a constraint that requires this affix to be to the left of the root. Since RED in this pattern is also a prefix, we must assume that the ALIGNMENT constraint that requires RED to be a prefix is ranked above /məŋ/ being a prefix which would give the RED + Affix + Root ordering in the output. Finally, ASH is a constraint that requires RED and base in the output to be in contact (this is similar to Raimy and Idsardi's (1997) *Gap constraint). Urbanczyk's definition of ASH can be adopted if it is treated as a violable constraint with violations occurring when either base and reduplicant are not contiguous or if the direction of copying violates Marantz's generalization (Marantz 1982).

Candidate (24a) is the most harmonic given the particular constraint ranking since there is complete identity between the base (underlined) and the reduplicant (in bold), the base coincides with the root, and the specified linear ordering of the affixes in the output is respected. Candidate (24b) is not as harmonic since the base calculated in the output contains more material than just the root. The affix /məŋ/ has been parsed as part of the base and this creates violations of FAITH-BR and BASE = ROOT which causes this candidate to be less harmonic. The lesser violation of the lower-ranked constraints, ROOT = STEM and ASH, does not save this candidate. Candidate (24c) correctly parses the base as only the root but places /məŋ/ outside of the reduplicant in the output which violates the relevant ALIGNMENT constraints causing it to be less harmonic. (24d) shows that adding material to the base in the output beyond the root and consequent additional material in the reduplicant does not produce a more harmonic candidate. The high-ranked BASE = ROOT eliminates any candidates that do have the base and stem coextensive.

From this discussion, we can see that adopting Kitto and de Lacy's proposal that the base is determined dynamically in reduplication provides some immediate benefits. The contradiction between the analysis of Indonesian offered by

McCarthy and Prince (1995*a*) is reconciled with Urbanczyk's (1996) proposed restrictions on the calculation of the base if we adopt the standard mode of explanation within OT that generalizations result from the interaction of violable constraints. By transforming the *adjacent string hypothesis* (ASH) into a violable constraint, the Indonesian interposing reduplication pattern is no longer a counterexample to ASH but is instead a case where some higher-ranked constraint causes a violation of ASH–the standard state of affairs within OT.

The dynamic view of the base also allows prosodic circumscription effects in reduplication patterns to be directly accounted for. Consider the pattern of reduplication in Samoan (Kenstowicz 1994*b*).

(25) táa ta-taa 'strike'
nófo no-nofo 'sit'
alófa a-lo-lofa 'love'
saváli sa-va-vali 'walk'

The generalization offered by Kenstowicz (1994*b*: 635) of this reduplication pattern is that a light syllable is prefixed to the trochaic foot independently required for penultimate stress assignment. This reduplication pattern is succinctly captured in the dynamic base theory by simply specifying the base as "the main stressed syllable." Complementing this generalization with a high ranking of the ASH constraint creates the tableau in (26) which formalizes this analysis.

(26)

	RED + savali	Base = σ'	Faith-BR	ASH	Stress
☞	a. sa-**va**-<u>vá</u>li				
	b. **sa**-<u>sá</u>-vali				*!
	c. **sa**-sa<u>vá</u>li			*!	
	d. **sa**-sa<u>vá</u>li		*!*		
	e. **sa**-<u>sa</u>váli	*!			

The tableau in (26) shows how the interaction of the constraints that capture the stress pattern of Samoan (the cover constraint Stress), the constraint that specifies what the base is (Base = σ' "base equals syllable with main stress"), Faith-BR and ASH all cooperate to produce the correct surface pattern of reduplication. Candidate (26a) satisfies all of these constraints in that there is penultimate stress, the base is this stressed syllable, base and reduplicant are directly next to each other satisfying ASH and the entire stressed syllable is copied. All other candidates in (26) deviate from satisfaction of one of these constraints either misplacing the stress (26b), violating ASH (26c), copying the wrong string of segments (26d), or finally choosing the wrong base (26e). This analysis has the advantage of utilizing the surface-apparent stress pattern as the main determinant of what the reduplicant should be through the specification of what the base is. No type of prosodic circumscription or "misalignment" of the reduplicant is necessary. All the learner has to do is identify what the base is. This task is aided in Samoan by the fact that the base is the syllable with main stress, presumably a highly salient target.

A final advantage of the dynamic theory of the base is that it provides a principled explanation for the lack of Hamilton-Kager Conundrum (McCarthy and Prince 1999) effects in reduplication. The Hamilton-Kager Conundrum is the moniker for the observation that although segmental backcopying effects are found in reduplication, there are no attested cases of the backcopying of a reduplicative template resulting in the truncation of a base. The tableau in (27) presents this hypothetical situation.

(27)

	/RED + tilparku/	RED = MinWd	Max-BR	Max_{IO}
☞	a. tilpa-tilpa			***
	b. tilpa-tilparku		*!**	
	c. tilparku-tilparku	*!		

As McCarthy and Prince (1999: 30) discuss, by ranking a templatic constraint and Max-BR above MaxIO a candidate that deletes parts of the base in order to satisfy Max-BR and the templatic requirements placed on the reduplicant is the most harmonic. Candidate (27a) presents this effect and the other candidates (27b, c) that violate either Max-BR or the templatic constraint (RED = MinWd) are less harmonic.

There have been two types of responses to the Hamilton-Kager Conundrum. The first as outlined in McCarthy and Prince (1994) is to deny or remove reduplicative 'templates' from OT. This proposal is known as *generalized template theory* (GTT). The idea behind GTT is that if there are no constraints that state templatic requirements on reduplicants (such as RED = MinWd) then there is no way to create a constraint ranking like that in

(27) which will produce templatic backcopying. There are two main problems with this solution. The first is that it is not clear that all reduplicative templates can be produced through the interaction of other constraints as suggested by McCarthy and Prince. Kager (1999: 227) uses the constraint RED = σ and in a footnote states, "We leave open the consequences of adopting this constraint for Generalized Template theory." Kager's analysis highlights the uncertainty of the empirical adequacy of this aspect of GTT. Specific reduplication patterns that must be addressed are heavy syllables and VC(C) patterns because it is unclear how these prosodic shapes emerge from the interaction of prosodic well-formedness constraints. See Raimy (2000*a*) for further discussion of this issue.

The second problem with the GTT approach is that the generalizations about reduplication patterns that were encoded in templates disappear with the elimination of templates. One of the goals of generative phonology is to identify what are the relevant generalizations a learner has to make when acquiring a language. GTT denies that a speaker of a language makes any distinct generalization about a given reduplication pattern. Instead, constraints interact to produce the correct surface patterns of reduplication but this leads to a fractured generalization spread across numerous rankings between individual constraints. It is unclear whether this type of effect should be considered a generalization and it is even less clear that this type of generalization is an improvement over a template or adds to our knowledge about human language.

The other response to the Hamilton-Kager Conundrum is presented by Spaelti (1997). Spaelti argues that all 'reduplication specific' effects result from the *emergence of the unmarked* (McCarthy and Prince 1994) ranking seen in (28).

(28) Faith-IO >> Markedness >> Faith-BR

This approach removes the Hamilton-Kager Conundrum not by eliminating specific constraints from Con but by limiting the possible constraint rankings. While the meta-ranking Faith-IO >> Faith-BR mimics the other stipulated meta-ranking Faith-Root >> Faith-Affix and thus appears to indicate that there is some generalization to be made about the structure of Con, the emergence of the unmarked solution to the Hamilton-Kager Conundrum also faces empirical problems. Specifically, Faith-BR must be ranked higher than Faith-IO in order to account for segmental backcopying effects. Consider the tableau in (29) which presents McCarthy and Prince's analysis of nasal spread in Malay (as presented by Kager 1999: 236).

(29)

	RED + waŋɪ	IDENT-BR (nasal)	*NV$_{ORAL}$	*V$_{NASAL}$	IDENT-IO (nasal)
☞	a. w̃ãŋ̃ĩ-w̃ãŋ̃ĩ			******	**
	b. waŋ̃ĩ-waŋ̃ĩ		*!*	**	
	c. waŋ̃ĩ-w̃ãŋ̃ĩ	*!*		****	**

The tableau in (29) shows that is it essential that IDENT-BR(nasal) is ranked higher than IDENT-IO(nasal) otherwise the backcopying of nasality in Malay can not be captured. Consequently we see that Spaelti's (1997) meta-ranking of FAITH-IO >> FAITH-BR is too restrictive and not empirically supported. One possible solution is to split FAITH-BR into MAX/DEP and IDENT families and only allow IDENT-BR to be ranked above FAITH-IO. This move is entirely stipulatory though and provides no explanation of the lack of Hamilton-Kager Conundrum effects.

More promisingly, the dynamic theory of the base allows a different solution to the Hamilton-Kager Conundrum. If we reconsider the tableau in (27), we can see that one of the crucial assumptions involved here is that the base is coextensive with the stem/root. Consider the tableau in (30) which abandons this strict assumption and allows the base to be determined through constraint interaction.

(30)

	/RED + tilparku/	RED = MinWd	MAX-BR	MAX$_{IO}$	BASE = STEM
	a. **tilpa**-tilpa			*!**	
	b. **tilpa**-tilparku		*!**		
	c. **tilparku**-tilparku	*!			
☞	d. **tilpa**-tilparku				***

With the dynamic base constraint BASE = STEM ranked below MAX-IO, backcopying truncation no longer necessarily occurs when a reduplicative template and MAX-BR are ranked above MAX-IO. Whether the Hamilton-Kager Conundrum occurs or not is now a function of the ranking between FAITH-IO and whatever constraints determine the base. This is a welcomed result since backcopying of segmental processes can now be understood as emanating from the free ranking of Faith-BR, Faith-IO, and relevant markedness constraints. Templatic backcopying can be ruled out via a meta-ranking of Faith-IO >> Base Constraints without affecting present analyses of segmental backcopying effects. While this solution to the Hamilton-Kager Conundrum still requires a stipulated meta-ranking, it does provide a principled answer as to why segmental processes and prosodic templates behave differently. The form of this explanation is that segmental backcopying only involves the interaction of markedness, Faith-IO, and Faith-BR, and backcopying is just one of the typological possibilities allowed by the free re-ranking of constraints. Templatic backcopying is not a typological possibility because of meta-ranking that restricts the family of Base Constraints to be ranked below Faith-IO. The overall effect of this ranking is that when there is a conflict between high-ranking Faith-BR and Faith-IO, the response will be the modification of the base region in the output with no impact on the actual Faith-IO mapping.

It can now be seen that the dynamic theory of the base in reduplication is the only empirically adequate and coherent hypothesis. The coherency of this hypothesis results from it utilizing the main mechanism of expressing generalizations available to OT, namely, constraint interaction. The empirical adequacy of this hypothesis resides in being able to capture reduplication patterns where the base and reduplicant are separated by segmental material that is not part of either in violation of the *adjacent string hypothesis* (ASH). We are not worried that ASH can be violated since one of the main tenets of OT is that all constraints can be violated. Cases where ASH must not be violated (as in Urbanczyk's work on Lushootseed) are accounted for by ranking ASH sufficiently high in the constraint hierarchy and cases where ASH is violated (as in Indonesian interposed reduplication) are handled with a lower ranking of ASH. Additional support for the dynamic base hypothesis is found in its novel solution to the Hamilton Kager Conundrum. By distinguishing between the interplay of the calculation of a base and prosodic requirements placed on the reduplication and the role Ident plays along segmental dimensions we can begin to see why prosodic templates never backcopy. All of these points indicate that within the OT research program the idea of a dynamic base in reduplication should be pursued further.

* * * * * * * * * * * * * * * * * * * **

Having now determined that the dynamic base hypothesis appears to be the most adequate way of understanding aspects of the Genoutput structure produced in reduplicated structures, we can return to the main issue of this section. This issue is acquisition and how the structure of Gen affects it. For reasons of clarity and space, only Genoutputs that coincide with the targeted output form for the Temiar example will be considered in this discussion. Each of the different approaches to calculating the base and reduplicant allow for a plethora of less harmonic Genoutputs to be possible candidates. Space precludes us from presenting all of these failed candidates but a learner does not have the luxury of limiting their hypothesis space like this. The fact remains that all of these alternatives must be considered by the child who is learning Temiar. This is the main problem with the Correspondence Theory of reduplication. We see above that when the positions on reduplicative structures are culled from the present literature and one that is theoretically coherent and empirically adequate is settled on, there are vast possibilities of Genoutputs that must be considered when a child is acquiring a language. To compound this problem it is not clear which of the Genoutput structures discussed in this section for Temiar is the most harmonic. Each one can be the most harmonic based on some ranking of constraints which leads to the question of which grammar the child should arrive at. If our theory does not provide a way of determining what grammar we think a child should be striving for, then we will never be able to explain how language is acquired.

The Raimy model of reduplication does not suffer from this analytic indeterminacy. The representation the child should acquire for the Temiar form in (4) is the representation in (5) repeated below as (31).

(31) $\# \rightarrow \mathrm{s} \rightarrow \mathrm{l} \rightarrow \text{ɔ} \rightarrow \mathrm{g} \rightarrow \%$

The representation in (31) is the simplest representation possible within the Raimy model of reduplication that will produce the correct surface form. Any further addition of precedence links to (31) only complicates the representation further without producing any benefit in computation or empirical adequacy. The fact that there is a single representation that can be easily identified through the metric of analytic simplicity indicates that the Raimy model provides a more constrained hypothesis space to the learner. There is no analog to the question of what the correct Genoutput structure is for Temiar for the Raimy model. This produces a strong argument in favor of the Raimy model of reduplication over the Correspondence Model. Since the Raimy model provides a more constrained hypothesis space to a learner for what the representation of a reduplicated form should be, this model of reduplication should be preferred over the Correspondence Model of reduplication. To further support this conclusion, it must be recognized that the hypothesis space for the child acquiring an OT grammar is actually much worse than presented in this section if full and free constraint re-ranking is possible and if Eval considers every possible candidate produced by Gen.

5.8 Computational profligacy in correspondence theory

The above discussion of GenOutput structures shows the analytic indeterminacy present in CT with respect to analyzing reduplication. This indeterminacy directly results from the massive expressive power of the system based on the freely generated non-morphological and non-prosodic output structure of Red. This amount of expressive power also has implications for language typology. As mentioned in Section 5.2, the Raimy model has a natural markedness metric based on formal complexity but CT does not. The lack of this markedness metric in CT prevents useful typologies from being constructed with presently accepted constraints. Consider the data in (32) which shows perfective reduplication of full grade stems in Sanskrit (data is taken from Kager (1999) who cites Steriade (1988) and Whitney (1889)).

(32)	pa-prat^{h}-a	'spread'
	ma-mna:-u	'note'
	sa-swar	'sound'
	da-d^{h}wans-a	'scatter'

Kager (1999: 214–15) discusses the relevance of this reduplication pattern as an instance of the emergence of the unmarked. Specifically, Kager presents the constraint ranking in (33) to account for this pattern.

(33)	Faithfulness	>> Well-Formedness	>> Reduplicative Identity
	Max-IO	>> *Complex	>> Max-BR, Contiguity-BR

The ranking in (33) appears to be innocuous and is required in order to account for the Sanskrit data in (32) but does not tell the whole story of this reduplication pattern. One aspect omitted from Kager's analysis of this pattern is how the reduplicant is limited in shape to a single syllable. This omission does not alter Kager's main point of discussing this reduplication pattern that contiguity can be violated in base-reduplicant mappings but it does leave open what ramifications this fact has for typological claims made by OT. What shape restriction is put on the reduplicant is crucially important in fully accounting for reduplication in Sanskrit. Consider the tableau in (34). Since there are no "shape" or "restrictor" constraints ranked above Max-BR in this tableau, total reduplication will result. Note that we will assume that "the base is the stem" for expository reasons and this facet of the analysis can be changed if need be.

(34)

	RED + prat^h-a	Max-IO	*Complex	Max-BR	Cont-BR
	a. pa-prat^{h}a		*	**!*	*
	b. pra-prat^h-a		**!	**	
	c. pat^h-prat^h-a		*	**!	*
☞	d. pat^{h}a-prat^{h}a		*	*	*

The most harmonic candidate in (34) is (34d) which copies the entire base except for /r/ which would create a complex onset in the reduplicant.[10] All other candidates either copy too little of the base (34a, c) or copy the complex onset (34b). Kager's sketch of Sanskrit can be saved by simply ranking Red = σ "Align both edges of the reduplicant with the edges of a syllable" (Kager 1999: 227) and NoCoda above Max-BR. This produces the tableau and results in (35).

(35)

	RED + prat^h-a	Max-IO	*Complex	Red = σ	NoCoda	Max-BR	Cont-BR
☞	a. pa-prat^{h}a		*			***	*
	b. pra-prat^h-a		**!			**	
	c. pat^h-prat^h-a		*		*!	**	*
	d. pat^{h}a-prat^{h}a		*	*!		*	*

[10] We assume that Dep-IO and/or Dep-BR is ranked above *Complex to prevent a candidate such as **pirat^{h}a-prat^{h}a* from emerging as optimal.

(35) shows the necessity of ranking some sort of "shape" constraints above MAX-BR in order to derive the occurring surface forms in Sanskrit perfective reduplication. From this point we can now ask a typological question. Specifically, what are the typological predictions given the constraints used in (35) under different rankings? More to the point, consider the particular ranking presented in tableau (36) for a hypothetical input *prabtru*. What does this tableau tell us?

(36)

	RED + prabtru	MAX-IO	*COMPLEX	MAX-BR	CONT-BR	RED = σ	NOCODA
	a. pa-prabtru		**	***!**	*		*
	b. pra-prabtru		***!	****			*
	c. pab-prabtru		**	***!*	*		**
☞	d. pabtu-prabtru		**	**	**	*	**
	e. prabtru-prabtru		***!*			*	**

Candidate (36d) is the most harmonic candidate given the ranking in (36). This particular candidate copies all segments except for ones that would lead to violations of *COMPLEX. Other candidates fare less well since they either copy less of the base (36a, c) or have gratuitous violations of *COMPLEX (36b, e).

The results found in (36) appear to be the standard state of affairs within OT until we recognize the fact that the constraint ranking in (36) characterizes a non-attested pattern of reduplication. The ranking in (36) produces a reduplication pattern that will simplify every complex onset in a reduplicant regardless of how many there are. There is no attested reduplication pattern where total reduplication occurs except for the deletion of segments in complex onsets and this is the pattern that the constraint ranking in (36) characterizes. The important aspect to see here is that there is no apparent way to distinguish the constraint ranking in (35) which produces an attested natural human language and the constraint ranking in (36) which produces a pattern that is not found in natural human language.

The free re-ranking of constraints to produce typologies is not a beneficial feature of OT grammars. In fact, results like those found in (36) indicate that the typologies created by the free re-ranking of constraints are a liability to OT since it is as easy to produce unattested patterns as it is to produce attested patterns. Not being able to distinguish between occurring and non-occurring patterns suggests that the CT model of reduplication is too powerful to produce a constrained hypothesis space that could guide acquisition.

The results in (36) are not unique within Correspondence Theory since Stemberger (1996)[11] points out that analogous non-occurring reduplication patterns can be produced by ranking NoCoda above Max-BR and Contiguity-BR. Consider the tableau in (37) which shows this result for the hypothetical input *pabtup*.

(37)

RED + pabtup	Max-IO	NoCoda	Max-BR	Cont-BR
a. pa-pabtup		**	***!*	
b. pab-pabtup		***!	***	
c. pabtu-pabtup		***!	*	
d. pabtup-pabtup		***!*		
☞ e. patu-pabtup		**	**	

The common theme that emerges when we consider tableaux (36–7) is that there is no necessary connection between total reduplication and maintaining reduplicant internal contiguity in the OT approach to reduplication. In contrast to this, natural human language appears to connect total reduplication with respecting the contiguity of the base. The Raimy model of reduplication has this characteristic. To see how this result obtains, we will begin by seeing how the Sanskrit reduplication pattern in (32) is accounted for in the Raimy model. Consider the representation in (38).

(38) # → p → r → a → t^h → a → % >>> pa-prat^{h}a

[11] Stemberger (1996) contains analogous arguments based on the *Complex Onset facts which inspired the discussion of the Sanskrit facts in this chapter.

(38) presents the precedence graph that is required to account for the Sanskrit 'core syllable' reduplication pattern presented in (32). The important thing to recognize about the graph in (38) is that two distinct links, [p → a] and [a → p], must be added to produce this reduplication pattern. The link [a → p] creates the loop that causes repetition of segmental material. If only this link is added, simple light syllable reduplication (*prat*^{h}*a* >> *pra-prat*^{h}*a*) is produced. The additional link from [p → a] causes the surface appearance of the reduplicant violating the contiguity of the base. This jump link must be independently specified as distinct from the reduplicative back link. The markedness of this type of reduplication pattern is immediately captured within the Raimy model since two distinct precedence links must be added. Less marked reduplication patterns (ones where the contiguity of the base and reduplicant do not diverge) only require a single precedence link to be added. This is a desired attribute since the metric of analytic simplicity allows marked and unmarked reduplication patterns to be easily distinguished within the Raimy model.

With this result in hand, we can now investigate how contiguity in the base and reduplicant is preserved within the Raimy model. Consider the representations in (39).

(39)

a. # → p → r → a → b → t → r → a → % >>> prabtra-prabtra

b. # → p → r → a → b → t → r → a → % >>> prabtra-prabtra

c. # → p → r → a → b → t → r → a → % >>> prabtra-prabtra

(39a) shows a precedence graph that will result in total reduplication. There is no possible way for the reduplicant to diverge from the base with respect to contiguity since there is only a single precedence path through the base in this representation. (39b) presents a graph where an additional link has been added which creates an alternative precedence path through the base. Since there are now two distinct paths through the base, the base and reduplicant can diverge along the dimension of contiguity. As pointed out in Raimy (2000*a*) the additional link from [p → a] will be followed first given the nature of the linearization process, thus the surface form of (39b) indicates a prefixing pattern of reduplication.

(39c) presents a precedence graph that coincides with a reduplicant that strips out every complex onset that occurs in a base. This representation is equivalent to the output form produced by the constraint ranking in (36). Immediately, we can see that a difference between (39b) and (39c) is that (39c) has added another jump link in order to omit this complex onset from the reduplicant in the linearized form. We can generalize this behavior in that an extra jump link needs to be added for each complex onset that needs to be omitted in the output. The dependency between characteristics of the base and the number of links added is one that does not appear to occur in natural human language. This provides an explanation for why contiguity violations do not occur in patterns of total reduplication.

The Raimy model of reduplication derives this behavior of contiguity preservation in total reduplication patterns from the fundamental principles on how reduplicative structures are built. Total reduplication results from the addition of a precedence link from the end of a form to the beginning of the form. This additional link does not alter the precedence path through the base in any way. In order to produce the effect of omitting all complex onsets (or codas) in the reduplicant a variable number of additional links must be added to the precedence graph that is dependent on how many complex onsets there are present in the precedence graph.

The only obvious way of producing the complex onset-stripping behavior in the reduplicant is to make the rule that adds the needed jump link iterative.[12] This is an entirely *ad hoc* move with no motivation behind it. There is no reason why the type of morphological rule involved in adding a jump link should be iterative. Proposals on iterative rules (Myers 1991; Halle and Vergnaud 1987) limit iteration to phonological rules that define either inventories or well-formedness aspects of representations. Morphological rules that add precedence links do not fall under either of these categories. Since there is no way to motivate the iteration of the jump link rule, there is no way (other than a brute force stipulation) for the Raimy model to produce a pattern of total reduplication with word-internal contiguity violations. This is another welcomed result since this limit in the productive power of the Raimy model coincides with what we know about the existing patterns of reduplication in the world's languages.[13]

[12] Interestingly, ludlings may differ precisely on this point (Bagemihl 1995).

[13] Given this restriction on what an iterative rule in the phonology is, we can hypothesize that iterative morphological rules are ludlings.

A final argument which indicates that the CT model of reduplication dramatically overgenerates possible reduplication patterns is based on string reversal. Pinker and Prince (1988) discuss the relevance of string reversal in evaluating representational models because:

> [the] most challenging requirement we can place on a representational system is that it should exclude the impossible. Many kinds of formally simple relations are absent from natural language, presumably because they can not be mentally represented . . . A quintessential unlinguistic map is relating a string to its mirror image reversal (this would relate *pit* to *tip*, *brag* to *garb*, *dumb* to *mud*, and so on); although neither physiologically nor physics forbids it, no language uses such a pattern.
>
> (Pinker and Prince 1988: 99–100)

Stemberger (1996) argues that CT easily produces string-reversal reduplication patterns. Consider the tableau in (40) (taken from Stemberger 1996: 148).

(40)

	/akison/	Onset	Contiguity	Linearity	Anchoring
	a. akison	*!			
☞	b. nosika			*...	*...
	c. kasino		*!	*...	*...
	d. nakiso		*!	*...	*...

The constraints in (40) are all well-accepted ones (all proposed in McCarthy and Prince 1995*a*). What Stemberger has noticed is that if Onset and Contiguity are ranked above Linearity and Anchoring with Max and Dep ranked above Onset (this is omitted in the tableau) then vowel-initial inputs will string-reverse. Candidate (40b) is the most harmonic since there are no violations of Onset and Contiguity. If free re-ranking of constraints is the underlying principle or basis of typologies within CT (or Optimality Theory in general) then we must conclude that CT is much too powerful a model of grammar.

The problem that arises within CT is not that string reversal can be produced but that there is no method of distinguishing between a ranking of constraints that produces string reversal and constraint rankings that bar string reversal. An adequate model of grammar should be able to characterize this distinction in some manner. The Raimy model of reduplication has a natural way of making this distinction. First we must note that string reversal is found in some language games in natural language. Bagemihl (1995) offers the example from Tagalog presented in (41).

(41) *Golagat* (Gil 1990)
puti 'white' > itup

Further evidence for the possibility of string reversal in human language is found in the enjoyment of palindromes. The issue here is how to characterize processes that only occur in language games versus processes that occur as part of a grammar of a natural human language. If we consider how string reversal is accomplished in the Raimy model, a natural solution to this dilemma is seen.

(42) a. # → p → u → t → i → %

b. # → p → u → t → i → % >>> itup

c. (i) ADD # → [_%] "make last segment the first segment"

(ii) ADD [#_] → % "make the first segment the last segment"

(iii) ADD A → [B /_→g] *iterate*

"add a link from a following segment to the preceding segment and iterate"

(42b) shows the precedence graph that is required in order to produce the surface effect of string reversal and (42c) presents the algorithm required to produce this precedence graph. There are at least two ways in which the algorithm in (42c) which characterizes string reversal in the Raimy model is crucially distinct from processes found in natural language. The first, which has already been discussed in reference to complex onset simplification in total reduplication patterns, is that to produce string reversal in the Raimy model an iterative process must be invoked as indicated in (42c, iii). The second way string reversal is distinct from natural processes is in the number of precedence links that must be added. In addition to the iterative process of adding links in (42c, iii) two additional distinct precedence links must be added (42c, i/ii). This results is a total of three distinct link adding components to string reversal with one of these processes necessarily being iterative. These characteristics clearly indicate that string reversal is a much more complicated process than reduplication or simple affixation. This is the exact result that we want from a representational system and it highlights further the distinction between CT and the Raimy model of reduplication.

To summarize this section, both CT and the Raimy model of reduplication provide adequate empirical coverage of the known patterns in reduplication. Despite this equivalence, CT and the Raimy model differ in whether the computation of "natural" patterns found in human language is distinguished from the computation of "unnatural" patterns. CT is such a powerful computational system that it is unable to distinguish between natural and unnatural patterns in human language. In other words, CT predicts that unnatural patterns are as likely to occur as natural patterns are in human language. The Raimy model on the other hand easily distinguishes between natural and unnatural patterns based on the complexity of the required computation to produce the required precedence graphs. Simple computations such as the addition of a single link in order to produce reduplication map onto unmarked human language processes. Slightly more complex computations such as the addition of two links to account for the Sanskrit complex onset elimination pattern of partial reduplication are also available in natural human language but they are "marked." Finally, truly complex operations only appear in the realm of language games where the linguistic grammar is utilized beyond its normal limits in a creative manner.

5.9 Summary

Both theories of reduplication discussed here require new representational resources–OT adds Correspondence Theory, Generative Phonology adds non-linear temporal relations proposed by Raimy (2000*a*).[14] Correspondence Theory has been extremely useful in analyses of reduplication primarily because it is so powerful. In fact, it is overly powerful in representational possibilities in that it induces an exponential explosion in the number of candidates which are distinct phonologically but identical phonetically. On the computational side, CT is also overly powerful since the constraints added to Con when freely re-ranked to create language typologies produce non-occurring patterns of language as easily as they produce occurring patterns. In contrast, the Raimy model's introduction of non-linear temporal links to phonological representations adds the minimum amount of power necessary to describe the concept of repetition. Non-linear links have several other advantages, such as deriving markedness relations, capturing modularity considerations, and

[14] One could also pursue the other logical possibilities, OT with non-linear temporal relations or Generative Phonology with correspondence.

making predictions about the behaviour of other potentially similar phenomena (geminate integrity, truncation effects, etc.).

In conclusion, since OT and Generative Phonology now have equivalent (or nearly equivalent) empirical coverage with respect to reduplication, two final points should be made. The first point is that argumentation based on empirical facts from reduplication no longer directly bears on the issue of computational differences between OT and Generative Phonology. McCarthy and Prince (1995*a*) first presented this type of argument by showing that serial models of reduplication are incapable of capturing backcopying phenomena. Raimy (2000*a*, *b*) addresses these arguments and illustrates how the enhanced precedence representations provide a conceptually elegant and empirically adequate analysis of backcopying effects. The second and main point of this chapter is that since the Raimy model of reduplication presents a less powerful change to representations in phonology than Correspondence Theory does, it should be adopted as a more desirable and explanatory theory of representations and reduplication. Because the Raimy model of reduplication is less powerful than CT, it offers a more constrained grammar space which provides a more tractable learnability problem for children. Representations for reduplication in the Raimy model are easier to learn because there is only a single possible representation for a given reduplication pattern, thus allowing a cue/trigger-based learning algorithm that simply notices repetitions in a string of phonemes. The CT model of reduplication not only has to provide a method for the learner to notice reduplication but also has to indicate how the learner chooses between possible representations of a given reduplication pattern. The fact that there is no choice among different representations for specific reduplication patterns in the Raimy model argues strongly that this model is more constrained than CT which provides multiple possible representations for any reduplication pattern. Since the Raimy model is more constrained than CT it provides more explanatory analyses of reduplication and thus should be preferred.