CUMULATIVE FAITHFULNESS EFFECTS IN PHONOLOGY

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Dedicated to my mother, Marjorie,
who shows interest no matter what,

and in memory of my father, Joseph,
whose phonological quirks I wish I could study.

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CUMULATIVE FAITHFULNESS EFFECTS IN PHONOLOGY

One of the hallmarks of optimality theory (OT) is strict domination: multiple low-ranked constraint violations cannot gang up on a higher-ranked constraint. However, such cumulative interactions have been shown to occur. This thesis examines the subset of cumulative interactions called cumulative faithfulness effects (CFEs). CFEs occur when a single unfaithful mapping is allowed in a word, but multiple unfaithful mappings are not. In languages with CFEs, violations of multiple lower-ranked faithfulness constraints gang up on a single higher-ranked constraint to eliminate outputs that are unfaithful in multiple ways, while allowing singly-unfaithful outputs to survive. The key generalization is that for languages in which multiple repair processes could be used to repair a marked element, the least unfaithful repair process is chosen. The fact that these effects are attested in a variety of languages and language domains presents a problem for OT, which cannot account for them. Moreover, CFEs produce transparent outputs and resemble conspiracies, two phonological phenomena for which OT is typically adept at accounting.

The thesis thus has three goals. The first is descriptive: I seek to determine under what circumstances CFEs occur. A typology of CFEs is proposed, illustrating that there are at least three different ways in which faithfulness constraints can behave cumulatively. The second goal is to determine in what phonological domains CFEs occur. It is shown that CFEs are a pervasive phenomenon; examples are provided from fully-developed languages, first-language acquisition, and loanword adaptation. Finally,

the third goal is analytical: what is the best constraint-based analysis for CFEs? Because OT cannot account for them, either some addendum to OT must be proposed, or some other constraint-based theory must be appealed to. Harmonic grammar (HG), a constraint-based theory in which each constraint carries a weight and candidates are evaluated based on the cumulative weight of their violations, is argued to provide the best analysis of CFEs. Multiple low-weight constraints may thus combine to overcome a single higher-weight constraint. Moreover, HG can account not only for those cases in which multiply-unfaithful outputs are disallowed, but also for cases in which multiply-unfaithful outputs occur.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

"The shortest way to do many things is to do only one thing at once."

--Samuel Smiles, *Self-Help*

1.1 Introduction

Optimality theory (OT; Prince and Smolensky, 1993/2004) has been argued to be superior to rule-based theories of phonology for a number of reasons. Two of the hallmarks of OT are its ability to deal with conspiracies and its capacity to produce transparent outputs. OT provides a unified account of conspiracies (Kisseberth, 1970; Kiparsky, 1976), which in rule-based phonology were accounted for with a number of individual rules that all converged on the same output restrictions. Moreover, OT deals with transparent process interactions like feeding and bleeding by means of parallel evaluation; there is no need for rule ordering or intermediate representations. OT clearly has an advantage in dealing with conspiracies and transparent processes.

On the other hand, OT has been criticized for not being able to account for other types of interactions. For instance, OT cannot account for opacity effects like counterfeeding and counterbleeding without recourse to modifications of the theory, some of which are relatively drastic. OT also has difficulty explaining a class of effects known as gang effects. This is because strict domination, one of the key tenets of OT, holds that satisfaction of multiple lower-ranked constraints cannot make up for violation of a high-ranked constraint; that is, a candidate that violates a high-ranked constraint, even if only once, is worse than a candidate that violates multiple lower-ranked constraints. Strict domination eliminates the possibility that multiple low-ranked constraints can gang up on a higher ranked constraint. In recent research, however, it has been shown that gang effects, also called cumulative constraint interactions, do occur in both phonology and syntax (Itô and Mester, 1998; Keller, 2005; Jäger and Rosenbach, 2006; Kager and Shatzman, 2007; Pater, Bhatt and Potts, 2007; Pater, Jesney and Tessier, 2007; Tesar, 2007; Jesney and Tessier, 2008; Coetzee and Pater, to appear). In a gang effect, two otherwise violable constraints conspire to eliminate a candidate that violates them both, preferring instead a candidate that violates a higher-ranked constraint only once.

Consider, for instance, the standard account of German coda devoicing. In German, voiced obstruents are permitted prevocalically, implying that FAITH (shorthand here for a number of faithfulness constraints like IDENT[voice], which requires that input and output correspondents have the same value for the feature voice, and MAX, which militates against segmental deletion) is ranked above the familiar markedness constraint *VOIOBS, which prohibits voiced obstruents. Coda consonants also occur, indicating that FAITH is also ranked above NOCODA. Voiced coda obstruents, however, are not permitted. The only way to rule out a candidate with a voiced coda is to rank some markedness constraint above FAITH, but given that voiced obstruents and codas are allowed generally, neither *VOIOBS nor NOCODA can fill this role. This ranking paradox has been solved with the commonly-used constraint *VOICODA, which essentially combines *VOIOBS and NOCODA (Itô and Mester, 1997). Without such a combined constraint, we cannot explain why two marked structures are banned when each is individually acceptable. In essence, *VOIOBS and NOCODA, when both are violated, gang up on FAITH.[1]

The extent to which cumulative constraint interactions occur has yet to be documented. The greater part of the discussion of cumulativity has focused on the cumulative interaction of markedness constraints, as in German: two low-ranked markedness constraints gang up to eliminate one candidate in favor of another candidate that violates a higher-ranked constraint (e.g., Itô and Mester, 1998; Pater, Bhatt and Potts, 2007). Cumulative interactions among faithfulness constraints, here called *cumulative faithfulness effects (CFEs*; also elsewhere called doubly-derived environment blocking effects (Farris, 2007)), have often been overlooked. If cumulative interactions are real, however, we expect it to be typologically possible that faithfulness constraints could undergo the same range of cumulative interactions that we see in markedness constraints. Indeed, Pater, discussing a theory of weighted constraint interactions, provides examples in which markedness constraints behave cumulatively, as well as examples in which a markedness constraint gangs up with a faithfulness constraint to eliminate a marked structure when it is derived. He does not discuss cumulative faithfulness interactions, however, and he goes on to ask the question that is the driving force behind this thesis:

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[1] Another example of constraint conjunction is the English prohibition against [h] in coda position. English allows [h] to occur in onset position, and allows codas more generally, implying that the constraints *h and NOCODA are ranked below the faithfulness constraints like MAX that militate against valid repairs. In order to avoid [h] in coda position, we can conjoin *h and NOCODA to arrive at a constraint like $*h]_{\sigma}$. For an alternative analysis involving the alignment of the feature [spread glottis] with the left edge of a foot, see Davis and Cho (2003).

"To what extent are predicted gang effects observed?" (Pater, 2006: 10). CFEs are predicted in any account that allows for cumulative markedness effects. The primary questions explored in this thesis are as follows: what types of CFEs occur, in what language domains do CFEs occur (e.g., do they arise in acquisition or loanword phonology?), and how can they be accounted for in a constraint-based theory? These issues are important and relevant to the present state of phonological knowledge because of their impact on phonological theory. If cumulative interactions are more common than previously believed, then the case for a weighted-constraint approach to grammar is stronger. Constraints that can be assigned numerical values are more in line with the current focus on computational models of phonological acquisition and constraint interaction; thus arguments for weighted constraint theories are in demand.

This thesis takes up the issue of cumulative constraint interactions in the domain of faithfulness constraints, which have not been researched in detail. The fact that these effects are attested in a variety of languages and language domains presents a problem for OT. Moreover, CFEs will be shown to produce outputs that are transparent in the standard sense, and multiple conspiracies converge to produce these transparent outputs. That OT cannot provide a satisfactory account of CFEs is a big blow to the theory, particularly because these are exactly the types of phenomena that OT has been lauded for explaining in a concise way. This raises important questions about the viability of OT in accounting for exactly the phenomena it was intended to explain.

The thesis thus has three goals. The first is descriptive: I seek to determine under what circumstances CFEs occur. Which faithfulness constraints can do the ganging-up, and which constraints are ganged-up-on? The result of these questions is a typology of

CFEs, illustrating that there are many ways in which faithfulness constraints can behave cumulatively. The second goal is to determine in what phonological domains CFEs occur. Do they arise in fully-developed languages, first-language acquisition or loanword adaptation? If CFEs can be shown to exist in each of these domains, then we can make the case that they are a pervasive phenomenon. Finally, the third goal is analytical: what is the best constraint-based analysis for CFEs? Because they result in a ranking paradox in standard OT, either some addendum to OT must be proposed, or some other constraint-based theory must be appealed to.

In pursuit of the first goal of providing a typology of CFEs, the table in (1) lists possible cumulative interactions. In a theory in which the constraint set is limited to markedness and faithfulness constraints, it is logically possible that any two constraints could gang up on any third constraint. Moreover, because a given constraint may be violated more than once by a candidate, it is also logically possible that a single constraint, when violated multiple times, could behave cumulatively with respect to another constraint. The ten possible cumulative interactions in (1) reflect these possibilities. The first four interactions, (1a-d), are those in which two markedness constraints gang up on some other constraint; these will henceforth be referred to as cumulative markedness effects. The last two interactions, (1i-j), are combined effects, describing cases in which a markedness constraint and a faithfulness constraint gang up on a third constraint. (1i), for instance, characterizes a grandfather effect, in which a marked structure is prohibited only when it is derived (Pater, 2006). In order to determine the full range of cumulative interactions, it will be necessary to explore each of these possibilities. This thesis, however, focuses solely on CFEs, shown in bold (1e-h).

(1) Typology of cumulative interactions

		Ranking	Result
Cumulative markedness effects	a.	M2 + M3 > M1	The combined violations of two markedness constraints trade off for the violation of a third markedness constraint
	b.	M1 + M2 > F1	The combined violations of two markedness constraints trade off for the violation of a faithfulness constraint
	c.	M2 + M2 > M1	Multiple violations of a markedness constraint trade off for the violation of another markedness constraint
	d.	M1 + M1 > F1	Multiple violations of a markedness constraint trade off for the violation of a faithfulness constraint
Cumulative faithfulness effects	**e.**	**F1 + F2 > M1**	**The combined violations of two faithfulness constraints trade off for the violation of a markedness constraint**
	f.	**F2 + F3 > F1**	**The combined violations of two faithfulness constraints trade off for the violation of a third faithfulness constraint**
	g.	**F2 + F2 > F1**	**Multiple violations of a single faithfulness constraint trade off for the violation of another faithfulness constraint**
	h.	**F1 + F1 > M1**	**Multiple violations of a single faithfulness constraint trade off for the violation of a markedness constraint**
Combined effects	i.	M2 + F1 > M1	The combined violations of a markedness constraint and a faithfulness constraint trade off for the violation of another markedness constraint
	j.	M1 + F2 > F1	The combined violations of a markedness constraint and a faithfulness constraint trade off for the violation of another faithfulness constraint

This thesis argues that the typology of cumulative interactions is robust, with effects extending beyond markedness into faithfulness. That is, faithfulness constraints can work together to eliminate structures that are too unfaithful. CFEs occur when the grammar has to choose between multiple unfaithful mappings, that is, when markedness constraints requiring unmarked outputs dominate faithfulness constraints. These high-ranked markedness constraints force the grammar to produce an unfaithful output, but how that output is realized is determined by the ranking of the lower-ranked faithfulness constraints. Thus multiple types of gang-up effects are possible. Low-ranked faithfulness constraints can gang up on a higher-ranked faithfulness constraint, as in (1f, g), resulting in the selection of a candidate in which a single faithfulness constraint is violated, rather than multiple faithfulness constraints. In these cases, the process that leads to violation of a single faithfulness constraint can be thought of as the *fell-swoop* process, because it eliminates multiple marked structures with a single faithfulness violation. Low-ranked faithfulness constraints can also gang up on a higher-ranked markedness constraint, as in (1e), resulting in the presence of marked structure in the output only when the repair of that marked structure would require multiple faithfulness violations.

From the analytical perspective, I argue that harmonic grammar (HG; e.g., Legendre, Miyata and Smolensky, 1990a, 1990b; Smolensky and Legendre, 2006), a theory of weighted constraint interactions, provides the best analysis of cumulative interactions. Though local constraint conjunction (LC; Smolensky, 1995; Łubowicz, 2002; Smolensky, 2006), an extension to OT proposed to deal with cumulative interactions, can account for CFEs, many criticisms of the theory raise doubts about its effectiveness, as will be discussed in more detail in §1.3 of this chapter and in Chapter 4. HG, on the other hand, correctly predicts the existence of cumulative interactions with no special mechanisms. In HG, each potential output candidate is characterized by the sum of its weighted violation scores. This evaluation procedure ensures that even low-weight constraints have some say in choosing the output. CFEs are easily modeled in HG by assigning the fell-swoop faithfulness constraint or the violable markedness constraint a weight that is greater than either of the low-ranked faithfulness constraints, but less than their sum. The candidate that violates only the fell-swoop or violable markedness constraint thus wins over a candidate that violates both of the lower-ranked faithfulness constraints. HG also allows us to define the terms "more faithful" or "less faithful" in terms of cumulative faithfulness weight. A candidate whose faithfulness violations add up to a larger absolute value than another candidate is considered less faithful. In sum, the HG account illustrates that grammars like to be unmarked in as faithful a way as possible.

This chapter is organized as follows. In §1.2, the issue of cumulativity in phonology is reviewed. §1.3 introduces constraint-based analyses of cumulativity, arguing that HG provides a better analysis than LC. §1.4 outlines the organization of the thesis.

1.2 Cumulative phonological interactions

The primary types of cumulative interaction listed in (1) are cumulative markedness effects and cumulative faithfulness effects. Much more work has focused on the cumulative interactions of markedness constraints; the cumulative interactions of faithfulness constraints have not been explored in detail. The following sections summarize prior work on cumulativity.

1.2.1 Cumulative markedness effects

Cumulative interactions have been primarily discussed with regards to the cumulative interaction of markedness constraints. Such effects, also referred to as *worst-of-the-worst* effects (Prince and Smolensky, 1993/2004; Smolensky, 1995), occur when the violation of a single markedness constraint is permitted, but the violation of multiple markedness constraints within a given domain is not. The German coda devoicing discussed above is one example. Another example can be found in Yidin^y's segmental inventory (Kirchner, 1992; Prince and Smolensky, 1993/2004). Yidin^y allows the complex coronal segments n^y and d^y, and it allows simple consonants at the more marked dorsal and labial places of articulation. Complex consonants with non-coronal place of articulation, however, are prohibited, presumably because they contain two marked structures: complex segments and non-coronal place of articulation. Cumulative markedness effects are also attested in loanword acquisition. Japanese, which typically disallows sequences of two voiced obstruents within a word, as well as voiced geminates, allows each to occur in loanwords (Nishimura, 2003; Kawahara, 2006; Pater, Bhatt and Potts, 2007). However, when a borrowed word would include both a voiced geminate and another voiced obstruent, the geminate is optionally devoiced. That is, for those cases in which devoicing occurs, the doubly-marked structure is disallowed, even though each of the independent marked structures is permitted.

Finally, cumulative markedness effects have been acknowledged in first-language acquisition. For instance, Levelt, Schiller and Levelt (2000), in examining the order of acquisition of syllabic structures in Dutch, note that children go through four stages in which their productions do not violate multiple markedness constraints, though individual markedness constraints can be violated (also see Albright, Magri and Michaels, 2008). In the first of these cumulative markedness stages, the child produces syllables with codas (CVC) as well as onsetless syllables (V); the child fails, however, to produce the syllable that combines these marked structures, namely an onsetless syllable with a coda (*VC). The same is true in later stages of complex onsets and codas; a child may produce both a complex onset (CCV) and a coda (CVC), but not in the same syllable (*CCVC), or a child may produce a complex coda (CVCC) and an onsetless syllable (V), but not in the same syllable (*VCC). Finally, the fourth cumulative markedness stage occurs when the child can produce a complex onset (CCV) and a complex coda (CVCC), but cannot combine the two in one syllable (*CCVCC). Note that these acquisition patterns reflect a worst-of-the-worst effect that is not found in fully-developed languages (Prince and Smolensky, 1993/2004).

It is clear, then, that markedness interactions can and do interact cumulatively. In the next section, we turn to cumulative interactions among faithfulness constraints, a topic that has not been so frequently discussed.

1.2.2 Cumulative faithfulness effects

Whether input-to-output mappings can display cumulative interactions has not been fully explored (though cf. Jesney and Tessier, 2008, in which the authors discuss how specific and general faithfulness can gang up to eliminate a marked structure in a particular context). Given that CFEs arise when unfaithful mappings are permitted, they are predicted to occur in grammars in which markedness constraints are high-ranked and faithfulness constraints are low-ranked. We would thus expect to see CFEs in first language acquisition, as it is generally assumed that markedness constraints outrank faithfulness constraints in the initial state (e.g., Smolensky, 1996b; Gnanadesikan, 2004). CFEs should also occur in the adaptation of loanwords from a language that allows complex structures into a language that bans complex structures and in fully-developed languages when morphological concatenation creates marked structures that are otherwise banned.

For example, consider Kikuyu, a language discussed in more detail in Chapter 2 (where relevant data are also provided). The Kikuyu CFE is the result of morphophonological processes that occur when a nasal prefix is added to a consonant-initial stem. Kikuyu disallows sequences of a nasal followed by a voiceless obstruent. When an underlying voiceless stop is prefixed by a nasal, the stop is realized as voiced. Kikuyu also disallows sequences of a nasal followed by a fricative. When an underlying voiced fricative is preceded by a nasal, the fricative is realized as a stop. Given these two unfaithful mappings, we would expected a voiceless fricative, when preceded by a nasal (creating a doubly-marked structure), to undergo both stopping and voicing. Instead, the nasal is deleted. The nasal deletion process circumvents stopping and devoicing, effectively avoiding a doubly-unfaithful output. Both the expected output (in which stopping and devoicing have occurred) and the attested output (in which the nasal has been deleted) are unmarked. When the Kikuyu grammar is choosing between unmarked outputs, it chooses the least unfaithful.

A branch of phonology in which cumulative faithfulness interactions have been discussed (though not under that label) is the Theory of Constraints and Repair Strategies (TCRS; Paradis, 1996). In this theory, phonotactic constraints determine allowable surface forms, and repair strategies determine the repair of disallowed surface forms. TCRS was originally applied to loanword phonology and the kinds of adaptations that occur when words are borrowed from one language into another. Two main principles determine allowable adaptations. The Preservation Principle argues that segmental information must be preserved (often with some repair). This principle is at odds with the Threshold Principle, which states that there is a limit (or a threshold) on the number of repairs that can occur in the attempt to preserve a surface form. When that threshold is crossed, segments may be deleted, rather than preserved. In effect, these principles combine to say that repairs (unfaithful mappings) are allowed, but too many mappings cannot combine; instead, deletion (a fell-swoop repair) is preferred. Paradis and colleagues apply TCRS to a number of examples of CFEs in loanword phonology (Paradis, 1996; Paradis and LaCharite, 1997; Paradis and Prunet, 2000; Paradis and LaCharite, 2001; LaCharite and Paradis, 2005).

One much-discussed instance in which faithfulness cumulativity may play a role is in the opaque mappings known as chain shifts. In a chain shift, some high-ranked markedness constraint starts a shift in mappings, such that the input /a/ is realized as the output [b], but the input /b/ is realized as the output [c]. The question is why the input /a/ is not realized as [c]. One explanation for disallowing the /a/→[c] mapping is that it incurs multiple faithfulness violations. Chain shifts also pose a problem for OT, but the problem is different from that posed by CFEs. Chain shifts result in opaque outputs, where the generalization that /b/ is disallowed appears to be untrue in surface forms (for more discussion of chain shifts and how they relate to CFEs, see Chapter 5). CFEs, we will see, typically result in surface transparency.

In almost all of the CFEs discussed in this thesis, the fell-swoop repair is some kind of deletion (segmental or featural). This means that when a grammar has the choice between deleting a segment or feature and repairing it by violating multiple faithfulness constraints, deletion is preferred. Deletion is somehow more faithful than the violation of multiple faithfulness constraints. This may seem counter-intuitive because deletion would seem to be a more drastic repair than, for instance, a change in voice and a change in manner. This thesis, however, will argue that a single deletion can be less unfaithful than multiple featural changes, and that this difference in degree of faithfulness is reflected in the cumulative weights of faithfulness constraints in HG. This is counter to arguments made by some researchers (e.g., McCarthy, 2007b) that when a segment is deleted, the single deletion incurs violations not only of a general segmental deletion constraint like MAX, but also of a number of more specific constraints like MAX[place] and MAX[voice]. Under this view, segmental deletion is more costly than simple place or voice changes. Examining deletion versus featural changes and even epenthesis in weighted-constraint theories may have implications for how we define notions like degree of faithfulness.

Because CFEs have not been the focus of much research, this thesis is attempting to fill a gap in the literature on cumulative interactions. The next section turns to the second goal of the thesis: accounting for CFEs in a constraint-based theory.

1.3 Constraint-based analyses of cumulativity

As mentioned above, cumulative interactions present a problem for OT because they create a ranking paradox. In this section, we examine the ranking paradox in a cumulative markedness effect, and then we consider two possible alternative solutions: LC and HG.

1.3.1 Local constraint conjunction

One of the original motivations for positing strict domination in OT was to rule out the possibility of gang effects (Prince and Smolensky, 1993/2004). However, Prince and Smolensky did acknowledge some gang effects, particularly in markedness interactions, which they called worst-of-the-worst effects. LC was proposed as a solution to such problems, with the argument that "constraint interactions can be stronger locally than non-locally" (Smolensky, 1995: 4). In local conjunction, which Smolensky describes as an available operation in OT, two constraints are combined such that a candidate that violates both of the conjuncts also violates the conjoined constraint. The conjoined constraint is always ranked above its individual counterparts. Many of the constraints that we think of as standard OT constraints, such as *VOICODA, mentioned in §1.1 above, are really conjoined markedness constraints. *VOICODA stands for the conjunction of NOCODA and *VOICEDOBSTRUENT in the domain of a single segment.

LC is a convenient solution to the cumulativity problem because it essentially overrides strict domination. If the locus of violation of two constraints overlaps, then those constraints may conjoin to eliminate candidates in which the two constraints are violated, even though candidates in which a single constraint is violated are allowed. The tableaux in (2) illustrate a cumulative interaction in LC. The tableaux in (2a, b) show that the constraint C1 must be ranked above each of the constraints C2 and C3. In (2c), however, the conjoined constraint C2&C3 eliminates the candidate that violates both of the lower-ranked constraints. Note that had the conjoined constraint not been present, candidate a. would have won, even though it violates a greater number of constraints than candidate b violates.

(2) Cumulativity in LC

a. C1 >> C2

$/input_1/$	C2&C3	C1	C2	C3
a. ☞ candidate a			*	
b. candidate b		*!		

b. C1 >> C3

$/input_2/$	C2&C3	C1	C2	C3
a. ☞ candidate a				*
b. candidate b		*!		

c. C2&C3 >> C1

$/input_3/$	C2&C3	C1	C2	C3
a. candidate a	*!		*	*
b. ☞ candidate b		*		

Though LC can account for cumulative interactions, some major criticisms of the theory have been put forth. The primary criticism is that conjoining constraints in too large a domain can predict unattested grammars. Pater, Bhatt and Potts (2007) note that if NOCODA and *VOICEDOBSTRUENT are conjoined in the domain of a word, rather than in the domain of a segment, as discussed above, unattested grammars could result. For instance, if these constraints are conjoined in the domain of a word and the conjoined constraint is ranked above IDENT[voice], then we can arrive at a grammar in which an underlyingly voiced onset devoices only in those cases in which the word has a coda. Such a pattern is unattested. (For a more in-depth discussion of the criticisms of LC, see Chapter 4.) HG does away with the problems of LC, in part because it limits constraint trade-offs to interactions that are co-relevant (dependent on one another) and local (in the same small domain) (Pater, Bhatt and Potts, 2007). The next section introduces HG.

1.3.2 Harmonic grammar

An alternative to LC is HG (Legendre, Miyata and Smolensky, 1990a, 1990b; Smolensky and Legendre, 2006). HG was a precursor to OT and was originally intended to model connectionist networks. Each phonological input and output can be thought of as a node in the grammar, with links between them symbolizing input-output pairs. Each link has a weight; the cumulative weight of all the links between an input and an output determines its activation. If heavier weights are given to more likely outputs, or more likely input-output pairs, then the resulting candidates are more likely to be activated in the grammar. HG was originally rejected in favor of OT because HG was argued to predict some grammars that do not seem to occur in the linguistic typology. More recently, though, Pater, Bhatt and Potts (2007) have shown that HG actually predicts a limited range of languages, particularly if restrictions are placed on the domain of evaluation of certain constraints, and HG has had a resurgence (e.g., Goldrick and Daland, 2007; Jesney and Tessier, 2007; Pater, Bhatt and Potts, 2007; Pater, Jesney and Tessier, 2007). Most importantly, one argument for rejecting HG was that it predicted gang effects, while OT did not. If these gang effects are found to occur, and not infrequently, then this is a strong argument for HG.

HG differs from OT in that constraints are weighted rather than ranked. Constraints with greater weights would translate into higher-ranked constraints in OT, while low-weight constraints are similar to low-ranked constraints. The resulting crucial difference between the two models that strict domination is a key feature of OT but not of HG. Because of the symbolic nature of OT's constraints, a higher-ranked constraint strictly dominates a lower-ranked one—no number of violations of the lower-ranked constraint can overcome the violation of a higher-ranked constraint (McCarthy, 2002a). On the other hand, in HG, multiple violations of low-weight constraints may, when added together, "gang up" on a higher-weight constraint, allowing low-weight HG constraints to have more power than low-ranked constraints in OT.

The HG tableaux in (3) illustrate the account of a cumulative interaction. In each tableau, the weight of each constraint is listed under the constraint name. Weights are always positive real numbers. Following Legendre et al. (2006), violations are shown as negative numbers that correspond to the number of violations of a constraint incurred by a given candidate. This allows for the possibility (not explored in this thesis) of constraints which may reward candidates with positive violations rather than penalizing them with negative ones. For each candidate, the relative harmony (H) is calculated as follows: each violation is multiplied by the weight of the constraint violated, and the resulting weighted violations are summed across constraints. The formula in (4) demonstrates the harmony evaluation. The candidate with the highest harmony (the harmony closest to zero, or with the lowest absolute value) wins. Harmony is shown in the rightmost column. In order to produce a cumulative interaction, as in (3c), one constraint (here C1) must have a weight that is greater than either C2 or C3 but less than the sum of C2 and C3. C2 and C3 thus trade off against C1. As Pater, Bhatt and Potts note, "…for cumulativity to have an effect in HG, the multiple violations in the sub-optimal candidate must be able to be traded off against a smaller number of violations in the optimum" (2007: 12).

(3) Sample HG tableaux (Jesney & Tessier, 2007)

a. $W_{C1} > W_{C2}$

/input/	C1 w=3	C2 w=2	C3 w=2	H
a. ☞ candidate a		-1		-1(2) = **-2**
b. candidate b	-1			-1(3) = **-3**

b. $W_{C1} > W_{C3}$

/input/	C1 w=3	C2 w=2	C3 w=2	H
a. ☞ candidate a			-1	-1(2) = **-2**
b. candidate b	-1			-1(3) = **-3**

c. $W_{C2} + W_{C3} > W_{C1}$

/input/	C1 w=3	C2 w=2	C3 w=2	H
a. candidate a		-1	-1	-1(2) + -1(2) = **-4**
b. ☞ candidate b	-1			-1(3) = **-3**

(4) Harmony formula

H(candidate x) = $W_{C1}(c1_x) + W_{C2}(c2_x) + W_{C3}(c3_x) + \ldots + W_{Cn}(cn_x)$

(Where H stands for cumulative harmony and cn_x stands for the number of violations of a particular constraint incurred by candidate x.)

It is important to note that the actual numbers used for weights in the above tableaux are arbitrary; what is crucial is the relationship between the weights. As noted by Tesar (2007), the difference in the number of violations of a constraint is crucial; if a given candidate violates a constraint x number of times, and another candidate violates the same constraint x+1 number of times, then the second candidate will always have a lower harmony on that constraint, whether the weight of the constraint is 1 or 1000. Note that we could assign the constraints symbolic weights and arrive at the same output, as is shown in (5). The variable x could be assigned any numeric value; moreover, the weight of C1 could be assigned any numeric value between x and 2x.

(5) Symbolic weights in HG

/input/	C1 $2x > w > x$	C2 $w = x$	C3 $w = x$	H
a. candidate a		-1	-1	2x
b. ☞ candidate b	-1			$2x > w_a > x$

Several proposals utilizing weighted constraints to deal with phonological or syntactic cumulativity exist in the literature: for instance, Graded Constraint Theory (McClelland, 2007), the Split Additive Model (Albright, Magri and Michaels, 2008), Linear Optimality Theory (Keller, 2000), Maximum Entropy (Jäger, 2003), and Stochastic OT (Boersma, 1998). Many of these theories have also been applied to gradient effects, as has HG (Legendre, Miyata and Smolensky, 1990a, 1990b). One type of gradient effect accounted for with weighted constraints is gradient well-formedness, the phenomenon in which speakers of a language are able to distinguish between degrees of well-formedness of structures that are not in their own language (e.g., Coleman and Pierrehumbert, 1997; Sorace and Keller, 2005; Hayes and Wilson, in press). McClelland (2007) also applied weighted constraints to account for the frequency with which marked patterns occur in English, showing that the more markedness constraints a given structure violates, the less frequent it is in the language. Weighted constraint theories have also been used to account for grammatical or phonological variation (e.g., Boersma and Hayes, 2001; Jäger and Rosenbach, 2006).

Though HG seems to provide a better account of cumulative interactions than standard OT, HG is not without criticism. Unattested grammars are predicted when gradiently violated constraints are allowed in the theory, as in many constraint-based accounts of stress (Legendre, Sorace and Smolensky, 2006). Moreover, the cumulative aspect of HG allows for global candidate evaluation, the evaluation of an entire input-output mapping at once (Pater, Bhatt and Potts, 2007). Depending on the weight of constraints, this can allow grammars which do not seem likely. Pater and colleagues provide the following example. Imagine a language which requires ATR harmony among adjacent vowels, capitulating to the demand of AGREE[ATR] at the expense of IDENT[ATR], and a set of inputs in which the final vowel is +ATR and all the other vowels are -ATR. If AGREE[ATR] is assigned a weight of 5.5 and IDENT[ATR] is assigned a weight of 1, then we can arrive at a grammar in which a word with five pairs of adjacent vowels undergoes harmony, but in a word with six pairs of adjacent vowels, harmony is blocked. This is possible because six pairs of vowels that have to undergo harmony violate IDENT[ATR] six times, at a cumulative weight of 6 (6x1). This is greater than the single violation of AGREE[ATR] incurred by the fully faithful candidate (1x5.5=5.5). This is a problem because in no attested language does the presence or absence of vowel harmony depend on the number of vowels in the word, but HG's cumulative evaluation predicts such grammars.

Finally, HG does not allow for collective harmonic bounding (Prince, 2002; Tesar, 2007). Collective bounding occurs in OT when candidate a. is harmonically bounded by candidate b. under one constraint ranking and by candidate c. under another constraint ranking. That is, candidate a. is not completely harmonically bounded by one other candidate; instead, the presence of two or more other candidates means that candidate a. will not win under any constraint ranking. Because HG constraints are weighted and a candidate's violations of every constraint count toward that candidate's cumulative harmony, collective bounding can be overridden by certain constraint weightings (for a specific example and a mathematic explanation, see Tesar, 2007).

Pater, Bhatt and Potts (2007) provide restrictions on HG that help solve some of the problems raised here. In particular, they appeal to a version of Harmonic Serialism (McCarthy, 2006, 2007a) called Local Harmonic Serialism. This thesis is not intended to evaluate the possible solutions to such problems. It is important, however, to point out cases in which HG predicts grammars that OT does not predict, particularly when those grammars are attested in real languages. This thesis argues that CFEs do occur in a variety of language domains, and because HG can account for them, it deserves consideration.

1.3.3 Accounts of Japanese cumulative markedness effect

This section introduces the problems with an OT account of cumulative interactions, as well as the solutions provided by LC and HG. As a case study, we turn to the Japanese loanword example discussed above, which was originally provided by Pater, Bhatt and Potts (2007). Data are presented in (6). Unlike its native phonology, Japanese loanwords allow the sequence of two voiced obstruents within a word (6a) as well as voiced geminate consonants (6b). When these two structures would co-occur in a word, though, the geminate is optionally devoiced (6c). Here we will be examining the cases in which devoicing does occur, as this repair eliminates the doubly-marked structure.

(6) Japanese cumulative markedness effect (data from Pater, Bhatt and Potts, 2007)

a. Lyman's Law violated in loanwords

[bagii]	'buggy'	[bagu]	'bug'
[bogii]	'bogey'	[dagu]	'Doug'
[bobu]	'Bob'	[giga]	'giga'

b. Prohibition against voiced geminates violated in loanwords

[webbu]	'web'	[kiddo]	'kid'
[sunobbu]	'snob'	[reddo]	'red'
[habburu]	'Hubble'	[heddo]	'head'

c. Optional devoicing of geminates in words that contain another voiced obstruent

[guddo] ~ [gutto]	'good'	[doggu] ~ [dokku]	'dog'
[beddo] ~ [betto]	'bed'	[baggu] ~ [bakku]	'bag'
[doreddo] ~ [doretto]	'dredlocks'	[budda] ~ [butta]	'Buddha'
[baddo] ~ [batto]	'bad'	[doraggu] ~ [dorakku]	'drug'
[deibiddo] ~ [deibitto]	'David'	[biggu] ~ [bikku]	'big'

The relevant constraints are listed in (7). Markedness constraints ban voiced geminates, as well as multiple voiced obstruents in a word (Itô and Mester, 1986, 2003a). The faithfulness constraint violated by the attested repair is IDENT[voice].

(7) Constraints relevant for the Japanese cumulative markedness effect

*VOICEDGEMINATE: Voiced geminates are banned

*2VOICE: No more than one voiced obstruent is allowed per word

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

The tableaux in (8) illustrate the cumulative markedness effect. In order to preserve multiple voiced obstruents in a word, IDENT[voice] must be ranked above

*2VOICE, as in (8a). Likewise, to avoid devoicing of a voiced geminate, IDENT[voice] must be ranked above *VOICEDGEMINATE, as is illustrated in (8b). The combination of these two rankings, though, means that the attested devoiced candidate will be ruled out by the high-ranked IDENT[voice], as in (8c). Because IDENT[voice] strictly dominates the two markedness constraints, their combined violation is not sufficient to eliminate candidate a. in (8c). Note that the attested repair in (8c), geminate devoicing, repairs both markedness violations at once; devoicing the singleton would repair the violation of *2VOICE, but the violation of *VOICEDGEMINATE would remain. Here and throughout the thesis, the rightward-pointing manual indicator (☞) indicates the winner chosen by the OT or HG grammar, and the leftward-pointing manual indicator (☜) indicates an attested winner that has not been chosen by the grammar.

(8) Standard OT fails to account for Japanese

a. IDENT[voice] >> *2VOICE

/bagu/ 'bug'	IDENT[voice]	*VOICEDGEMINATE	*2VOICE
a. ☞ bagu			*
b. baku	*!		

b. IDENT[voice] >> *VOICEDGEMINATE

/webbu/ 'web'	IDENT[voice]	*VOICEDGEMINATE	*2VOICE
a. ☞ webbu		*	
b. weppu	*!		

c. Ranking paradox

/guddo/ 'good'	IDENT[voice]	*VOICEDGEMINATE	*2VOICE
a. ☞ guddo		*	*
b. ☜ gutto	*!		
c. kuddo	*!	*	

Given this ranking paradox, we can employ either of the two solutions discussed above. To account for the Japanese cumulative markedness effect with locally conjoined constraints, it is necessary to conjoin the two markedness constraints and to rank the conjoined constraint above IDENT[voice]. The newly conjoined constraint is defined in (9). The tableaux in (10) illustrate this solution. In (10a,b), the locally conjoined constraint is irrelevant because both of its counterparts are not violated. The ranking of the other constraints chooses the faithful candidate in each of these tableaux. In (10c), on the other hand, the locally conjoined constraint eliminates the doubly-marked candidate in favor of a candidate in which the geminate has devoiced.

(9) Locally conjoined constraint

*VOIGEM&*2VOI$_W$: The combination of a voiced geminate and another voiced obstruent is banned within the domain of a word

(10) Japanese cumulative markedness effect in LC

a. IDENT[voice] >> *2VOICE

/bagu/ 'bug'	*VOIGEM&*2VOI$_W$	ID[voice]	*VOICEDGEM	*2VOICE
a. ☞ bagu				*
b. baku		*!		

b. IDENT[voice] >> *VOICEDGEMINATE

/webbu/ 'web'	*VOIGEM&*2VOI$_W$	ID[voice]	*VOICEDGEM	*2VOICE
a. ☞ webbu			*	
b. weppu		*!		

c. Locally conjoined constraint eliminates doubly-marked candidate

/guddo/ 'good'	*VOIGEM&*2VOI$_W$	ID[voice]	*VOICEDGEM	*2VOICE
a. guddo	*!		*	*
b. ☞ gutto		*		
c. kuddo		*	*!	

Citing criticisms of LC mentioned above, Pater, Bhatt and Potts (2007) instead account for the Japanese loanword voicing problem in HG. By assigning each of the two markedness constraints a weight lower than the weight of the faithfulness constraint IDENT[voice], they assure that voiced geminates can appear in loanwords, as can multiple voiced obstruents. However, when a candidate violates both markedness constraints at the same time, the cumulative weight of those constraints outweighs the faithfulness constraint, and that candidate loses. Weighting arguments for Japanese are given in (11). This display shows the weighting relationships among constraints necessary to achieve the desired outputs. For instance, in the first line, IDENT[voice] must have a greater weight than *2VOICE in order for the output [bagu] to be more harmonic than [baku] for the input /bagu/. As in the hypothetical example in (3), the weight of IDENT[voice] (C1) must be greater than the weight of either of the markedness constraints, but less than the sum of the weights of the markedness constraints.

(11) Constraint weightings necessary for Japanese

Weighting	Result		
$W_{ID[voice]} > W_{*2VOICE}$	/bagu/	bagu > baku	
$W_{ID[voice]} > W_{*VOICEDGEMINATE}$	/webbu/	webbu > webbu	
$W_{ID[voice]} < W_{*VOICEDGEMINATE} + W_{*2VOICE}$	/guddo/	gutto > guddo	

HG tableaux are shown in (12). In (12a), candidate b.'s violation of IDENT[voice] is sufficient to overcome candidate a.'s violation of *2VOICE, and in (12b), candidate b.'s violation of IDENT[voice] is enough to overcome candidate a.'s violation of *VOICEDGEMINATE. In (12c), however, the cumulative harmony of candidate a., which results from the addition of the violations of *VOICEDGEMINATE and *2VOICE, is great enough to overcome the single violation of IDENT[voice] in candidate b. Thus candidate b. has a higher harmony and is the winner. The violations of *2VOICE and *VOICEDGEMINATE trade off for a single violation of IDENT[voice].

(12) Japanese cumulative markedness effect in HG

a. $W_{ID[voi]} > W_{*2VOICE}$

/bagu/ 'bug'	IDENT[voice] w=3	*VOICEDGEM w=2	*2VOICE w=2	H
a. ☞ bagu			-1	-2
b. baku	-1			-3

b. $W_{ID[voi]} > W_{*VOICEDGEMINATE}$

/webbu/ 'web'	IDENT[voice] w=3	*VOICEDGEM w=2	*2VOICE w=2	H
a. ☞ webbu		-1		-2
b. weppu	-1			-3

c. $W_{ID[voice]} < W_{*VoicedGeminate} + W_{*2Voice}$

/guddo/ 'good'	IDENT[voice] w=3	*VOICEDGEM w=2	*2VOICE w=2	H
a. guddo		-1	-1	-4
b. ☞ gutto	-1			-3
c. kuddo	-1	-1		-5

In sum, both LC and HG can account for this cumulative markedness effect. However, the LC account requires conjoining two markedness constraints within the domain of a word, a relatively large domain. The HG account does not require any special tools—it uses the same constraints and weighting strategies used in non-cumulative interactions. HG seems almost tailor-made to suit cumulative interactions; these interactions are the primary case that distinguishes HG from OT, and as they have been shown to occur, HG seems preferable. The rest of this thesis will argue that HG can provide the best account of cumulative interactions in general and CFEs specifically, and criticisms of LC will be discussed in more detail in Chapter 4.

1.4 Outline of the thesis

The thesis consists of six chapters. Chapters 2, 3, and 4 present CFEs in three language domains: fully-developed languages, first language acquisition, and loanword adaptation, respectively. Chapter 5 returns to the issue of CFEs in fully-developed languages, presenting some examples that are unusual or challenging for HG.

Chapter 2 describes the characteristics of a CFE in detail, focusing on two examples from fully-developed languages: Kikuyu (an example of 1f above) and Greek (an example of 1g). In this chapter, I present diagnostics of a CFE and explore the interaction from a rule-based as well as a constraint-based perspective. In rule-based theory, CFEs typically require three rules and are usually mutual-bleeding interactions, in which the fell-swoop rule bleeds two other rules, either of which would have bled the fell-swoop rule if ordered first. CFEs also incorporate overlapping conspiracies, phenomena in which multiple processes are necessary to avoid a given structure (Kisseberth, 1970; Kiparsky, 1976); that is, in each CFE, rules A and B conspire to eliminate a given marked structure, and rules A and C conspire to eliminate another marked structure. Because each of the conspiracies has A (the fell-swoop process) as a conspirator, the conspiracies overlap. This chapter also illustrates how CFEs can come about through morphological or lexical concatenation.

Chapter 3 turns to first-language acquisition, providing four examples of CFEs from both normally-developing and delayed phonologies. As mentioned above, developing phonologies provide a rich source for CFEs because of the (relatively standard) assumption that markedness constraints outweigh faithfulness constraints in the initial state. CFEs occur when faithfulness constraints are relatively low-ranked, and so are predicted to occur in the early stages of language acquisition. The CFEs in this chapter extend the range of fell-swoop repair processes, illustrating that constraints on deletion of specific segments as well as deletion of features or feature nodes can play a role. Chapter 3 also examines the HG-Gradual Learning Algorithm (HG-GLA; Jesney and Tessier, 2007), arguing that its method of promoting and demoting constraints may lead directly to the prediction of a CFE in developing phonologies.

In Chapter 4, CFEs that arise in the course of loanword adaptation are presented. Five examples from three different languages are discussed. Each of these languages has a relatively unmarked segmental and syllabic inventory in the native phonology, indicating that markedness constraints have remained relatively high-ranked and faithfulness constraints relatively low-ranked, even for adult speakers. When words are borrowed from languages with more complex structures, the relatively low-ranked faithfulness constraints play a role in determining the unfaithful mappings. This can be thought of as an "emergence of the faithful" effect: the pattern of unfaithful mappings shows that the language prefers to reduce markedness in the most faithful way possible. This chapter also presents a CFE in which *three* faithfulness constraints gang up on a fourth; that is, the cumulative violation of any two of the faithfulness constraints is permitted, but the cumulative violation of three is not. This example indicates that different languages may have different tolerance thresholds for cumulative interactions. Finally, Chapter 4 presents a comparison of LC and HG.

Chapter 5 returns to the issue of CFEs in fully-developed languages, examining three unusual CFEs. In the Shizuoka dialect of Japanese, a CFE arises that is unusual for two reasons: first, the fell-swoop repair in this example is epenthesis, rather than deletion, and second, it can be accounted for in standard OT. The reasons for this are discussed in detail. Chapter 5 also discusses the characterization of chain shifts as cumulative interactions, presenting two chain shifts in the language Fyem, one true chain shift and one that behaves more like a CFE. Because chain shifts are opaque, and HG is not equipped to deal with opacity effects, we explore the use of the Split Additive Model (Albright, Magri and Michaels, 2008) to account for chain shift CFEs. Finally, Luwanga is discussed as an example of (1e): two faithfulness constraints gang up on a markedness constraint, such that a marked output is preferred over a doubly-unfaithful one. While this CFE has a standard account in HG, it is presented in the "atypical CFEs" chapter because it cannot be accounted for in rule-based phonology.

The thesis concludes in Chapter 6. Several unresolved issues are discussed in this chapter. First, while this thesis argues that languages prefer to be as faithful as possible, there are many languages in which multiply-unfaithful outputs are allowed (e.g., feeding and counterbleeding interactions, as well as cases in which two processes do not need to be ordered, but both can apply in a given context). Possible explanations for the existence of multiply-unfaithful interactions are discussed. This chapter also argues that CFEs cannot be explained by an account based on misperception. The notion of "degree of unfaithfulness" is explored from a constraint-based point of view, and possible experimental instantiations of the topic are presented. Finally, we raise the issue of whether CFEs should be considered transparent or opaque. The chapter concludes with a reexamination of the typology given in (1) of this chapter.

CHAPTER 2

CUMULATIVE FAITHFULNESS EFFECTS IN FULLY-DEVELOPED LANGUAGES

2.1 Introduction

This chapter introduces the cumulative faithfulness effect phenomenon (henceforth CFE) through the examples of two unrelated, fully-developed languages. We begin in §2.2 with a prototypical CFE in the Bantu language Kikuyu. The Kikuyu CFE will be used to highlight some of the basic diagnostics of a CFE. A second CFE, found in some dialects of Greek, is introduced in §2.3. The Greek CFE illustrates a different portion of the cumulative interaction typology. A summary and conclusion are given in §2.4.

2.2 Kikuyu: A prototypical CFE

This section introduces a prototypical example of a CFE that exemplifies certain standard diagnostics common to CFEs. In Kikuyu, (Archangeli, Moll and Ohno, 1998; Peng, 2003, 2008) a Bantu language spoken primarily in Kenya, a CFE arises in the pattern of nasal prefixing.[1] Nasal prefixes are used in a number of grammatical morphemes, including noun plurals, denominal adjectives, and the first person object. Kikuyu disallows sequences of a nasal consonant followed by a voiceless obstruent, as

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[1] For alternative analyses of these Kikuyu data within an OT framework, see Archangeli et al. (1998) and Peng (2008).

well as sequences of a nasal consonant followed by a fricative.[2] The different repair processes used when these sequences are derived morphologically are shown in (1). In each display, the words in the left-hand column show the root morpheme without a nasal prefix, and the words in the middle column show the root when a nasal prefix has been added. The data in (1a) illustrate the post-nasal voicing pattern: an underlyingly voiceless stop or affricate is realized as voiced when it follows a nasal. The data in (1b) demonstrate the post-nasal stopping pattern: underlying voiced continuants (including fricatives, glides, and the sonorant [r]) are realized as stops post-nasally. The data in (1c) show what happens when a voiceless continuant follows the nasal. Given the voicing and stopping patterns illustrated in (1a) and (1b), the expected repairs for a nasal+voiceless continuant sequence would be voicing and stopping; instead, the nasal is deleted in these cases, leaving the voiceless fricative unchanged.

[2] In fact, many Bantu languages share the restrictions on NC clusters, as do languages from other families (e.g., Pater, 1999) and even first-language acquisition (chapter 3). The sequence of a nasal followed by a voiceless consonant has been shown to be a marked structure, (Pater, 1999; c.f. Archangeli et al. 1998) as has the sequence of a nasal followed by a continuant (Padgett, 1991; Ohala and Ohala, 1993; Ohala and Busà, 1995). Ohala and Busà (1995) argue that the sequence of a nasal followed by a voiceless fricative is particularly bad because of the acoustic properties of the two sounds; the formal analysis here would argue that this sequence is particularly bad because it violates two markedness constraints.

(1) Kikuyu nasal prefixes (data from Peng, 2008)

a. Post-nasal voicing

o-kɛnu	ŋ-gɛnu	'happiness/happy'
a-ker-eet-ɛ	ŋ-ger-eet-ɛ	'he/I have crossed (street)'
ko-a-tuur-a	koo-n-duur-a	'to ache him/me'
o-tɔɔŋga	n-dɔɔŋgu[3]	'wealth/wealthy'
ro-ʧuθe	ɲ-ʤuθe	'backbone/backbones'
a-ʧin-eet-ɛ	ɲ-ʤin-eet-ɛ	'he/I have burned'

b. Post-nasal stopping

o-βuθu	m-buθu	'rottenness/rotten'
ro-wɔra	m-bɔra	'sting/stings of bees'
a-re-et-ɛ	n-de-et-ɛ	'he/I have eaten'
ko-mo-yur-i-a	koo-ɲ-ʤur-i-a	'to let him/me fill'
ɣor-eet-ɛ	ŋ-gor-eet-ɛ	'he/I has bought'

c. Nasals delete before a voiceless fricative[4]

o-θɛru	θɛru	*ndɛru	'brightness/bright'
a-θɛk-ɛɛt-ɛ	θɛk-ɛɛt-ɛ	*ndɛk-ɛɛt-ɛ	'he/I have laughed'
a-θɔɔm-ɛɛt-ɛ	θɔɔm-ɛɛt-ɛ	*ndɔɔm-ɛɛt-ɛ	'he/I have read'

[3] Note that in this and some subsequent examples, Meinhof's Law, which states that an oral consonant should not appear between two nasal consonants, underapplies. This is an interesting phenomenon but is not relevant to the CFE; for an analysis, see Archangeli et al. (1998) or Peng (2008).

[4] The nasal consonant also deletes before the voiceless fricative [h]. While [h] follows the same pattern as [θ], it is unclear what the result of voicing and stopping the [h] would be, and so these data are not included.

Using Kikuyu as a model, it is now possible to define a CFE. The definition proposed in this thesis is given in (2).

(2) Definition of a CFE: A cumulative faithfulness effect occurs when

a. a language allows multiple independent unfaithful mappings to repair singly-marked structures, but

b. in the case of a doubly-marked (or potentially doubly-marked[5]) structure, the combination of those unfaithful mappings is not allowed (i.e., the cumulatively unfaithful mapping is dispreferred), and so

c. either

   i. a third independent unfaithful fell-swoop mapping intervenes to avoid the cumulatively unfaithful mapping and to eliminate the doubly-marked (or potentially doubly-marked) structure, or

   ii. the marked structure is allowed to surface only in those cases in which the alternative is a doubly-unfaithful repair.

The division in part c. of the definition reflects the difference between CFEs in which the constraint that is ganged-up-on is faithfulness or markedness. Part c.i. represents those cases in which the ganged-up-on constraint is faithfulness, and part c.ii. defines the cases in which the ganged-up-on constraint is markedness. In the majority of the CFEs discussed in this thesis, c.i. will hold. We will see an example in Chapter 5, however, of a c.ii. case. Kikuyu falls in the c.i. category. The grammar allows the

[5] This term will be defined and discussed in §2.3.

unfaithful mapping of a voiceless stop to a voiced stop, as well as the unfaithful mapping of a voiced fricative to a voiced stop. However, when both of those mappings could be combined, that is, mapping a voiceless fricative to a voiced stop, the unfaithfulness is too great and the multiple repairs fail. Instead, a third unfaithful mapping, the deletion of the nasal, does away with the doubly-marked structure.[6] The input structure is doubly-marked because it violates two markedness constraints: the constraint against a nasal followed by a voiceless obstruent and the constraint against a nasal followed by a fricative.

Certain diagnostics are common to CFEs in which faithfulness constraints gang up on other faithfulness constraints, as is the case for most of the CFEs cited in this thesis. Here we will discuss the five primary diagnostics and illustrate each with the Kikuyu example. The first diagnostic is given in (3).

(3) Diagnostic 1: CFEs show the interaction of (at least) three different processes, one of which has more narrowly defined structural description than the others.

In a rule-based account of Kikuyu, three rules are necessary. The first rule, Voicing, requires that all obstruents be voiced after nasals. The second rule, Stopping, causes all obstruents to be realized as [-continuant] following a nasal. We consider these two rules to be independent of one another because there are cases in which Voicing applies (e.g., 1a) and cases in which Stopping applies (e.g., 1b), but no cases, as we will

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[6] Deletion of the voiceless continuant, rather than the nasal, would also repair the doubly-marked structure in a single step, as would replacing the nasal with, for instance, a nasalized vowel. We assume these repairs violate other high-ranked constraints in the language.

see, in which Stopping and Voicing both apply. This is due to the third rule, Nasal Deletion, which is the most specific rule, deleting nasals before voiceless fricatives. These rules are shown in formal notation in (4).

(4) Kikuyu CFE rules

Voicing: [-sonorant] → [+voice] / [+nasal] ___

Stopping: [-sonorant] → [-continuant] / [+nasal] ___

Nasal Deletion: [+nasal] → Ø / ___ [-sonorant, -voice, +continuant]

Note that the structural description of the Nasal Deletion rule is much more specific than that of either of the other rules, which can apply to any post-nasal obstruent. Nasal Deletion, on the other hand, deletes a nasal only when it falls before a [-voice, +continuant] obstruent. We will call such a rule with a narrowly-defined structural description the *specific* rule or the *fell-swoop* rule (because it resolves two marked structures in a single rule), and as we will see, it plays a particular role in a CFE. The Voicing and Stopping rules are more general, requiring that obstruents occurring after a nasal be both [+voice] and [-continuant]. It would be possible to write the Kikuyu rules such that each structural description excludes all other structural descriptions. For instance, we could write the Voicing rule such that stops are voiced after nasals, rather than the more general Voicing rule mentioned above, requiring all obstruents to be realized as voiced following a nasal. Similarly, the Stopping rule could be written such that voiced fricatives are realized as stops after nasals, rather than the more general rule requiring that all obstruents be realized as stops after nasals. Such specific rules, however, miss the generalizations that all voiceless obstruents and all fricatives are banned post-nasally.

The second diagnostic common to all CFEs is given in (5).

(5) Diagnostic 2: The CFE processes are ordered in a mutual bleeding relationship, such that the narrowly defined rule bleeds each of the other rules.

In order to get the correct Kikuyu outputs, it is necessary to order Nasal Deletion before both Voicing and Stopping, as in the derivation on the left in (6). With this order, Nasal Deletion removes the nasal from the representation, bleeding both Voicing and Stopping. If the rules had been in the opposite order, as shown in the derivation on the right in (6), Voicing or Stopping would bleed Nasal Deletion. Note that the Voicing and Stopping rules need not be ordered relative to one another, but the order of those rules relative to Nasal Deletion is crucial.

(6) Mutual bleeding relationship in Kikuyu

	/n-θɛru/		/n-θɛru/
Nasal Deletion	θɛru	Voicing	n-ðɛru
Voicing	*bled*	Stopping	n-dɛru
Stopping	*bled*	Nasal Deletion	*bled*
	[θɛru]		*[n-dɛru]

Mutual bleeding relationships are sometimes problematic for optimality theory (e.g., Itô and Mester, 2003b), in that one of the possible outputs is attainable by constraint ranking, but the other is not. We will see in (10) below that this is also the case for mutual bleeding CFEs.

A third diagnostic relevant to a rule-based account is given in (7).

(7) Diagnostic 3: The processes participate in overlapping conspiracies; that is, the narrowly defined rule plays a role in each of (at least) two conspiracies.

In a conspiracy, multiple different processes work together to disallow a certain marked output, whether actively eliminating the marked output or passively failing to apply in the instances in which the rule's application would bring about the marked output (Kisseberth, 1970; Kiparsky, 1976). In the Kikuyu CFE, Stopping and Nasal Deletion work together to eliminate sequences of a nasal followed by a fricative, and Voicing and Nasal Deletion work together to repair sequences of a nasal followed by a voiceless obstruent. Nasal Deletion, the special rule, is thus active in each conspiracy.

Other diagnostic properties of CFEs relate to optimality-theoretic accounts of the phenomenon, as shown in (8).

(8) Diagnostic 4: Standard optimality theory typically cannot account for CFEs because a ranking paradox arises (typically among the faithfulness constraints).

The constraints relevant for Kikuyu are given in (9). Markedness constraints ban the two marked structures mentioned above, the sequences of a nasal followed by a voiceless obstruent and a nasal followed by a continuant. As nasals always agree with a following consonant in place of articulation, the constraint AGREE[place] is necessary; this constraint is never violated in Kikuyu and thus must be high-ranked. For space considerations, it will be left out of this and all subsequent tableaux, as will the faithfulness constraint that such a place change would violate, IDENT[place]. The voicing and stopping error patterns violate the faithfulness constraints IDENT[voice] and IDENT[continuant], respectively, and the deletion of the nasal consonant violates the faithfulness constraint MAX. It is important to remember that IDENT constraint and MAX constraints evaluate candidates in different ways. For a candidate to incur an IDENT violation, there must be corresponding segments in the input and the output that differ in some feature. To incur a MAX violation, though, an output candidate must lack some segment, or possibly some feature, that the input contained. That is, if a candidate has undergone deletion of a segment, then the candidate cannot violate IDENT at the locus of deletion, because there is no longer an output correspondent with which to compare the input. Note that the three faithfulness constraints listed in (9) correspond to the three processes mentioned in (3).

(9) Constraints relevant for the Kikuyu CFE

*NC̥: Sequences of a nasal followed by a voiceless obstruent are banned

*NFRIC: Sequences of a nasal followed by a [+continuant] consonant are banned

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

IDENT[continuant]: Input and output correspondents have the same value for the feature [continuant]

MAX: Input segments have output correspondents

A ranking paradox arises between MAX and the IDENT constraints, as shown in the tableaux in (10). In order for a voiceless stop to be realized as voiced after a nasal, rather than deleted, MAX must be ranked above IDENT[voice], as in (10a). Likewise, MAX must be ranked above IDENT[continuant] so that a voiced continuant is realized as a stop after a nasal, instead of being deleted, as in (10b). However, ranking both of the IDENT constraints below MAX means that a voiceless continuant will undergo post-nasal stopping and voicing, rather than nasal deletion, as in (10c).[7]

(10) Standard OT fails to account for Kikuyu

a. MAX >> IDENT[voice]

/N-kɛnu/ 'happy'	*NC̥	*NFRIC	MAX	ID[voice]	ID[continuant]
a. ŋkɛnu	*!				
b. ☞ ŋgɛnu				*	
c. kɛnu			*!		

b. MAX >> IDENT[continuant]

/N-βuθu/ 'rotten'	*NC̥	*NFRIC	MAX	ID[voice]	ID[continuant]
a. mβuθu		*!			
b. ☞ mbuθu					*
c. βuθu			*!		

[7] A candidate in which the nasal+voiceless continuant sequence is repaired by deletion of the voiceless continuant, rather than the nasal, is left out of this and subsequent tableaux. Such a candidate could be eliminated, however, by a high-ranked MAX[root] constraint, militating against deletion of a root consonant.

c. Ranking paradox

/N-θɛru/ ‘bright’	*NC̥	*NFRIC	MAX	ID[voice]	ID[continuant]
a. nθɛru	*!	*			
b. nðɛru		*!			
c. ntɛru	*!				
d. ☞ ndɛru				*	*
e. ☜ θɛru			*!		

The ranking paradox can be resolved in at least two ways, as is noted in (11).

(11) Diagnostic 5: A CFE ranking paradox can be resolved by accounts that take advantage of the cumulative effects of constraints, e.g., harmonic grammar (HG; Legendre, Miyata and Smolensky, 1990a, 1990b; Smolensky and Legendre, 2006) or local constraint conjunction (LC; Smolensky, 1995; Łubowicz, 2002; Smolensky, 2006).

The relative merits of HG and LC were already discussed in Chapter 1, and some analyses of CFEs within LC will be presented and argued against in Chapter 4. To demonstrate that both are capable of accounting for CFEs, though, each is presented below.

The problematic candidate in (10c) is candidate d., in which the post-nasal fricative has undergone both Stopping and Voicing. The attested output is candidate e., in which the nasal has been deleted and which violates the relatively high-ranked constraint MAX. To rule out candidate d., then, in an LC account, it is necessary to conjoin IDENT[voice] and IDENT[continuant] and to rank the conjoined constraint above MAX. The conjoined constraint will thus rule out the unattested candidate d. The definition of the LC constraint is given in (12).

(12) LC constraint

ID[voice]&ID[cont]$_S$: The conjunction of IDENT[voice] and IDENT[continuant] in the domain of a single segment; i.e., input and output correspondents have the same value for the features [voice] and [continuant]

Tableaux illustrating the effect of the LC constraint are shown in (13). The constraint is irrelevant in the tableaux in (13a) and (13b) because none of the unfaithful candidates in these tableaux violate both IDENT[voice] and IDENT[continuant]. In the tableau in (13c), however, the LC constraint successfully eliminates candidate d., leaving the other unmarked candidate, the deletion candidate e., as the optimal output.

(13) LC account of Kikuyu CFE

a. MAX >> IDENT[voice]

/N-kɛnu/ 'happy'	ID[voice]& ID[cont]$_S$	*NC̥	*NFRIC	MAX	ID[voice]	ID[cont]
a. ŋkɛnu		*!				
b. ☞ ŋgɛnu					*	
c. kɛnu				*!		

b. MAX >> IDENT[continuant]

/N-βuθu/ 'rotten'	ID[voice]& ID[cont]$_S$	*NC̥	*NFRIC	MAX	ID[voice]	ID[cont]
a. mβuθu			*!			
b. ☞ mbuθu						*
c. βuθu				*!		

c. LC constraint eliminates doubly-unfaithful candidate

/N-θɛru/ 'bright'	ID[voice]& ID[cont]$_S$	*NC̥	*NFRIC	MAX	ID[voice]	ID[cont]
a. nθɛru		*!	*			
b. nðɛru			*!			
c. ntɛru		*!				
d. ndɛru	*!				*	*
e. ☞ θɛru				*		

In an HG account, on the other hand, constraints are weighted rather than ranked and cumulativity is expressed as the sum of the weights of multiple constraints. In Kikuyu, the marked outputs are banned by high-weight markedness constraints. Because Kikuyu prefers featural changes to segmental deletion in the singly-derived cases, MAX must outweigh both IDENT[voice] and IDENT[continuant]. In the case where deletion is preferred, however, the sum of the weights of IDENT[voice] and IDENT[continuant] is enough to outweigh a single violation of MAX. The relevant weighting arguments are given in (14).

(14) Constraint weightings necessary for Kikuyu

Weighting	Result
$W_{\text{*NC̥}} > W_{\text{ID[voice]}}$	/N-kɛnu/ ŋgɛnu > ŋkɛnu
$W_{\text{*NFRIC}} > W_{\text{ID[continuant]}}$	/N-βuθu/ mbuθu > mβuθu
$W_{\text{MAX}} > W_{\text{ID[voice]}}$	/N-kɛnu/ ŋgɛnu > kɛnu
$W_{\text{MAX}} > W_{\text{ID[continuant]}}$	/N-βuθu/ mbuθu > βuθu
$W_{\text{MAX}} < W_{\text{ID[voice]}} + W_{\text{ID[continuant]}}$	/N-θɛru/ θɛru > ndɛru

The consequences of these weightings are shown in the tableaux in (15). The most crucial weightings among faithfulness constraints are shown above each tableau. (15a) and (15b) illustrate the necessity of assigning MAX a heavier weight than each of the IDENT constraints. The tableau in (15c), however, shows that the cumulative weight of the IDENT constraints is sufficient to exclude the doubly-derived candidate in favor of the deletion candidate.

(15) HG account of Kikuyu CFE

a. $W_{\text{MAX}} > W_{\text{ID[voice]}}$

/N-kɛnu/ 'happy'	*NC̥ w=2	*NFRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. ŋkɛnu	-1					-2
b. ☞ ŋgɛnu				-1		-1
c. kɛnu			-1			-1.5

b. $W_{\text{MAX}} > W_{\text{ID[continuant]}}$

/N-βuθu/ 'rotten'	*NC̥ w=2	*NFRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. mβuθu		-1				-2
b. ☞ mbuθu					-1	-1
c. βuθu			-1			-1.5

c. $W_{\text{MAX}} < W_{\text{ID[voice]}} + W_{\text{ID[continuant]}}$

/N-θɛru/ 'bright'	*NC̥ w=2	*NFRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. nθɛru	-1	-1				-4
b. nðɛru		-1		-1		-3
c. ntɛru	-1				-1	-3
d. ndɛru				-1	-1	-2
e. ☞ θɛru			-1			-1.5

The Kikuyu CFE is of the (1f) type in the typology in Chapter 1: the violations of two faithfulness constraints trade off for the violation of a third, such that the Kikuyu phonology prefers to delete a segment rather than change both its [voice] and [continuant] specifications. Most of the CFEs described in this thesis fall into this category in the typology. In the next section, though, we turn to a CFE from a different category.

2.3 Greek: Another portion of the CFE typology

In the Kikuyu CFE above, the violations of two faithfulness constraints traded off for the violation of a third. Because constraints may be violated more than once in a grammar, however, it is possible that two violations of a single faithfulness constraint may trade off for the violation of a different faithfulness constraint. An example comes from Greek (Newton, 1972; Pater, 1996). Relevant data are given in (16). In Greek, adjacent obstruents agree in voice, as in (16a). This is true both of underlying and derived obstruent sequences. Moreover, as in Kikuyu, post-nasal obstruents must be voiced, as in (16b). Given active processes of voice assimilation and post-nasal voicing, the expected repair for a cluster like /mps/ would be [mbz], in which post-nasal voicing feeds voice assimilation. Instead, the nasal consonant is deleted, a fell-swoop process that eliminates the need for two other rules to apply. This is true of derived word-medial clusters (16c) and, in certain dialects (Chios, Rhodes, Cyprus, Lesbos, Samos), across word boundaries (16d). Note that this deletion is not due to a general ban on three-element clusters; the language contains words with clusters like [skn], [spr], [mbl], [ndr], and [xtr].

(16) Greek nasal-obstruent-obstruent clusters

a. Adjacent obstruents agree in voice (all dialects)

[érapsa][8]	'I sew, aorist'	cf. [rávo]	'I sew'
[ráftis]	'tailor'	cf. [rávo]	'I sew'
[náftis]	'sailor'	cf. [navaɣó]	'I get shipwrecked'
[kurástika]	'I am tired'	cf. [kurázo]	'I tire'
[avɣó]	'egg'	[péfko]	'pine'

[8] In some words, a manner dissimilation process results in a stop-fricative alternation that is not relevant to the CFE (Newton, 1972).

b. Postnasal obstruents are voiced (all dialects)

/ton + topo/	[tondopo]	‘the place’	cf. [topo]	‘place’
[kumbí]	‘button’	[émboros]	‘merchant’	
[pénde]	‘five’	[ándras]	‘man’	
[aɲg^{j}ía]	‘pots’	[siɲg^{j}enís]	‘relative’	

c. CFE across morpheme boundaries (all dialects)

/e-peNp-s-a/	[épepsa]	‘I send, aorist’	cf. [pémbo]	‘I send’
/e-sfiNk-s-a/	[ésfiksa]	‘I squeeze, aorist’	cf. [sfiŋgo]	‘I squeeze’
/laNp-si/	[lápsi]	‘flash’	cf. [lámbo]	‘shine’

d. CFE across word boundaries (Chios, Rhodes, Cyprus, Lesbos, Samos)

/ton + psefti/	[topséfti]	‘the liar’	*[tombzéfti][9]
/ton + kseno/	[tokséno]	‘the foreigner’	*[toŋgzéno]
/tin + tsimba/	[titsimbá]	‘he pinches her’	*[tind^{z}imbáyi]

In a rule-based framework, the Greek CFE would require three rules: Post-Nasal Voicing, Obstruent Voice Assimilation, and Nasal Deletion. Nasal Deletion is the most specific rule, requiring that nasals delete only when they precede two obstruents. In order to get the attested outputs, Nasal Deletion would be ordered first, bleeding the two voicing rules. If either of the voicing rules was ordered before Nasal Deletion, then Nasal Deletion would be bled. The Greek CFE is characterized by a mutual bleeding relationship, like Kikuyu. Moreover, this CFE also reflects overlapping conspiracies.

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[9] Greek also exhibits a process of nasal place assimilation, which is not relevant to the current CFE and will not be discussed further.

The Post-Nasal Voicing and Nasal Deletion processes conspire to eliminate sequences of a nasal followed by a voiceless obstruent, and the Obstruent Voice Assimilation and Nasal Deletion processes conspire to avoid sequences of adjacent voiced and voiceless obstruents. (The participation of Nasal Deletion in this second part of the conspiracy is not completely transparent, but the Nasal Deletion process essentially occurs to avoid creating a sequence of a voiced obstruent followed by a voiceless one. That is, Nasal Deletion contributes to the conspiracy by making sure that disagreeing clusters do not arise, while Obstruent Voice Assimilation repairs these sequences when they do arise.)

The constraints necessary to account for the Greek CFE are listed in (17). As in Kikuyu, a markedness constraint bans sequences of a nasal followed by a voiceless obstruent. Another markedness constraint bans adjacent obstruents that differ in [voice] specification. Faithfulness constraints require identity in the feature [voice] and militate against deletion.

(17) Constraints relevant for the Greek CFE

*NC̥: Sequences of a nasal followed by a voiceless obstruent are banned

AGREE[voice]: Adjacent obstruents that differ in [voice] specification are banned

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

MAX: Input segments have output correspondents

In standard OT, a ranking paradox arises between MAX and IDENT[voice]. The tableaux in (18) illustrate the paradox. (18a) shows that for an input with adjacent obstruents that differ in the voice feature, it is crucial for MAX to be ranked above

IDENT[voice] in order to get assimilation rather than deletion. Likewise, MAX must be ranked above IDENT[voice] to achieve post-nasal voicing in an NC̥ sequence instead of deletion, as in (18b). However, ranking MAX above IDENT[voice] prohibits the attested deletion candidate in (18c). Candidate c., which violates IDENT[voice] twice, once for the post-nasal consonant and again for the following consonant, is incorrectly predicted to win.

(18) Standard OT fails to account for Greek

a. MAX >> IDENT[voice]

/rávtis/ 'tailor'	*NC̥	AGREE[voice]	MAX	ID[voice]
a. rávtis		*!		
b. ☞ ráftis				*
c. rávis			*!	

b. MAX >> IDENT[voice]

/ton + topo/ 'the place'	*NC̥	AGREE[voice]	MAX	ID[voice]
a. tontopo	*!			
b. ☞ tondopo				*
c. totopo			*!	

c. Ranking paradox

/ton + psefti/ 'the liar'	*NC̥	AGREE[voice]	MAX	ID[voice]
a. tompsefti	*!			
b. tombsefti		*!		
c. ☞ tombzefti				**
d. ☜ topsefti			*!	

Note that the input to the tableaux in (18c) is not doubly-marked; it violates only one markedness constraint, *NC̥. This is an example of the *potentially doubly-marked* input mentioned in (2) above. The actual input violates only a single markedness constraint, but the expected repair for that markedness constraint, in this case Post-Nasal Voicing, would create another marked structure. This is reflected in candidate b. in (18c). In this candidate, Post-Nasal Voicing has occurred, creating a new marked sequence: a voiced obstruent followed by a voiceless one. Thus the input has the potential to violate a second markedness constraint; this occurs when the expected repair is made. The predicted winner in (18c), in which both the underlying marked structure and the created marked structure have been repaired, violates IDENT[voice] twice but is not eliminated by those violations because IDENT[voice] is too low-ranked.[10] In an HG account, however, the two violations of IDENT[voice] can gang up on MAX, eliminating candidate c. in favor of candidate d. Weighting arguments are shown in (19).

(19) Constraint weightings necessary for Greek

Weighting	Result	
$W_{AGREE[voice]} > W_{ID[voice]}$	/rávtis/	ráftis > rávtis
$W_{*NC̥} > W_{ID[voice]}$	/ton+topo/	tondopo > tontopo
$W_{MAX} > W_{ID[voice]}$	/rávtis/	ráftis > rávis
	/ton+topo/	tondopo > totopo
$W_{MAX} < W_{ID[voice]} + W_{ID[voice]}$	/ton+psefti/	topsefti > tombzefti

[10] An LC account of Greek would rely on the self-conjunction of IDENT[voice] in the domain of adjacent segments.

HG tableaux are in (20). As in Kikuyu, the high weight of the markedness constraints rules out any candidate that has not repaired marked structures. MAX has a weight of 1.5 and IDENT[voice] a weight of 1. When a candidate with a single violation of MAX competes with a candidate with a single violation of IDENT[voice], as in (20a,b), the higher weight of MAX eliminates the deletion candidate. When a candidate with a single violation of MAX competes with a candidate with two violations of IDENT[voice], as in (20c), however, the cumulative weight of the IDENT[voice] violations is enough to avoid that candidate in favor of the deletion candidate.

(20) HG account of Greek CFE

a. $W_{MAX} > W_{IDENT[voice]}$

/rávtis/ 'tailor'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=1	H
a. rávtis		-1			-2
b. ☞ ráftis				-1	-1
c. rátis			-1		-1.5

b. $W_{MAX} > W_{IDENT[voice]}$

/ton + topo/ 'the place'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=1	H
a. tontopo	-1				-2
b. ☞ tondopo				-1	-1
c. totopo			-1		-1.5

c. $W_{MAX} < W_{IDENT[voice]} + W_{IDENT[voice]}$

/ton + psefti/ 'the liar'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=1	H
a. tompsefti	-1				-2
b. tombsefti		-1			-2
c. tombzefti				-2	-2
d. ☞ topsefti			-1		-1.5

The Greek CFE differs from the Kikuyu CFE in that two low-ranked faithfulness constraints do not gang up on a third; instead, the multiple violations of a single low-weight faithfulness constraint, IDENT[voice], trade off for a single violation of a higher-weight constraint, MAX. This is an instance of the CFE category (1g) in Chapter 1. This illustrates that it is not simply the violation of too many different faithfulness constraints that is problematic; it is the cumulative violation of all faithfulness constraints, whether that refers to multiple violations of one constraint or single violations of multiple constraints. In Greek, as in Kikuyu, being too unfaithful, as measured by the cumulative weight of all faithfulness constraints, is disallowed.

It is important to note that HG does not exclude languages in which outputs do violate multiple faithfulness constraints, as is true, for instance, in examples of feeding or counterbleeding interactions. In Chapter 6, we examine another dialect of Greek, one in which multiply-unfaithful outputs are allowed. In that chapter, we also discuss why multiply-unfaithful outputs are sometimes allowed.

2.4 Conclusion

This chapter has introduced the definition of a CFE and proposed a number of useful diagnostics in determining whether a language contains a CFE, which are repeated in (21) below. The Kikuyu and Greek examples illustrated two of the four logically possible CFE types, both instances in which some faithfulness constraints gang up on another faithfulness constraint. The diagnostics introduced in this chapter are true of cases in which it is a faithfulness constraint that is ganged-up-on. In Chapter 5, a third type of CFE, one in which faithfulness constraints gang up on a markedness constraint, will be exemplified and discussed. This case will require some minor modification of the diagnostics given in this chapter.

(21) Five diagnostics of a CFE

1. CFEs show the interaction of (at least) three different processes, one of which has more narrowly defined structural description than the others.
2. The CFE rules are ordered in a mutual bleeding relationship, such that the special rule bleeds each of the other rules.
3. The rules participate in overlapping conspiracies; that is, the special rule plays a role in each of (at least) two conspiracies.
4. Standard optimality theory typically cannot account for CFEs because a ranking paradox arises (typically among the faithfulness constraints).
5. The CFE ranking paradox can be resolved by accounts that take advantage of the cumulative effects of constraints, e.g., HG or LC.

As noted above, the majority of the CFEs analyzed in this thesis are of the (1f) type in the typology in Chapter 1; that is, they are cases in which the violations of two different faithfulness constraints trade off for a violation of a third faithfulness constraint. This type of CFE is not only found in fully-developed languages; it also occurs in developing phonologies. In Chapter 3, we examine CFEs found in first-language acquisition, and in Chapter 4, we will turn to CFEs in loanword adaptation.

CHAPTER 3

CUMULATIVE FAITHFULNESS EFFECTS IN FIRST-LANGUAGE ACQUISITION

3.1 Introduction

This chapter introduces and analyzes cumulative faithfulness effects (henceforth CFEs) in first-language acquisition. As discussed in Chapter 1, CFEs occur when multiple markedness constraints outrank or outweigh multiple faithfulness constraints, which themselves are differentially ranked or weighted, forcing the grammar to choose between multiple unmarked (and thus unfaithful) mappings. L1 acquisition is thus a prime source for CFEs—most researchers agree that in the initial state, markedness constraints outrank faithfulness constraints, thus setting up the type of grammar in which CFEs are likely to be found. The four examples discussed in this chapter come both from normally developing and delayed phonologies, showing that CFEs are naturally occurring and not uncommon phenomena. The normally-developing examples come from the famous case study of Amahl (Smith, 1973). The phonologically-delayed examples are drawn from the Developmental Phonology Archive at Indiana University (Gierut, 2008). The Archive includes data on more than 200 children with phonological delays who were participating in a larger descriptive and experimental investigation of phonological development. The chapter begins with a general discussion of the study of first-language phonological acquisition and the assumptions that are made here (§3.2). §3.3 illustrates two nearly identical CFEs in which segmental deletion is used to avoid a two-feature repair; §3.4 discusses a CFE in which deletion of one segment is used to avoid a two-step repair which consists of deletion of another segment plus a featural repair. §3.5 introduces a CFE in which featural deletion is used to avoid a two-feature repair. A discussion of the acquisition process is given in §3.6, with a summary and conclusion in §3.7.

3.2 Assumptions about first-language acquisition

Before we can delve into the analysis of the CFEs found in first-language acquisition, some assumptions about the acquisition process must be stated. In this section, assumptions about the child's underlying representations, her perception, and her initial-state grammar will be discussed.

3.2.1 Underlying representations

In prior analyses of children's phonologies, assumptions about the child's underlying representations varied widely. Some researchers argued that children had correct, adult-like underlying representations (e.g., Smith, 1973; Ingram, 1974, 1975; Menn, 1978; Donegan and Stampe, 1979; Demuth, 1995; Pater and Paradis, 1996; Dinnsen, O'Connor and Gierut, 2001; Gnanadesikan, 2004; Dinnsen and Gierut, 2008a), while others claimed that children's underlying representations were different from adults' (e.g., Kornfeld and Goehl, 1974; Macken, 1980; Weismer, Dinnsen and Elbert, 1981; Maxwell, 1984; Leonard and McGregor, 1991; Jaeger, 1997; Fikkert, 2006). With the advent of optimality theory, such arguments became less important. One of the fundamental principles of OT is “richness of the base” (Prince and Smolensky, 1993/2004), which states that underlying representations may not be restricted. All outputs must be derived by the ranking of constraints, not by limits placed on underlying representations. This means that we cannot posit that children have restricted underlying representations; for instance, if a child fails to produce the sound /z/, this must be due to a high-ranking markedness constraint banning [z] in the output, rather than an inventory constraint on the child’s underlying representation. It is still possible that the child’s underlying representation differs from the adult’s, but in any case, the constraint ranking must be such that if correct underlying representations were posited, the attested output is still derived.[1]

This thesis takes the view that for the most part, children do have adult-like underlying representations. Several pieces of evidence for this claim exist. First, while children go through various stages of mispronunciation, their comprehension tends to be correct. The argument here is that the child can correctly comprehend the phonological contrasts made by adults because their underlying representations match the surface forms produced by adults (Smith, 1973). A second piece of evidence comes from children’s alternations. A child with a word-final deletion process may produce ‘dog’ as [dɔ] but ‘doggie’ as [dɔgi]. The correct production of the consonant in medial position implies that the child has the correct underlying representation and that a rule, process, or constraint ranking produces the word-final devoicing (Weismer, Dinnsen and Elbert, 1981). Evidence of knowledge of a target distinction, even in children who seem to

[1] Note that this does position does not exclude the fact that sometimes children internalize incorrect representations for individual words, as evidenced by specific lexical items that retain incorrect productions well after the misproduced sound has been learned (e.g., Bernhardt and Stemberger, 1998).

neutralize the contrast, has been provided by acoustic analyses (e.g., Forrest and Rockman, 1988; Forrest, Weismer, Hodge, Dinnsen and Elbert, 1990; Forrest, Weismer, Elbert and Dinnsen, 1994). That is, some children have been shown to produce covert contrasts that are not obvious to the adult listener, but are nevertheless present. Moreover, there is evidence that some children overgeneralize learned sounds, using them as replacements for other sounds. This can lead to pronunciations that are correct in early stages of learning but become incorrect later (e.g., Smith, 1973; Bernhardt and Stemberger, 1998; Gierut, 1998). While this might seem to be counterevidence to the claim that the child's underlying representations are correct, these problems have been dealt with in OT without violating richness of the base (e.g., Dinnsen and Gierut, 2008a and citations therein). (For alternative views of underlying representations in constraint-based frameworks, see, e.g., Bernhardt and Stemberger, 1998; Pater, 2004.)

3.2.2 Perception

A second point assumed here is that children's perception of the ambient language is correct (other viewpoints have been expressed by, e.g., Braine, 1976; Macken, 1980). As mentioned above, it has been shown that children's comprehension often precedes their production (e.g., Jusczyk, 1997; Stager and Werker, 1997; Werker and Stager, 2000). This has been called the "comprehension/production dilemma" (e.g., Yeni-Komshian, Kavanagh and Ferguson, 1980a, 1980b; Smolensky, 1996a). The child's accurate perception of sounds, compared with the outputs his grammar produces, should, over time, be the motivation for constraint re-ranking or re-weighting. Several methods for dealing with the comprehension/production dilemma have been put forth (Smolensky, 1996a; Hale and Reiss, 1998; Pater, 2004). Most importantly, though, we assume here that a child's failure to produce a sound, or to produce a sound accurately, is not due to the child's misperception, but due to the constraint ranking of the production component of the grammar.

3.2.3 The initial state

The study of acquisition from an optimality theoretic perspective has become a major topic of study in recent years. Here we provide a very brief overview of first-language acquisition and constraint reranking; the reader is directed to broader overviews of the subject for more detail (see, e.g., Barlow and Gierut, 1999; Kager, Pater and Zonneveld, 2004; Dinnsen and Gierut, 2008b). The question of how children acquire the correct constraint ranking for the language to which they are exposed has led to a number of assumptions about the initial-state ranking. First of all, it has been argued that in the initial state, markedness constraints outrank faithfulness constraints (e.g., Smolensky, 1996b; Gnanadesikan, 2004; cf. Hale and Reiss, 1998). This initial ranking explains why children's early outputs are typically so unmarked, and it also avoids the subset problem, a long-acknowledged problem for acquisition (Baker, 1979; Angluin, 1980). The grammars of some languages are more complex than others, with more sounds or sound patterns allowed. The less complex grammars can be seen as subsets of the more complex grammars. When a child (or an L2 learner) is learning a language, it is possible that she might hypothesize a grammar less restrictive than the true grammar, but still consistent with the input she hears. She will never hear negative evidence to prove that her grammar is not sufficiently restrictive, and so the learner arrives at a grammar that is more complex than necessary. Ranking the markedness constraints high in the initial state, and demoting them minimally, ensures that the learner's grammar is as restrictive as possible. Several theories have been put forth on how the child moves from the initial-state ranking to the ranking of the adult language. For example, the recursive constraint demotion algorithm (RCD; Tesar and Smolensky, 1998) asserts that as the child hears forms that do not match the outputs of her grammar, she demotes the constraint that had eliminated the correct (newly heard) winner below the highest-ranked constraint that her grammar's previous, incorrect winner violated. This ensures minimal demotion of constraints, leaving the markedness constraints as high as possible and making the grammar as restrictive as possible. In RCD, constraints are always demoted, never promoted.

A somewhat different set of assumptions about the initial weighting in harmonic grammar have been made and are outlined by Jesney and Tessier (2007), who adapt the Gradual Learning Algorithm (GLA; Boersma, 1998; Boersma and Hayes, 2001) for HG. Jesney and Tessier argue that the only necessary weighting bias in an HG account is that output-oriented constraints are weighted above input-oriented constraints in the initial state. The result of this is that markedness constraints and output-to-output faithfulness constraints begin with a greater weight than input-to-output faithfulness constraints. Jesney and Tessier propose that in the initial state, faithfulness constraints have a weight of zero, and markedness constraints have a weight of some positive number (they use 100); this initial weighting serves to keep the grammar restrictive. According to the GLA, as the learner hears outputs that fail to match the outputs produced by his grammar, the learner increases by some small amount the weight of constraints violated by his previous, incorrect winner, and decreases by some small amount the weight of constraints violated by the observed, correct winner. Thus constraints both increase and decrease in weight (unlike RCD). Jesney and Tessier also propose that the weights of the output-oriented faithfulness constraints be adjusted faster than those of the input-oriented constraints to ensure that learning is restrictive.

In the rest of this chapter, we examine a number of CFEs and discuss the HG weightings required to account for the children's outputs. In §§3.3-3.5, we will not discuss how the child might arrive at the constraint weightings necessary for CFEs, but we return to this issue in §3.6.

3.3 Two similar CFEs

Our first example of a CFE in first-language acquisition comes from Smith's (1973) influential diary study of Amahl, a typically developing child learning British English. Smith details Amahl's phonological acquisition from about two to four years of age; the examples in (1) come from Amahl's data between ages 2;3 (years;months) and 2;5.[2] During this stage, Amahl exhibited an allophonic voicing pattern in the stop series: all word-initial stops were realized as voiceless unaspirated lenis, all word-medial stops were realized as voiced, and all word-final stops were realized as voiceless fortis. The most relevant of these patterns for the issue at hand is the word-final devoicing of all stops, as is shown in (1a). The second pattern is fricative stopping: coronal fricatives in all word positions are realized as stops, with the voicing corresponding to the allophonic

[2] Smith gives Amahl's age in the years;days format; to be consistent with the other children in this chapter, the age is converted instead to years;months, with the months estimated from the number of days. The data for this CFE come from Stages 1-4 of Amahl's acquisition, which occurred between the 60th and 137th days of his second year.

pattern, as in (1b).[3] The CFE arises when we examine the behavior of target word-final voiced fricatives. Given the evidenced stopping and devoicing patterns, we might expect word-final /z/ to be realized as [t]; instead, this segment is deleted entirely. This pattern is shown in (1c).

(1) Amahl (2;3 to 2;5)

a. Word-final stop devoicing

[b̥ɛt]	‘bed’	[g̊uːp]	‘cube’	[ɛk]	‘egg’
[d̥ɛt]	‘red’	[wʌp]	‘rub’	[g̊ɛk]	‘leg’

b. Fricative stopping

[b̥ʌt]	‘bus’	[d̥ʌn]	‘sun’	[d̥u]	‘zoo’
[b̥ʌt]	‘brush’	[d̥əːt]	‘shirt’	[d̥ɛ]	‘there’
[b̥aːt]	‘bath’	[d̥əːd̥iː]	‘thirsty’		

c. Word-final voiced fricatives delete

[nɔiː][4]	‘noise’	[d̥iː]	‘cheese’	[b̥iː]	‘please’
[nuː]	‘nose’	[g̊aːgiː]	‘glasses’	[d̥idə]	‘scissors’
[b̥aiə]	‘pliers’	[nuː]	‘news’		

[3] Labials in general seem either exempt from or only marginally susceptible to the error patterns mentioned above. It seems as though the error patterns which govern other segments were beginning to be eradicated for labials at this stage.

[4] Amahl frequently, but not consistently, lengthens the vowel before an underlyingly voiced obstruent, whether it is deleted or devoiced. While this violates the constraint IDENT[long], this is not a problem if that constraint is assumed to have a very low weight. The lengthening of a vowel before a deleted obstruent produces a counterbleeding opacity effect. As counterbleeding is not the focus of this thesis, this effect will be ignored here. For two different methods for dealing with counterbleeding in optimality theory, see McCarthy (1999, 2007a).

Smith (1973: 27-31) provides a series of rules (shown in (2)) to account for these error patterns. One rule, R11, mandates the deletion of the coronal fricative [z] in word-final position. Two other rules account for fricative stopping (R24) and the complementary distribution of voicing, requiring voiceless stops in word-final position (R25). As Smith notes, R11 must precede R24 and R25; thus a word-final /z/ is deleted before stopping and devoicing have a chance to apply. This is a bleeding relationship; the rule deleting word-final /z/ bleeds the stopping and devoicing rules. Note that if R24 or R25 preceded R11, stopping or devoicing would bleed z-deletion. The rules are thus in a mutual bleeding relationship, one of the hallmarks of a CFE.

(2) Amahl's rules

	/bɛd/	/bʌs/	/nɔiz/
a. R11: Final voiced-fricative deletion			
[+cont, +voice] → ø / ___ #	---	---	nɔi
b. R24: Fricative stopping			
[-son] → [-cont]	---	bʌt	---
c. R25: Final devoicing			
[-son, -cont] → [-voice] / ___ #	bɛt	---	---
d. Other rules	b̥ɛt	b̥ʌt	nɔiː
	[b̥ɛt]	[b̥ʌt]	[nɔiː]

Amahl's CFE is mirrored in the data of another child, Child ED47, whose error patterns are virtually identical to Amahl's, with one important difference: while Amahl's error patterns are concentrated primarily in word-final position, Child ED47 exhibits word-initial neutralization. The data in (3a) demonstrate that voiced and voiceless coronal stops are both realized as voiceless stops word-initially; the same voiced and voiceless coronal stops contrast postvocalically (3b).[5] Child ED47 also presents with a stopping pattern, but unlike Amahl, this pattern is restricted to initial position (3c); in final position, stops and fricatives contrast (3d). Word-initial voiced coronal fricatives, which might be expected to both stop and devoice, are instead deleted (3e).

(3) Child ED47 (5;5)

a. Initial [t] and [d] merge to [t]

[tis]	'teeth'	[tag]	'dog'
[toz]	'toes'	[tiʊ]	'deer'
[tɛnt]	'tent'	[tiri]	'deer-i'
[teɔ]	'tail'	[towɚ]	'door'

b. Postvocalic [t] and [d] contrast

[it^h]	'eat'	[haɪd]	'hide'
[$ba\text{ɪ}t^h$]	'bite'	[bʌd]	'bed'
[waɪt]	'light'	[waɪd]	'ride'
[$h\text{æ}t^h$]	'hat'	[wid]	'read'
[$n\text{ʌ}t^h$]	'nut'	[mʌd]	'mud'

[5] As in Amahl's case, labial segments are immune to these error patterns.

c. Initial [s] is realized as [t]

[tɪŋk]	'sink'	[tɪnə]	'santa'
[tʌni]	'sunny'	[tup]	'soup'
[tɑk]	'sock'		

d. Postvocalic [s] and [z] contrast

[wes]	'yes'	[tʰiz]	'cheese'
[wɛs]	'dress'	[ðiz]	'these'
[veɪs]	'vase'	[bʌz]	'buzz'
[aɪs]	'ice'	[toz]	'toes'
[bʌs]	'bus'	[woz]	'rose'
[maʊs]	'mouse'	[nɔiz]	'noise'

e. Initial [z] is deleted

[ibə]	'zebra'	[ɪki]	'ziggy'
[ipɚ]	'zipper'	[ɪpɪn]	'zipping'
[ud]	'zoo'		

Unlike Amahl, Child ED47 has a phonological delay. Children with phonological delay do not exhibit any other organic or speech problems; they have normal hearing, normal oral-motor control, normal non-verbal intelligence, and normal vocabulary development. Child ED47 scored within normal limits on the Peabody Picture Vocabulary Test (PPVT; Dunn and Dunn, 1981), a test of receptive and expressive vocabulary. He scored at the 9th percentile, however, on the Goldman-Fristoe Test of Articulation (GFTA; Goldman and Fristoe, 1986), an indication that his phonology was severely delayed relative to his age-matched peers. That is, the sound patterns of children with phonological delays simply lag behind those of their normally-developing peers. For example, Child ED47's error patterns at age 5;5 are strikingly similar to Amahl's at age 2;5.

Child ED47's initial neutralization patterns may be surprising from the point of view of fully-developed languages, in which initial position is a strong, prominent position and contrasts are more likely to be neutralized postvocalically (e.g., Beckman, 1998; Lombardi, 1999; Smith, 2002). However, many children, both typically developing and phonologically delayed, exhibit massive initial neutralization while retaining postvocalic contrasts. Dinnsen and Farris-Trimble (2008b) discuss a number of such cases and provide an appendix with an extensive list of examples from the child-acquisition literature. They argue that in the initial state, it is actually final position that is prominent, motivating an initial-state ranking of the prominence-assigning constraints FINALPROM >> INITIALPROM, defined in (4).

(4) Prominence-assigning constraints

INITIALPROM: The initial constituent of a syllable, foot or prosodic word must be prominent

FINALPROM: The final constituent of a syllable, foot or prosodic word must be prominent

These constraints indicate which part of the prosodic unit is prominent; when FINALPROM outranks INITIALPROM, final constituents (i.e., the rhyme of the syllable, or the final syllable of the foot, or the final foot of the prosodic word) are prominent, as is the case for Child ED47. When the other ranking obtains, the initial constituents are prominent, as for Amahl. The tableaux in (5) illustrate how the ranking of these two constraints chooses between phonetically identical candidates with different prominence. Prominence is indicated by underlining. The tableau in (5a) shows that for Amahl, the ranking of INITIALPROM over FINALPROM requires that all words have initial prominence. The tableau in (5b), on the other hand, illustrate that the opposite ranking allows for only words with final prominence for Child ED47.

(5) Tableaux assigning prominence

a. Amahl exhibits initial prominence

/CVC/	INITIALPROM	FINALPROM
a. ☞ $\underline{C}VC$		*
b. $C\underline{VC}$	*!	
c. CVC	*!	*

b. Child ED47 exhibits final prominence

/CVC/	FINALPROM	INITIALPROM
a. $\underline{C}VC$	*!	
b. ☞ $C\underline{VC}$		*
c. CVC	*!	*

What causes the change from final to initial prominence for adults? Dinnsen and Farris-Trimble (2008b) argue that as the size of a child's lexicon increases, it undergoes reorganization, causing a reranking of the prominence-assigning constraints, and children begin to show the effects of initial prominence. Thus rather than defining optimality theoretic constraints by initial or final position, as has been the custom (e.g., Beckman, 1998), Dinnsen and Farris-Trimble argue that these constraints should be defined by prominent contexts, with the ranking of the prominence-assigning constraints determining what the prominent context is at any given stage of acquisition.

The constraints necessary to account for the CFEs of Amahl and Child ED47 are listed in (6). The markedness constraints are defined by weak context, meaning that the marked structure is banned in weak position only. Thus the same constraints are relevant for both Amahl and Child ED47; the difference between their phonologies lies in their different prominent positions. As initial position is prominent for Amahl, voiced obstruents are banned in final position. Likewise, since Child ED47 has voice and manner contrasts postvocalically, the markedness constraints banning voiced obstruents and fricatives in weak contexts will serve to eliminate these structures initially. Prominence-sensitive markedness constraints, like context-sensitive markedness constraints, have context-free counterparts. These constraints ban marked structures in all positions. Since Amahl has no fricatives in any position, it is clear that the context-free constraint *FRICATIVE is high-ranked; in his tableaux, then, the context-free markedness constraint will be shown in place of the prominence-sensitive one. For both children, faithfulness constraints militating against change in voice or continuancy, as well as deletion, are relevant.

(6) Constraints relevant for Amahl's and Child ED47's CFEs

*VOICE$_{Weak}$: Voiced obstruents are banned in nonprominent position

*FRIC$_{Weak}$: Fricatives are banned in nonprominent positions

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

IDENT[continuant]: Input and output correspondents have the same value for the feature [continuant]

MAX: Input segments have output correspondents

As the tableaux above in (5) showed, the ranking of INITIALPROM above FINALPROM determines which word position is prominent for Amahl and Child ED47; in the following tableaux, only candidates with the correct prominence assignment are shown, and the prominence-assigning constraints are omitted from the tableaux. Amahl's ranking paradox is shown in (7). Because voiced obstruents never appear in the weak position and fricatives never occur at all in Amahl's outputs, it is clear that the markedness constraints against them must be high-ranked. A ranking paradox between the faithfulness constraints occurs, however. MAX must be ranked above IDENT[voice] and IDENT[continuant] to compel preservation of the final obstruents in words like 'bed' and 'bus', respectively, as in (7a,b). The high ranking of MAX, however, would eliminate the attested deletion candidate in (7c), [nɔiː], for input 'noise' in favor of the doubly-derived output, [nɔit].

(7) Standard OT fails to account for Amahl's CFE

a. MAX >> IDENT[voice]

/bɛd/ 'bed'	*VOICE$_{Weak}$	*FRICATIVE	MAX	ID[voice]	ID[cont]
a. b̥ɛd	*!				
b. ☞ b̥ɛt				*	
c. b̥ɛ			*!		

b. MAX >> IDENT[continuant]

/bʌs/ 'bus'	*VOICE$_{Weak}$	*FRICATIVE	MAX	ID[voice]	ID[cont]
a. b̥ʌs		*!			
b. ☞ b̥ʌt					*
c. b̥ʌ			*!		

c. Ranking paradox

/nɔiz/ 'noise'	*VOICE$_{Weak}$	*FRICATIVE	MAX	ID[voice]	ID[cont]
a. n̲ɔiːz	*!	*			
b. n̲ɔis		*!		*	
c. n̲ɔiːd	*!				*
d. ☞ n̲ɔit				*	*
e. ☜ n̲ɔiː			*!		

Child ED47's ranking paradox is illustrated in (8) below. These tableaux are identical to Amahl's, except that the structures that violate the constraints are found in word-initial position. Thus output [tɪki] is incorrectly predicted for input ‘ziggy’, rather than the attested output [ɪki].

(8) Standard OT fails to account for Child ED47’s CFE

a. MAX >> IDENT[voice]

/dɔg/ ‘dog’	*VOICE$_{Weak}$	*FRIC$_{Weak}$	MAX	ID[voice]	ID[cont]
a. dag	*!				
b. ☞ tag				*	
c. ag			*!		

b. MAX >> IDENT[continuant]

/sup/ ‘soup’	*VOICE$_{Weak}$	*FRIC$_{Weak}$	MAX	ID[voice]	ID[cont]
a. sup		*!			
b. ☞ tup					*
c. up			*!		

c. Ranking paradox

/zɪgi/ ‘ziggy’	*VOICE$_{Weak}$	*FRIC$_{Weak}$	MAX	ID[voice]	ID[cont]
a. zɪki[6]	*!	*			
b. sɪki		*!		*	
c. dɪki	*!				*
d. ☞ tɪki				*	*
e. ☜ ɪki			*!		

[6] The violation of IDENT[voice] incurred by the mapping of /g/ to [k] is not shown here as it is shared by every candidate.

For both Amahl and Child ED47, the change from input /s/ or /d/ to output [t] is allowed, but the change from /z/ to [t] is not. The problem with the change from target /z/ to output [t] does not rest in the markedness constraints, as [t] is a completely unmarked segment and an acceptable substitute for /s/ and /d/. Rather, the trouble with substituting [t] for /z/ is that it is too unfaithful. Amahl's grammar must choose between two equally unmarked outputs for a word like 'noise': [nɔit] and [nɔiː]. The output [nɔit] violates two relatively low-weight faithfulness constraints, IDENT[voice] and IDENT[continuant], but the output [nɔiː] violates one relatively high-weight constraint, MAX. Amahl's grammar chooses the most faithful of the unmarked outputs, measured by the cumulative weight of violated faithfulness constraints. When the two unmarked outputs each violate only one faithfulness constraint, deletion is not permitted. This result can be obtained in an HG account by weighting the faithfulness constraints such that a single violation of MAX outweighs a single violation of either of the IDENT constraints, but the cumulative violation of both IDENT constraints outweighs MAX. In other words, the violations of IDENT[voice] and IDENT[continuant] trade off for a violation of MAX. Relevant weighting arguments are given in (9). (The same constraint weightings are necessary for Child ED47.)

(9) Constraint weightings necessary for Amahl

Weighting	Result	
$W_{*VOICEWeak} > W_{ID[voice]}$	/bɛd/	bɛt > bɛd
$W_{*FRICATIVE} > W_{ID[cont]}$	/bʌs/	bʌt > bʌs
$W_{MAX} > W_{ID[voice]}$	/bɛd/	bɛt > bɛ
$W_{MAX} > W_{ID[cont]}$	/bʌs/	bʌt > bʌ
$W_{MAX} < W_{ID[voice]} + W_{ID[cont]}$	/nɔiz/	nɔi > nɔit

The first four of these weightings are illustrated in (10a,b), where the weight of MAX is 1.5 and the weight of each of the IDENT constraints is 1. In (10c), however, the cumulative harmony of candidate d., the doubly-derived candidate, is 2 (the sum of the weights of each of the IDENT constraints). This harmony overcomes the single violation of MAX incurred by candidate e., which thus wins.

(10) HG account of Amahl's CFE

a. $W_{MAX} > W_{ID[voice]}$

/bɛd/ 'bed'	*VOICEWeak w=2	*FRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. b̥ɛd	-1					-2
b. ☞ b̥ɛt				-1		-1
c. b̥ɛ			-1			-1.5

b. $W_{MAX} > W_{ID[continuant]}$

/bʌs/ 'bus'	*VOICEWeak w=2	*FRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. b̥ʌs		-1				-2
b. ☞ b̥ʌt					-1	-1
c. b̥ʌ			-1			-1.5

c. $W_{\text{MAX}} < W_{\text{ID[voice]}} + W_{\text{ID[continuant]}}$

/nɔiz/ ‘noise’	*VOICEWeak w=2	*FRIC w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. nɔiːz	-1	-1				-4
b. nɔis		-1		-1		-3
c. nɔiːd	-1				-1	-3
d. nɔit				-1	-1	-2
e. ☞ nɔiː			-1			-1.5

Just as Amahl’s CFE could be easily accounted for in HG, so can Child ED47’s. Again, the account is identical. Tableaux are shown in (11).

(11) HG account of Child ED47’s CFE

a. $W_{\text{MAX}} > W_{\text{ID[voice]}}$

/dɔg/ ‘dog’	*VOICEWeak w=2	*FRICWeak w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. dag	-1					-2
b. ☞ tag				-1		-1
c. ag			-1			-1.5

b. $W_{\text{MAX}} > W_{\text{ID[continuant]}}$

/sup/ ‘soup’	*VOICEWeak w=2	*FRICWeak w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. sup		-1				-2
b. ☞ tup					-1	-1
c. up			-1			-1.5

c. $W_{\text{MAX}} < W_{\text{ID[voice]}} + W_{\text{ID[continuant]}}$

/zɪgi/ ‘ziggy’	*VOICE$_{\text{Weak}}$ w=2	*FRIC$_{\text{Weak}}$ w=2	MAX w=1.5	ID[voice] w=1	ID[cont] w=1	H
a. zɪki	-1	-1				-4
b. sɪki		-1		-1		-3
c. dɪki	-1				-1	-3
d. tɪki				-1	-1	-2
e. ☞ ɪki			-1			-1.5

In each of the two CFEs presented in this section, the children deleted a segment, rather than making a two-feature repair. In the next section, we turn to a CFE in which two different types of deletion are at odds; one type of deletion is used to avoid another type of deletion that would have necessitated a two-step repair.

3.4 A differential deletion CFE

The next example of a CFE in acquisition also comes from Amahl, in particular his production of nasal+obstruent sequences. The data shown in (12) come from stages 1-7 of Amahl’s acquisition of English, which span the ages 2;3 to 2;6.[7] At the early stage of acquisition, Amahl disallowed all nasal+obstruent sequences. By stage 2, however, he was starting to acquire nasal+voiced obstruent sequences, and so the focus here is on target nasal+voiceless obstruent sequences. As we saw above, Amahl has a fricative stopping process, shown with examples of final /s/ in (12a). Moreover, in target nasal+voiceless stop sequences, Amahl deletes the nasal, as in (12b). When the nasal is

[7] In days, stages 1-7 span ages 2;60 to 2;157.

followed by a voiceless fricative, such as /s/, however, the /s/ is deleted, as in (12c). Note that this process avoids the other logically possible repair, in which the nasal deletes and the /s/ is realized as [t].

(12) Amahl's NC̥ sequences (2;3 to 2;6)

a. Fricative stopping

[b̥ʌt]	'bus'	[weːt]	'face'	[d̥uːt]	'juice'
[aut]	'house'	[ait]	'ice'	[mait]	'mice'
[nait]	'nice'	[b̥əːt]	'purse'	[d̥ɛt]	'yes'

b. Nasals delete before voiceless stops

[ɛt]	'ant'	[b̥ʌp]	'bump'	[g̊ik]	'drink'
[g̊aut]	'count'	[wæp]	'ramp'	[b̥ik]	'pink'

c. Voiceless fricative [s] deletes after a nasal

[d̥itən]	'distance'	[ɛbənin(in)]	'ambulance'
[b̥ætən]	'balance'		

This CFE is particularly interesting because deletion of the obstruent in a word like 'distance' is used to avoid a two-step repair in which deletion would still have been one of the steps. That is, Amahl always uses deletion to repair nasal+voiceless obstruent clusters (which are banned by the markedness constraint *NC̥, defined in (13)), but he has different deletion patterns depending on the structure of the cluster. This indicates that the constraint MAX must be split into at least two independent constraints, MAX[obstruent] and MAX[nasal]. These constraints, also defined in (13), require the preservation of obstruents and nasals independently of one another.[8]

(13) Constraints relevant for Amahl's second CFE

*NC̥: Sequences of a nasal followed by a voiceless obstruent are banned

MAX[obstruent]: Input obstruent consonants have output correspondents

MAX[nasal]: Input nasal consonants have output correspondents

As long as it is the only repair for a given structure, Amahl prefers to delete the nasal in a nasal+voiceless obstruent cluster, leaving the obstruent. However, when the deletion of the nasal would leave an obstruent that still has to undergo a repair, such as a fricative, then the fricative is instead deleted. The deletion of the fricative thus eliminates two marked structures at once: a fricative, and a nasal+voiceless consonant sequence. A ranking paradox arises, however, in a standard optimality theoretic account. (14a) simply shows that stopping, rather than deletion, is the preferred repair for a singleton voiceless fricative. In a nasal+voiceless obstruent cluster, however, some type of deletion always occurs. MAX[obstruent] must outrank MAX[nasal] in order to preserve the obstruent in a

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[8] Note that these constraints are not meant to preserve a feature, such as the feature [+nasal], but instead to preserve a segment which is defined by that feature. They can be thought of as MAXSEG[obstruent] and MAXSEG[nasal], respectively. That is, only the deletion of an obstruent segment or a nasal segment could violate MAX[obstruent] or MAX[nasal], respectively; the change from an /n/ to a [t], for example, would instead violate an IDENT constraint, which we are assuming here to be high ranked. MAXSEG[nasal] is distinct from MAXFEATURE[nasal], used in Chapter 4 to militate against the deletion of a nasal feature.

word like ‘ant’, as in (14b); however, this ranking would also preserve the obstruent in a word like ‘distance’, as in (14c), which is not the attested pattern.

(14) Standard OT fails to account for Amahl’s NC̥ sequences

a. MAX[obstruent] >> IDENT[continuant]

/bʌs/ ‘bus’	*NC̥	*FRIC	MAX[obs]	MAX[nasal]	ID[cont]
a. b̥ʌs		*!			
b. ☞ b̥ʌt					*
c. b̥ʌ			*!		

b. MAX[obstruent] >> MAX[nasal]

/ænt/[9] ‘ant’	*NC̥	*FRIC	MAX[obs]	MAX[nasal]	ID[cont]
a. ɛnt	*!				
b. ☞ ɛt				*	
c. ɛn			*!		

c. Ranking paradox

/dɪstəns/ ‘distance’	*NC̥	*FRIC	MAX[obs]	MAX[nasal]	ID[cont]
a. d̥istəns	*!	*			
b. d̥itəs		*!			
c. ☞ d̥itət				*	*
d. ☜ d̥itən			*!		

[9] Because vowel quality issues do not affect any of the arguments in this section, we will not be accounting for any of Amahl’s vowel productions.

As was the case for the other CFEs we have seen, Amahl's repairs of NC̥ sequences can easily be accounted for in HG. Here the two MAX constraints must have different weights: MAX[obstruent] must outweigh MAX[nasal], but must not outweigh the sum of MAX[nasal] and IDENT[continuant]. Weighting arguments are given in (15) (excluded in this display are some of the weighting arguments from (9) that are also relevant in this example).

(15) Constraint weightings necessary for Amahl's CFEs, continued

Weighting	Result	
$W_{*NC̥} > W_{MAX[nasal]}$	/ænt/	ɛt > ɛnt
$W_{MAX[obs]} > W_{MAX[nasal]}$	/ænt/	ɛt > ɛn
$W_{MAX[obs]} < W_{ID[cont]} + W_{MAX[nasal]}$	/dɪstəns/	dɪstən > dɪstət

In the tableaux in (16), MAX[obstruent] has a weight of 1.5, while MAX[nasal] has a weight of 1, as does IDENT[continuant]. The weight of MAX[obstruent] is thus too great to allow deletion of an obstruent in (16a,b); obstruents are not deleted except in the case where a candidate with such a deletion is in competition with an equally unmarked candidate in which the nasal has been deleted and the fricative is realized as a stop. That candidate, candidate c. in (16c), violates both MAX[nasal] and IDENT[continuant], the combined weight of which outweigh the single violation of MAX[obstruent] in candidate d. Thus candidate d. has a higher cumulative harmony. MAX[nasal] and IDENT[continuant] essentially gang up on MAX[obstruent].

(16) HG account of Amahl's NC̥ sequences

a. $W_{MAX[obs]} > W_{ID[continuant]}$

/bʌs/ 'bus'	*NC̥ w=2	*FRIC w=2	MAX[obs] w=1.5	MAX[nasal] w=1	ID[cont] w=1	H
a. b̥ʌs		-1				-2
b. ☞ b̥ʌt					-1	-1
c. b̥ʌ			-1			-1.5

b. $W_{MAX[obs]} > W_{MAX[nasal]}$

/ænt/ 'ant'	*NC̥ w=2	*FRIC w=2	MAX[obs] w=1.5	MAX[nasal] w=1	ID[cont] w=1	H
a. ænt	-1					-2
b. ☞ æt				-1		-1
c. æn			-1			-1.5

c. $W_{MAX[obs]} < W_{ID[continuant]} + W_{MAX[nasal]}$

/dɪstəns/ 'distance'	*NC̥ w=2	*FRIC w=2	MAX[obs] w=1.5	MAX[nasal] w=1	ID[cont] w=1	H
a. dɪstəns	-1	-1				-4
b. dɪtəs		-1		-1		-3
c. dɪtət				-1	-1	-2
d. ☞ dɪtən			-1			-1.5

The fact that we had to split MAX into two separate constraints, each requiring retention of a particular type of segment, implies that MAX-SEGMENT may not be such a simple constraint. In the discussion of Amahl's first CFE in §3.3, the constraint MAX was used, but in light of this second CFE, we could replace MAX in that account with MAX[obstruent]. The sound /s/ plays a role in each of these two CFEs, and the error pattern is consistent: /s/ is only deleted if its presence violates two markedness constraints. In this CFE, just as in the previous ones, segmental deletion circumvented the two-step repair. Only by deleting the fricative, however, could Amahl do away with two marked structures at once. Deletion of the nasal would have solved the problem of the cluster, but the fricative would have remained a problem. Amahl, then, chooses the deletion pattern that will require the fewest repair steps.

In the first CFE, shared by Amahl and Child ED47, we saw a case in which deletion was the repair used to avoid a two-feature change. In Amahl's second CFE, deletion of one type of segment was used to avoid a two-step change which included deletion of another type of segment. In the final CFE in this chapter, we turn to a case in which deletion of a geometric featural node, rather than a segment, is the relevant repair.

3.5 A featural-deletion CFE

The last example of a CFE from first-language acquisition discussed here comes from another child with a phonological delay. This child, Child ED13, a male age 4;1, scored below the 1st percentile on the Goldman-Fristoe Test of Articulation (Goldman and Fristoe, 1986), again indicating a severe phonological delay relative to age-matched peers. He presented with two processes which might be expected to interact: velar harmony and fricative stopping. The velar harmony pattern, shown in (17a), requires that a target coronal stop or affricate, i.e., a [-continuant] obstruent, be realized as a velar only when a velar follows elsewhere in the word. The data in (17b) and (17c) demonstrate that if no velar follows, coronal stops are realized target-appropriately, and coronal affricates are realized as stops. The forms in (17d) illustrate the stopping error pattern: coronal fricatives are realized as stops. We might expect the harmony and stopping processes to co-occur in a word that contains an /s/ before a /k/. Instead, in words in which the coronal fricative precedes a velar stop, the fricative is debuccalized, that is, realized as an [h], as in (17e).

(17) Child ED13 (4;1)

a. Coronal stops and affricates assimilate to a following velar

[gʌk]	'duck'	[gʌki]	'ducky'
[gɔ]	'dog'	[gɔg]	'dogs'
[gɔi]	'doggie'	[gɪo]	'tail'[10]
[gjɪkəm]	'chicken'	[goeɪ]	'jelly'

[10] Child ED13 includes liquids in his categorization of velars; this seems to be a changing part of his phonology, as some exceptions do occur. The lateral liquid [l] almost always causes assimilation when it occurs later in the word. The rhotic liquid [r] does not cause assimilation so frequently, but target /dr/ clusters are always realized as [g], as in the example [gʌm] for 'drum', which may be a form of coalescence. Here there is assumed to be some variation in whether liquids cause assimilation, and the few examples in which target /r/ does cause assimilation or target /l/ does not are omitted. The fact that liquids can trigger velar assimilation is not unusual; in fact, Amahl (Smith, 1973: 14) has a very similar process. Moreover, even postvocalic velars that are deleted can trigger assimilation. This produces a counterbleeding interaction, in which it appears that velar assimilation has overapplied in words in which the velar trigger has been deleted. See note 3 for references in accounting for counterbleeding interactions.

b. Coronal stops are realized faithfully when no velar follows

[tʌː]	'tub'	[tɪn]	'twin'
[tiʔ]	'teeth'	[tipi]	'teethy'
[tɛnʔ]	'tent'	[dɪʔ]	'dish'
[daʊ]	'door'	[daʊi]	'door-i'
[dijə]	'deer'	[dioi]	'deer-i'

c. Coronal affricates are realized as stops when no velar follows

[ti]	'cheese'	[tiʔi]	'cheesy'
[tɪʔ]	'chips'	[tijo]	'chair'
[dip]	'jeep'	[dʌmp]	'jump'
[du]	'juice'	[dupi]	'juicy'

d. Coronal fricatives are realized as stops

[t͞uʔ]	'soup'	[tupi]	'soupy'
[to]	'soap'	[topi]	'soapy'
[tʌn]	'sun'	[du]	'zoo'
[dibo]	'zebra'	[dɪpɪŋ]	'zipping'

e. Coronal fricatives are debuccalized before a velar

[hɔk]	'sock'	[hɔki]	'sock-i'
[haɪŋk]	'sink'		

From a rule-based point of view, Child ED13's phonology incorporates four rules. The first rule is Velar Harmony: a coronal stop assimilates in place to a following velar. This rule also applies to coronal stops derived by a rule of Deaffrication. The third rule, Stopping, requires that all supralaryngeal fricatives be realized as stops. Debuccalization, the fourth rule, substitutes the placeless fricative [h] for a coronal fricative that precedes a velar segment. We might expect Stopping and Velar Harmony to apply to the words in (17e), but instead, the Debuccalization rule bleeds the other two rules. If Stopping and Velar Harmony had applied first, they would have bled Debuccalization. As in the other CFEs discussed in this chapter, the rules are in a mutual bleeding relationship.

Note that Child ED13's CFE differs from those of Amahl and Child ED47 in two important ways. First, if Debuccalization did not bleed them, Stopping and Velar Harmony would be in a feeding relationship. In the previous CFEs in this chapter, the two general rules were independent of one another (e.g., Final Devoicing and Stopping are independent in Amahl's case). In the current example, though, Stopping must apply first to create a representation to which Velar Harmony could apply.[11] Feeding interactions are the prime example of doubly unfaithful outputs; the fact that CFEs can eliminate feeding interactions indicates that there may be a stage for some children at which feeding interactions are disallowed precisely because they are too unfaithful. Moreover, the underlying representations for words like those in (17e) are not doubly-marked; they contain only a single marked structure (the coronal fricative). However, it is as if the grammar can foresee the fact that if the Stopping rule applied, it would create

[11] It might be argued that velar harmony could apply to both fricatives and stops, but this misses the broader generalization that if target /s/ became [k] as a result of velar harmony, then velar harmony would have to incorporate a stopping process, for which we have independent evidence.

another marked structure that would require repair. Thus the underlying representation is *potentially doubly-marked*; that is, it has the potential to incur multiple markedness violations.

The second important difference between Child ED13 and the other children discussed in this chapter is that his CFE does not involve deletion of a segment. Both Amahl and Child ED47 avoid a doubly unfaithful output by deleting the doubly-marked segment. Child ED13, on the other hand, uses another strategy to repair the potentially-doubly-marked structure: he substitutes an unmarked sound. There are two possible explanations for this strategy. One is a syllabic explanation: perhaps it is the case that Child ED13 has a high-weight constraint requiring that words have onsets. Given that syllables with onsets are typologically unmarked, this is a reasonable assumption. An alternative explanation is that the constraint that militates against segmental deletion, MAX-SEG, has a greater weight in Child ED13's grammar than a constraint that militates against the deletion of an oral place feature, MAX[place] (in feature geometry terms, this might be thought of as a constraint against the delinking of the place node). The sound [h] is typically assumed to be placeless, as no constriction in the oral cavity is required to produce this sound (e.g., Steriade, 1987; Halle, 1995; Rose, 1996; Parker, 2001).[12] By simply removing any oral place feature from the input coronal fricative, Child ED13 arrives at an unmarked alternative without having to resort to wholesale segmental deletion.

The additional constraints needed to account for Child ED13's error pattern are defined in (18). Because the only fricative present in Child ED13's inventory is [h], we

[12] Some researchers (e.g., McCarthy, 1994; Lombardi, 2002) have argued that glottals are specified for pharyngeal place; the restriction to oral place here avoids this issue.

assume that the relevant markedness constraint is *SUPRALARYNGEALFRICATIVE. Also active in his grammar is a markedness constraint requiring agreement in place with a velar, AGREE[velar]. Because velar harmony only affects a coronal stop, the constraint is defined as such. In addition to IDENT[continuant], also previously defined, the constraint IDENT[coronal] is required, as this is the constraint that is violated in the change from /t/ to [k] in the harmonizing forms. MAX[place], as stated above, militates against the deletion of an oral place feature.

(18) Constraints relevant for Child ED13's CFE

*SUPRALARYNGEALFRICATIVE: Fricatives with a supralaryngeal place of articulation are banned

AGREE[velar]: Coronal stops are banned before a velar in the same word

IDENT[coronal]: Input and output correspondents have the same value for the feature [coronal]

MAX[place]: Input oral features have output correspondents

The inclusion of IDENT[feature] versus MAX[feature] constraints in Con is a much-debated issue. IDENT[feature] constraints militate against the change in features of segments that stand in correspondence; if an input segment has no output correspondent, then the IDENT[feature] constraints are irrelevant. MAX[feature] constraints, on the other hand, militate against the deletion of a given feature and are also violated when an entire segment is deleted. McCarthy and Prince (1995) use IDENT[feature] constraints, but note that MAX[feature] constraints may be necessary in Con, and McCarthy (2007b, to appear) has argued that MAX[feature] constraints are necessary for the gradual change required in optimality theory with candidate chains (OT-CC; McCarthy, 2007a). In OT-CC, chains of outputs, much like derivations, replace OT's universal candidate set. These chains must be gradual, that is, each step of the chain must violate only one faithfulness constraint relative to the prior step. McCarthy (2007b) uses the constraint MAX[place] as the necessary gradual intermediate step between a segment with oral place and the deletion of that segment. He argues that the chain <pat.ka, pa.ka> is invalid, because the deletion of the [t] violates two faithfulness constraints, MAX[place] and MAX-SEG. Instead, the valid chain would be <pat.ka, paʔ.ka, pa.ka>. For Child ED13, then, the change from /s/ to [h] violates MAX[place]. We argue here that the same change does not violate IDENT[coronal], because the input segment has a place feature and the output segment has no place feature. The [coronal] place feature of the underlying /s/ has simply been deleted. Thus the segments that stand in correspondence do not each have place features that can be compared.

With these additional constraints, it becomes clear that Child ED13's data produce a ranking paradox in OT. MAX[place] must be ranked higher than the IDENT constraints in order to get the attested output for 'duck' and 'sun', as is shown in (19a,b), but this ranking also predicts the feeding candidate [kɔk] for the input 'sock', as in (19c).[13]

[13] MAX-SEG is excluded from the following tableaux, but it would rule out a candidate like [ɔk] for the input 'sock'

(19) Standard OT fails to account for Child ED13's CFE

a. MAX[place] >> ID[coronal]

/dʌk/ 'duck'	AGREE	*SUPRAFRIC	MAX[place]	ID[coronal]	ID[cont]
a. dʌk	*!				
b. ☞ gʌk				*	
c. ʔʌk			*!		

b. MAX[place] >> ID[continuant]

/sʌn/ 'sun'	AGREE	*SUPRAFRIC	MAX[place]	ID[coronal]	ID[cont]
a. sʌn		*!			
b. ☞ tʌn					*
c. hʌn			*!		

c. Ranking paradox

/sɔk/ 'sock'	AGREE	*SUPRAFRIC	MAX[place]	ID[coronal]	ID[cont]
a. sɔk		*!			
b. tɔk	*!				*
c. ☞ kɔk				*	*
d. ☜ hɔk			*!		

The use of featural deletion to avoid a doubly-derived repair is simple to account for in HG. In the above examples, we saw that a MAX-SEGMENT constraint had to have a greater weight than the other relevant faithfulness constraints; here the MAX-FEATURE constraint fills that role instead. If MAX-FEATURE (here MAX[place]) is assigned a weight greater than that of IDENT[coronal] or IDENT[continuant], but less than the some of those two constraints, a CFE is the result. The violations of IDENT[coronal] and IDENT[continuant] trade off for a violation of MAX[place]. These weighting arguments are shown in (20).

(20) Constraint weightings necessary for Child ED13

Weighting	Result	
$W_{AGREE} > W_{ID[coronal]}$	/dʌk/	gʌk > dʌk
$W_{*SUPRAFRIC} > W_{ID[cont]}$	/sʌn/	tʌn > sʌn
$W_{MAX[place]} > W_{ID[coronal]}$	/dʌk/	gʌk > ʔʌk
$W_{MAX[place]} > W_{ID[cont]}$	/sʌn/	tʌn > hʌn
$W_{MAX[place]} < W_{ID[coronal]} + W_{ID[cont]}$	/sɔk/	hɔk > kɔk

In the HG tableaux in (21), the sum of the weights of IDENT[coronal] and IDENT[continuant] eliminate the candidate [kɔk] for input 'sock' (in 21c), but the fact that MAX[place] is heavier than either of the individual IDENT constraints means that the debuccalized candidates for input 'duck' (in 21a) and 'sun' (in 21b) are avoided in favor of the assimilated and stopped candidates, respectively.

(21) HG account of Child ED13

a. $W_{MAX[place]} > W_{ID[coronal]}$

/dʌk/ 'duck'	AGREE w=2	*SUPRAFRIC w=2	MAX[place] w=1.5	ID[cor] w=1	ID[cont] w=1	H
a. dʌk	-1					-2
b. ☞ gʌk				-1		-1
c. ʔʌk			-1			-1.5

b. $W_{\text{MAX[place]}} > W_{\text{ID[cont]}}$

/sʌn/ 'sun'	AGREE w=2	*SUPRAFRIC w=2	MAX[place] w=1.5	ID[cor] w=1	ID[cont] w=1	H
a. sʌn		-1				-2
b. ☞ tʌn					-1	-1
c. hʌn			-1			-1.5

c. $W_{\text{MAX[place]}} < W_{\text{ID[coronal]}} + W_{\text{ID[cont]}}$

/sɔk/ 'sock'	AGREE w=2	*SUPRAFRIC w=2	MAX[place] w=1.5	ID[cor] w=1	ID[cont] w=1	H
a. sɔk		-1				-2
b. tɔk	-1				-1	-3
c. kɔk				-1	-1	-2
d. ☞ hɔk			-1			-1.5

Child ED13's phonological patterns also bring up an important point regarding the number of faithfulness violations versus degree of unfaithfulness. In Child ED13's productions in (17), affricates are realized as stops when no velar follows, and they do assimilate to a following velar. The affricate stopping process is in response to a high-ranked markedness constraint banning affricates, and the repair process violates the constraint IDENT[branching]. The change from an affricate to a stop, as in (17a,c), does not violate IDENT[continuant], as both the affricate and the stop are [-continuant]. Both constraints are defined in (22) below.

(22) Additional constraints

*AFFRICATE: Affricates (segments with branching structure) are banned

IDENT[branching]: Input segments with branching structure have output correspondents with branching structure

Note that when affricates assimilate to a following velar, as shown in (17a), they violate both IDENT[branching] and IDENT[coronal]. The question is why these two constraints do not gang up on MAX[place], thus requiring pre-velar affricates to be realized as glottal stops? Pre-velar fricatives cannot violate the two constraints IDENT[continuant] and IDENT[coronal]. Why, then, are pre-velar affricates allowed to violate two constraints, and pre-velar fricatives not? The answer is two-fold. First, it is not always the case that two constraints have enough cumulative value to outweigh some higher-weight constraint. That is, it is possible that the combined value of IDENT[branching] and IDENT[coronal] is not sufficient to outweigh MAX[place]. Second, note that there is no glottal affricate. When the pre-velar fricative is realized as [h], that mapping only violates IDENT[coronal]—it does not violate Ident[continuant]. Were an affricate to be realized as a glottal stop, however, the mapping would violate IDENT[branching], because the glottal stop does not have branching structure. This means that for a pre-velar affricate, the assimilated candidate and the placeless candidate share a violation of IDENT[branching], and those violations essentially cancel one another out. The evaluation, then, is left up to the assimilated candidate's violation of IDENT[coronal] versus the placeless candidate's violation of MAX[place]. Since MAX[place] outweighs IDENT[coronal], the assimilated candidate wins.

These facts are illustrated in the tableaux in (23). In these tableaux, *AFFRICATE is shown in place of *FRICATIVE (which is irrelevant in these examples), and IDENT[branching] is shown in place of IDENT[continuant] (also irrelevant). *AFFRICATE is assigned a weight of 2, the same as the other markedness constraints, and IDENT[branching is assigned a weight of 1, the same as the other IDENT constraints. In (23a), an affricate that is not pre-velar is simply deaffricated, violating only IDENT[branching]. In (23b), on the other hand, a pre-velar affricate assimilates. Candidate a., the fully faithful candidate, and candidate b., which has simply deaffricated, both violate high-weight markedness constraints. As noted above, candidates c. and d. both violate IDENT[branching], and so that constraint is essentially irrelevant. The assimilated candidate also violates IDENT[coronal], which has a lower weight than MAX[place], the constraint violated by the glottal stop candidate. Thus we see that there is no gratuitous place feature deletion; a place feature can only delete when the alternative repair violates constraints whose cumulative value outweighs MAX[place]. In other words, a place feature will not delete when the deletion also violates another constraint. The fell-swoop repair only occurs when it only incurs a single unfaithful mapping.

(23) HG also accounts for doubly-unfaithful production of affricates

a. Affricate realized as coronal stop when not pre-velar

/ʤip/ 'jeep'	AGREE w=2	*AFFR w=2	MAX[place] w=1.5	ID[cor] w=1	ID[branch] w=1	H
a. ʤip		-1				-2
b. ☞ dip					-1	-1
c. ʔip			-1		-1	-2.5

b. Pre-velar affricate assimilates

/tʃɪkən/ 'chicken'	AGREE w=2	*AFFR w=2	MAX[place] w=1.5	ID[cor] w=1	ID[branch] w=1	H
a. tʃɪkəm		-1				-2
b. tɪkəm	-1				-1	-3
c. ʔɪkəm			-1		-1	-2.5
d. ☞ gjɪkəm[14]				-1	-1	-2

It is interesting that for Child ED13, affricates can undergo consonant harmony when fricatives cannot. One possible explanation is that for sounds to be in a trigger-target relationship with respect to harmony, they have to share certain features. For Child ED13, it seems that sounds that share the [-continuant] feature may be in harmony relationship, but for a sound to undergo harmony *and* to change its value for [continuant] is too great a change, as reflected in the greater weight of faithfulness violations incurred by such a candidate. Previous research has shown that when more marked sounds like alveolar fricatives or affricates undergo harmony, there is also an independent process reducing the fricatives or affricates to alveolar stops in the non-harmonizing contexts (Macken, 1978; Vihman, 1978; Dinnsen and Farris, 2007; Dinnsen and Farris-Trimble, 2008a). Thus it is the alveolar stop that is vulnerable to consonant harmony; when affricates or fricatives undergo the harmony, we can assume that the harmony is a result of the creation of an alveolar stop by stopping or deaffrication. That generalization is true of Child ED13: affricates underwent harmony (17a), but there was evidence of an independent deaffrication process (17c). More interestingly, though, fricatives did not

[14] We assume here that the [j] is not part of a branching onset, but is instead part of the nucleus.

undergo harmony, even though there was evidence of an independent stopping process. As the fricatives did not undergo harmony, they do not contradict the generalization drawn from Macken and Vihman's work. Nevertheless, it is an interesting fact that fricatives failed to harmonize, even though they did undergo stopping in non-harmonizing contexts. This simply lends credence to the argument that Child ED13's grammar did not allow outputs that were too unfaithful; alveolar fricatives can undergo stopping, but combining stopping with a change in place is just too unfaithful. This problem apparently does not arise with affricates, which do not undergo a change in continuancy. Because any repair for an affricate would require a change in branching structure, this repair washes out, and the change in place is not so costly.

The above discussion has examined three types of CFE: those in which segmental deletion is used to avoid a two-feature repair, those in which the deletion of one segment is used to avoid a two-step repair that consisted of deletion and featural change, and those in which featural deletion is used to avoid a two-feature repair. It seems, then, that constraints against deletion are particularly relevant in the acquisition of CFEs. In the next section, we explore the course of acquisition of the MAX constraints from the point of view of HG.

3.6 The weight of MAX

One of the most important issues in dealing with any acquisition-related phenomenon is determining how the child arrived at his grammar. In the preceding sections, how did Amahl, Child ED47, and Child ED13 arrive at grammars in which multiple faithfulness violations were dispreferred? In this section, we examine Jesney and Tessier's (2007) adaptation of the GLA to HG, henceforth HG-GLA. We will show that HG-GLA predicts a stage at which CFEs will arise, and also predicts a later stage at which doubly-derived outputs are preferred. This second (later) stage is shown to occur in Amahl's longitudinal sample.

3.6.1 How the weighting came to be

Jesney and Tessier propose a single initial-state weighting bias in HG-GLA: output-oriented (that is, markedness and output-to-output faithfulness) constraints begin with greater weights than input-output constraints. They propose that markedness constraints begin with a weight of 100, and input-to-output faithfulness constraints begin with a weight of zero. Zero is chosen, as opposed to a small number like 20, because in the case of an allophonic relationship, it is important that faithfulness not be able to influence the candidate selection. While this restriction may not be crucial in the present case, we nevertheless adopt Jesney and Tessier's initial weighting assumptions. Note that, up until this point, the HG tableaux have shown weightings in the small digits (e.g. 1, 2.5., etc.). The switch to larger numbers in this section (e.g., a range from 0-100) is simply a shift in perspective. In all cases, what is crucial is the relative weights among the constraints, along with the degree of change in weighting brought about by error-driven learning. The larger numbers here reflect the fact that the child may have to recognize many examples of a given error before the relevant weightings change enough to change the child's productions.

The tableaux in (24) illustrate the hypothetical initial state for Amahl's z-deletion CFE (Stage 0). Note that, because all faithfulness constraints are equally ranked in the initial state, and they have a lower weight than the markedness constraints, this grammar predicts variation between the deletion candidate and the stopped/devoiced candidate for each input. No earlier data for Amahl are available to test this prediction, but it does seem to be in line with the observation that deletion is relatively common in early stages of acquisition. Given these weights, it is expected that about half the time, Amahl would produce the deletion candidates, and about half the time he would produce the stopped and/or devoiced candidates.

(24) Hypothetical HG account of Amahl Stage 0

a. Variation between deletion and devoicing

/bɛd/ 'bed'	*VOICE$_{Weak}$ w=100	*FRIC w=100	MAX w=0	ID[voice] w=0	ID[cont] w=0	H
a. b̥ɛd	-1					-100
b. ☞ b̥ɛt				-1		0
c. ☞ b̥ɛ			-1			0

b. Variation between deletion and stopping

/bʌs/ 'bus'	*VOICE$_{Weak}$ w=100	*FRIC w=100	MAX w=0	ID[voice] w=0	ID[cont] w=0	H
a. b̥ʌs		-1				-100
b. ☞ b̥ʌt					-1	0
c. ☞ b̥ʌ			-1			0

c. Variation between deletion and stopping/devoicing

/nɔiz/ ‘noise’	*VOICEWeak w=100	*FRIC w=100	MAX w=0	ID[voice] w=0	ID[cont] w=0	H
a. nɔiːz	-1	-1				-200
b. nɔis		-1		-1		-100
c. nɔiːd	-1				-1	-100
d. ☞ nɔit				-1	-1	0
e. ☞ nɔiː			-1			0

In HG-GLA, constraint weightings are changed when the child recognizes that the output produced by his grammar does not match some production made by a speaker of the language, called the learning datum. This recognition spurs the grammar to slightly increase the weight of any constraint violated by the learner’s incorrect output, and to slightly decrease the weight of any constraint violated by the observed datum. Here we follow Jesney and Tessier by assuming that the plasticity, or the amount by which a constraint will increase or decrease following an observed mismatch, is greater for markedness constraints than for faithfulness constraints. We will thus use a plasticity of 1 for faithfulness constraints and 2 for markedness constraints.[15]

Imagine, then, that Amahl hears the word ‘bed’. The child compares this heard learning datum to the output produced by his own grammar, which varies between [b̥ɛt]

[15] In actuality, the plasticity decreases over time, so that the earlier learning data have a greater influence on the grammar than the later learning data; we will ignore this decrease for the time being. We also abstract away from the noise that is implemented computationally in HG-GLA to allow for stochastic evaluation. These are important attributes of the HG-GLA model, but are not crucial to understanding how CFEs may arise.

and [b̥ɛ]. On the assumption that each of these two outputs would be chosen about 50% of the time before learning begins, we will show the weighting change outcome for each of the two possible outputs. The tableaux in (25) show how the constraint weights will change as the learner compares his output to the learning datum for 'bed'. (25a) shows the weight adjustments made when Amahl compares the learning datum to his devoiced output candidate, and (25b) shows the weight adjustments made when Amahl compares the learning datum to his deletion output candidate. The arrows by the violation marks indicate that the constraint must decrease (→) or increase (←) in weight by the plasticity. The "old" weight shown under the constraint name in each tableau simply signifies the weight that was achieved by the prior learning datum comparison; new weights created by each of the comparisons are also shown.

(25) Learning triggered by hearing the learning datum 'bed'

a. 50% of the learner's previous outputs: [b̥ɛt]

/bɛd/ 'bed'	*VOICE$_{\text{Weak}}$ old w=100 new w=98	*FRIC old w=100	MAX old w=0	ID[voice] old w=0 new w=1	ID[cont] old w=0	H
a. b̥ɛd	-1 →					-98
b. ☞ b̥ɛt				← -1		-1

b. 50% of the learner's previous outputs: [b̥ɛ]

/bɛd/ 'bed'	*VOICE$_{\text{Weak}}$ old w=98 new w=96	*FRIC old w=100	MAX old w=0 new w=1	ID[voice] old w=1	ID[cont] old w=0	H
a. b̥ɛd	-1 →					-96
b. ☞ b̥ɛ			← -1			-1

In (25a), Amahl compares his output [b̥ɛt] to the observed learning datum [bɛd]. This tells him that he must decrease the weight of the markedness constraint *VOICE$_{Weak}$ and increase the weight of the faithfulness constraint IDENT[voice]. Next, in (25b), Amahl compares his output [b̥ɛ] to the same learning datum. This again will decrease the weight of *VOICE$_{Weak}$, but it increases the weight of MAX. Imagine now that Amahl, using the weights learned from the tableaux in (25), hears another learning datum, that for 'bus'. The tableaux in (26) illustrate the learning that the comparison of this learning datum with Amahl's previous output triggers.

(26) Learning triggered by hearing the datum 'bus'

a. 50% of the learner's previous outputs: [b̥ʌt]

/bʌs/ 'bus'	*VOICE$_{Weak}$ old w=96	*FRIC old w=100 new w=98	MAX old w=1	ID[voice] old w=1	ID[cont] old w=0 new w=1	H
a. b̥ʌs		-1 →				-98
b. ☞ b̥ʌt					← -1	-1

b. 50% of the learner's previous outputs: [b̥ʌ]

/bʌs/ 'bus'	*VOICE$_{Weak}$ old w=96	*FRIC old w =98 new w=96	MAX old w=1 new w=2	ID[voice] old w=1	ID[cont] old w=1	H
a. b̥ʌs		-1				-96
b. ☞ b̥ʌ			-1			-2

Because of the learning datum 'bus', Amahl decreased the weight of *FRICATIVE and increased the weight of IDENT[continuant] (when comparing the learning datum to his output [b̥ʌt]) and MAX (when comparing the learning datum to his output [b̥ʌ]).

Finally, assume that Amahl hears one more learning datum, that for the word 'noise'. The learning achieved by Amahl's comparison of the learning datum to his grammar's outputs is shown in (27).

(27) Learning triggered by hearing the datum 'noise'

a. 50% of the learner's previous outputs: [nɔit]

/nɔiz/ 'noise'	*VOICE$_{Weak}$ old w=96 new w=94	*FRIC old w=96 new w=94	MAX old w=2	ID[voice] old w=1 new w=2	ID[cont] old w=1 new w=2	H
a. nɔiːz	-1 →	-1 →				-188
b. ☞ nɔit				← -1	← -1	-4

b. 50% of the learner's previous outputs: [nɔiː]

/nɔiz/ 'noise'	*VOICE$_{Weak}$ old w=94 new w=92	*FRIC old w=94 new w=92	MAX old w=2 new w=3	ID[voice] old w=2	ID[cont] old w=2	H
a. nɔiːz	-1 →	-1 →				-184
b. ☞ nɔiː			← -1			-3

We see that after hearing the learning datum 'noise', Amahl decreased the weight of both markedness constraints and increased the weight of all three faithfulness constraints (IDENT[voice] and IDENT[continuant] because of the comparison with his previous winner [nɔit], and MAX because of the comparison with his previous winner [nɔiː]).

Look now at the weightings Amahl has arrived at after hearing the learning data ‘bed’, ‘bus’ and ‘noise’ and comparing each to both of his variable outputs. The weighting after making all six of these comparisons is shown in (28).

(28) Weight of constraints after learning

*VOICE$_{Weak}$	*FRICATIVE	MAX	ID[voice]	ID[cont]
w=92	w=92	w=3	w=2	w=2

Note first that the markedness constraints still have a much greater weight than any of the faithfulness constraints, meaning that Amahl’s outputs will still be unmarked (and hence unfaithful). More importantly, though, MAX has a weight greater than either of the IDENT constraints, but smaller than the sum of the IDENT constraints! This is exactly the relative weighting necessary for a CFE. This occurs because deletion is a possible repair for any of the marked structures in Amahl’s grammar. That is, Amahl can delete a voiced coda, or a fricative, or a voiced coda fricative—thus when he hears any of the three relevant learning data, he must increase the weight of MAX. The same is not true of the IDENT constraints—a change in voice quality is irrelevant if the target is a voiceless fricative, just as a change in continuancy is irrelevant if the input is a voiced coda stop. In other words, every time Amahl hears ‘bed’, or ‘bus’, or ‘noise’, he will increase the weight of MAX, but he will only increase the weight of IDENT[voice] when he hears ‘bed’ or ‘noise’, and he will only increase the weight of IDENT[continuant] when he hears ‘bus’ or ‘noise’. This means that after hearing this set of three words, MAX will have a weight that is 1.5 times greater than either of the IDENT constraints’ weights. (To prove the point, imagine the weighting adjustments if Amahl now heard each of the three words again: MAX would have a weight of 6, and IDENT[voice] and IDENT[continuant] would each have a weight of 4. If he then heard the same three words a third time, the weight of MAX would increase to 9, and the weight of the IDENT constraints to 6. The weight of MAX is always 1.5 times the weight of either of the IDENT constraints.) Note that because the weights of the faithfulness constraints are still so close together, the stochastic property of evaluation will sometimes produce a ranking in which the weight of MAX is lower than the weight of the IDENT constraints, allowing, at least for a time, for Amahl’s grammar to continue to vary between deletion and featural change candidates. Only when the weight of MAX is enough larger than the weight of the IDENT constraints that it will always dominate them will Amahl’s grammar consistently produce CFEs (and thus fail to increase the weight of MAX so frequently, because his grammar will less frequently produce incorrect deletion candidates).

This finding is, of course, contingent on the assumption that Amahl hears words with voiced codas, words with fricatives, and words with voiced coda fricatives at equal rates. This is far from being a proven fact. Even without this assumption of perfectly equal learning data, though, the fact remains that Amahl will have more opportunities to increase the weight of MAX than of either of the IDENT constraints, because of the simple fact that deletion can be used as a repair for a broader subset of the marked structures than either of the IDENT constraints (for instance, Amahl also uses segmental deletion as a repair for NC clusters, as was shown in (12)). This is in line with our thinking of deletion as a fell-swoop repair—it is a repair that can be used for almost any marked structure. We can thus expect the weight of MAX to increase at a greater weight than that of the IDENT constraints, and, for some period of time, we can also expect that the weight of MAX will not yet overtake the sum of the IDENT constraints.

If the weight of MAX is increasing at a greater weight than that of the IDENT constraints, this makes the prediction that at some point, the weight of MAX may overtake the cumulative weight of the IDENT constraints, effectively disallowing deletion as a possible repair process. We next turn to Amahl's longitudinal data to see if this prediction is borne out.

3.6.2 Amahl's longitudinal data

Amahl's first CFE, in which coda /z/ was deleted rather than undergoing stopping and devoicing, was evidenced during what Smith called stages 1-4. No examples of coda /z/ in a monomorph occur again until stage 8. The data in (29) show Amahl's production of coda /z/, as well as coda voiced obstruents and fricatives in all positions, during stages 8 and 9, which span the ages 2;6-2;7. The data in (29a) illustrate that Amahl still had a process of final devoicing, though the final stops he produced at this stage were what Smith describes as voiceless lenis, rather than voiceless fortis. (29b) shows that coronal fricatives were still stopped in all word positions at this stage. The data in (29c) are the most interesting, however. At this stage, coda /z/ was realized as a voiceless stop. That is, Amahl began to allow a substitute that was doubly-derived by the processes of stopping and devoicing, and deletion was no longer an allowable repair

(29) Amahl’s coda /z/ doubly-derived interaction (2;6–2;7)

a. Word-final stop devoicing

[mæd̥]	‘mad’	[rɛd̥/lɛd̥/d̥ɛd̥]	‘red’
[lʌg̊]	‘rug’	[b̥iːaːd̥]	‘beard’
[wag̊]	‘flag’	[b̥ɛd̥]	‘bread’
[g̊aːpg̊uːp]	‘bath-cube’	[g̊ud̥]	‘good’

b. Fricative stopping

[d̥ɔːt]	‘salt’	[d̥it]	‘dish’
[d̥it]	‘sit’	[g̊iptit]	‘Christmas’
[d̥æt]	‘sash’	[ailæt]	‘eyelash’
[d̥oː]	‘throw’	[d̥ɛt/jɛt]	‘yes’
[d̥iː]	‘three’	[nɔːt]	‘north’
[waːdə]	‘father’	[b̥iːt/buiːt]	‘police’
[b̥iːd̥it]	‘pieces’		

c. Voiced fricatives realized as voiceless stops

[d̥oːd̥]	‘those’	[d̥iːd̥]	‘these’
[g̊uːd̥]	‘clothes’	[d̥uːd̥]	‘use’
[inkɔːt]	‘because’	[d̥iː/(d̥iːd̥)]	‘cheese’[16]
[b̥iː/b̥iːd̥]	‘please’		

[16] At this stage, Amahl produced the words ‘cheese’ and ‘please’ in free variation, producing forms with final voiced obstruents as well as forms in which the voiced fricative was deleted. Some variation is expected as constraints adjust during the learning process; here we will focus on the forms with final voiceless obstruents.

It is clear that the weighting of Amahl's constraints has changed between the prior stage and this stage. In order for the doubly-unfaithful repair candidate to win over the deletion candidate for a word like 'those', the weight of MAX must be greater than the cumulative weight of IDENT[voice] and IDENT[continuant]. Note that at the weight adjustment schedule assumed above, once learning begins, MAX would always weigh 1.5 times more than either of the IDENT constraints. If the weight of MAX and the IDENT constraints always increased at this rate, MAX could never outweigh the sum of the IDENT constraints. Clearly, though, Amahl is hearing a great variety of learning data, each of which contributes to his adjustment of constraint weights. As noted above, we can assume that Amahl heard more of the evidence necessary to increase the weight of MAX than that necessary to increase the weight of either of the IDENT constraints, simply because deletion is more often an available repair, and so Amahl's grammar would more often incorrectly select a deletion candidate to compare to the learning datum. It thus does not seem too much of a stretch to imagine that eventually, the weight of MAX will overcome the cumulative weight of the IDENT constraints. When this occurs (assuming that the markedness constraints still have greater weight than the IDENT constraints), deletion will cease to be an allowable repair. A set of rankings that would account for this stage are shown in (30). The tableaux in (30a, b) illustrate that coda devoicing and fricative stopping still occur. More importantly, the tableau in (30c) shows that in the case of an input coda voiced fricative, both stopping and devoicing occur, because the cumulative weight of IDENT[voice] and IDENT[continuant] is smaller than the weight of MAX.

(30) HG account of Amahl's later stages

a. Coda stops are still devoiced

/mæd/ 'mad'	*VOICE$_{Weak}$ w=30	*FRIC w=30	MAX w=38	ID[voice] w=18	ID[cont] w=18	H
a. mæd	-1					-30
b. ☞ mæd̥				-1		-18
c. mæ			-1			-38

b. Fricatives are still realized as stops

/d̥iʃ/ 'dish'	*VOICE$_{Weak}$ w=30	*FRIC w=30	MAX w=38	ID[voice] w=18	ID[cont] w=18	H
a. d̥iʃ		-1				-30
b. ☞ d̥it					-1	-18
c. d̥i			-1			-38

c. Coda voiced fricatives undergo both devoicing and stopping

/ðoz/ 'those'	*VOICE$_{Weak}$ w=30	*FRIC w=30	MAX w=38	ID[voice] w=18	ID[cont] w=18	H
a. doz	-1	-1				-60
b. dos		-1		-1		-48
c. dod	-1				-1	-48
d. ☞ d̥oːd̥				-1	-1	-36
e. do			-1			-38

In sum, Jesney and Tessier's HG-GLA is able to account for the conception of Amahl's CFE, as well as for later stages of his learning. The table in (31) lists three stages in Amahl's learning: the hypothetical initial state, the attested CFE stage, and the attested later stage that allowed doubly-derived outputs. At each stage, the weighting of the faithfulness constraints determines the allowable repairs for marked structures. A number of important questions remain, however. Is it really the case that learners have an initial state in which the available repairs for marked structures vary? What assumptions can we make about the distribution of the learning data available to the child? Is it really the case that the faithfulness constraints are all equally ranked at the initial stage, or is there evidence for weighting distinctions among them? These questions remain for further study.

(31) Hypothesized progression of MAX weighting

Stage	Amahl's stage	Weighting	Result
0	0 (hypothesized)	$W_{IDENT1} = W_{IDENT2} = W_{MAX}$	Variable deletion and feature change
1	1-4	$W_{MAX} > W_{IDENT1}$ $W_{MAX} > W_{IDENT2}$ $W_{IDENT1} + W_{IDENT2} > W_{MAX}$	Deletion only to avoid doubly-derived repairs
2	8-9	$W_{MAX} > W_{IDENT1} + W_{IDENT2}$	Deletion not allowed at all

3.6.3 Revisiting assumptions about the underlying representation

Finally, this section returns briefly to the set of assumptions outlined in §3.2 of this chapter, particularly §3.2.1. We have been assuming that each of the children described in this chapter has adult-like underlying representations for the forms produced. While this assumption is relatively widely accepted, here we consider possible alternative ways to explain the fact that single repairs cannot always simply combine to eliminate doubly-marked (or potentially doubly-marked) structures.

Apart from the cumulative effects of faithfulness constraints, how else might we explain the fact that each of the children in this chapter deletes a particular segment or feature only when it avoids a doubly-derived repair? One alternative is to claim that the child's underlying representations are incorrect. To make this claim, however, it would still be necessary to argue that the child represents singly-marked and doubly-marked structures differently. For instance, we might argue that Amahl's productions actually reflect his underlying representations. That is, perhaps he represents the word 'bed' as /b̥ɛt/, the word 'bus' as /b̥ʌt/, and the word 'noise' as /nɔiː/. If these representations are correct, however, we would still have to account for the fact that the structures that would potentially undergo multiple repairs (e.g., voiced coda fricatives) are represented differently than those that would potentially undergo single repairs, implying that Amahl still knows something about the relative markedness of the sounds he fails to represent! One might also argue that Amahl's underlying representations simply do not include doubly-marked structures. Recall, however, Child ED13, whose underlying representations for words like 'sock' were, we claimed, only *potentially* doubly-marked. It is not possible to claim that Child ED13 simply excludes doubly-marked structures from his inventory, as each of the words 'duck', 'sun' and 'sock' contain only a singly-marked structure.

It seems, then, that whether or not these children's underlying representations are adult-like, we must assume they at least know something about the relative markedness of the structures that they represent (or fail to represent). If this is the case, then positing underlying representations that at least match the adult input may actually be most parsimonious.

3.7 Summary and conclusion

This chapter has offered examples and analyses of four different CFEs in typical and delayed phonological acquisition. In each of these CFEs, deletion, whether of a segment or a feature, was used to avoid some other doubly-unfaithful repair. The use of featural deletion rather than segmental deletion in the case of Child ED13 demonstrated a number of important points. First, there are processes other than featural deletion that can avoid a doubly-derived repair. Second, in some CFEs, the two rules that are bled by the specific rule may be in a feeding relationship, rather than being independent of one another. This leads to the third important point: the input itself may not be doubly-marked but instead may be potentially doubly-marked; that is, its structure may be such that eliminating one marked structure may result in a second marked structure that also must be repaired.

It was shown that while OT has difficulty in accounting for these CFEs, HG can account for them easily, because the cumulative value of multiple faithfulness violations can overcome a single violation of a higher-weight constraint. In HG, these three different CFEs, involving featural and segmental deletion, have essentially identical analyses. In each case, the constraint corresponding to the fell-swoop deletion repair had a weight that was one and a half times greater than that of the lower-weight faithfulness constraints. As a result, a violation of the fell-swoop constraint was worse than a single violation of one of the lower-weight faithfulness constraints but was preferable to two violations of the lower-weight faithfulness constraints. It was also argued that HG can incorporate constraints relativized to weak positions, as well as constraints on which context is prominent for a given speaker.

Finally, we showed how these CFEs might come about from the perspective of the HG-oriented Gradual Learning Algorithm, which actually predicts a stage in which constraints that govern fell-swoop repairs, like MAX, may have greater weights than constraints that govern more specific featural repairs. Moreover, a later stage in which doubly-derived outputs are allowed, exemplified by Amahl, can also be accounted for in the HG-GLA. Evidence that CFEs are learnable is important in our argument that such cumulative effects are not unusual or unexpected. The fact that CFEs arise in acquisition as well as fully-developed languages is also evidence that children's grammars reflect possible adult grammars.

This chapter has argued that the prevalence of CFEs in first-language acquisition is due to the initial state ranking of markedness constraints above faithfulness constraints. In the next chapter we turn to CFEs in an area that shares some features with first-language acquisition: loanword adaptation.

CHAPTER 4

CUMULATIVE FAITHFULNESS EFFECTS IN LOANWORD ADAPTATION

4.1 Introduction

The current chapter discusses five examples of cumulative faithfulness effects in the adaptation of loanwords into three languages. Loanword phonology can be a rich source for CFEs: when a language with a relatively simple segmental inventory and/or structure borrows from a language with a more complex segmental inventory and/or structure, then adaptations are likely. Moreover, because of its simple structure, the borrowing language is likely to have high-ranked markedness constraints and low-ranked faithfulness constraints. Again, this is the type of grammar in which CFEs are most likely to occur. The examples in this chapter demonstrate that not only is a borrowing language a good source for CFEs, but that multiple CFEs may arise in a single borrowing language due to the collusion of multiple high-ranked markedness constraints. §4.2 begins with the assumptions made here about loanword adaptation. §§4.3, 4.4 and 4.5 present examples of CFEs in the languages Fon, Fula and Hawaiian, respectively. Theoretical implications are discussed in §4.6. In that section, one of the leading alternatives, local constraint conjunction (LC), is considered and compared with harmonic grammar (HG) accounts, and it is argued that the HG accounts are more parsimonious. The role of syllabic versus segmental repairs in loanword adaptation is also examined. The chapter ends with a summary conclusion in §4.7.

4.2 Assumptions about loanword adaptation

First of all, what is a loanword? When any two languages come in contact, some degree of borrowing is expected. It is important to distinguish, however, between the different degrees of borrowing common to different situations. For instance, in some languages with very close contact, pidgins arise out of the need for a shared language. On the other end of the spectrum, some bilinguals may use words from one language when speaking the other; this is known as code-switching. In neither of these examples should the words be considered borrowings, in the first because the pidgin represents a third language, with words and grammatical concepts taken from both contact languages, and in the second because it does not constitute a shared lexical representation across a community of speakers. Here we will adopt the definition of borrowing discussed in Paradis and LaCharité (1997), which is itself adapted from Poplack, Sankoff and Miller's (1988) definition:

(1) Definition of a loanword (Paradis and LaCharité, 1997)

An individual L2 word, or compound functioning as a single word, which

(a) is incorporated into the discourse of L1, the recipient language;

(b) has a mental representation in L1 (as opposed to code-switches, Myers-Scotton, 1992); and thus

(c) is made to conform with at least the outermost peripheral phonological constraints of L1, which represent absolute constraints in L1.

In using this definition of a loanword, we are excluding words that are not in use by multiple speakers of the borrowing language. This does not, however, mean that every speaker must necessarily share the same adaptations. This point is particularly relevant in §4.5 below, which details the adaptation patterns of a single speaker of Hawaiian.

Before any analysis of loanwords can occur, it is necessary to state the set of assumptions being made about the borrowers' perception and representations. Two competing theories are prevalent in the study of loanword adaptation (see LaCharité and Paradis, 2005 for a detailed discussion). Under the phonetic approximation model, borrowers (who are taken to be imperfect speakers of the L2) either misperceive or misinterpret source sounds and adapt them as they are (mis)perceived (e.g., Kenstowicz 2003; Silverman 1992; Yip 1993). On the other hand, in the phonological approximation model, borrowers are argued to be bilinguals who have full access to the phonologies of both the source and borrowing languages. For this reason, phonetic misperception is not expected (Paradis and LaCharité, 1997; Ulrich, 1997; Paradis and Prunet, 2000; Paradis and LaCharité, 2001; LaCharité and Paradis, 2005). A dichotomy has been drawn between these two theories—few theories consider a midpoint analysis in which both phonetics and phonology influence loanword adaptation (c.f. Iverson and Lee, 2004).

The phonetic model of loanword adaptation relies heavily on the perceptual abilities of borrowers. In this model, borrowers may misperceive sounds from the source language that do not exist in the borrowing language, or they may misinterpret the categorization of a sound, hearing a phonetic variant of a sound in the source language and interpreting it as phonemic. This analysis implies that speakers do not have any knowledge of the phonology of the source language—the perceived sounds are not interpreted at the phonological level of the source. This theory does have some drawbacks. First, in the assumption that borrowing speakers do not have access to the phonology of the source language, the generalization that many of the speakers who initiate borrowings are bilinguals is glossed over. Likewise, LaCharité and Paradis (2005) point out that speakers consistently adapt a source sound as the *phonologically* most similar sound in the borrowing language, even if there is another sound that is phonetically more similar. That is, when some borrowed sound could potentially fit into two categories in the borrowing language, one because of phonetic similarity and the other because of phonological similarity, the majority of borrowings fit into the phonological similarity category. For instance, the English flap, which functions as an allophone of /t/ and /d/ in English, is phonetically very similar to the Mexican Spanish rhotic flap. Nevertheless, in almost all cases of flap adaptation, the Mexican Spanish speakers borrow it as a /t/ or /d/, a phonological match, though not a phonetic match (LaCharité and Paradis, 2005). Moreover, Smith (2006) argues that while perceptual explanations are often available for loanword adaptations, they are frequently insufficient.

On the other hand, the phonological model of loanword adaptation, exemplified by the Theory of Constraints and Repair Strategies (TCRS, Paradis, 1996) argues that borrowers (who are bilinguals in this model) adapt sounds based on their phonological representations in the source and borrowing languages. Another example of this involves Spanish and English stops (example from LaCharité and Paradis, 2005). English voiced stops, with VOTs of 0-30 milliseconds, are phonetically similar to Spanish voiceless stops. Yet Spanish speakers borrow English voiced stops as Spanish voiced stops, matching the phoneme category of the source. There are problems with this model as well, however. For instance, many experiments have shown that the perceptual judgments made by non-native speakers (even high-level bilinguals) are not identical to the perceptual judgments made by native speakers of a language (e.g., Bohn and Flege, 1997).

In the following examination of loanword adaptation, we will see that in each example, certain sounds are deleted only when they arise in a multiply-marked environment (where their adaptation would require multiple processes). It is tempting to follow the phonetic model of loanword adaptation and claim that the borrowers simply did not perceive these sounds, and therefore did not produce them. However, this account fails to explain why the exact same sounds were adapted when they occurred in less marked environments (where their adaptation would require fewer processes). While it is true that the perceptibility of sounds is based in part on their context (e.g., Steriade, 2001a, 2001b), it misses the generalization to claim that the contexts in which these sounds are least perceptible is also the context in which they would require the greatest number of adaptation processes. Moreover, as noted by LaCharité and Paradis (2005), deletion is actually a relatively infrequent pattern in the adaptation of loanwords (in their loanword corpus, which includes over 42,000 malformations, deletion only occurs in 2.6% of repairs). LaCharité and Paradis claim (and the data in this thesis support) that deletion is an available repair only when the alternative repair exceeds a certain threshold of unfaithfulness. Thus we begin with the assumption that in the languages discussed below, the borrowing speakers correctly perceived the words they borrowed, and that their underlying representations match the outputs produced by speakers of the loaning language. That is, it is assumed (consistent with richness of the base (Prince and Smolensky, 1993/2004)) that borrowers begin with a representation that is identical to the production of French words by French speakers (as for Fula and Fon in §§4.3 and 4.4), or English words by English speakers (as for Hawaiian in §4.5). This means that all adaptations made were the result of the phonology of the borrowing speakers.

4.3 Fon

We begin with a CFE found in the language Fon, a Gbe language spoken in Benin (Gbeto, 2000; Kenstowicz, 2003). Central to the problem of borrowing words from French and English is the fact that Fon has only one liquid, [l]. No rhotic liquids appear in the language. French and English [r], then, must be adapted.[1] In addition, the maximal syllable is CCV. No syllable in Fon has a coda; borrowed words with codas must repair this structure. Relevant loanword data are given in (2). (2a) shows that both French and English /l/ surface faithfully in the onset. (2b) demonstrates that when French or English /l/ appears in coda position in the source language, the coda is repaired with a following epenthetic vowel. The data in (2c) show that French or English rhotics are adapted as [l] when they appear in the onset. The data in (2d), however, illustrate that input coda rhotics are deleted. Given the fact that onset rhotics are adapted as [l], and that coda /l/ is repaired with epenthesis, we might have expected a coda input rhotic to undergo both lateralization and epenthesis, but instead it is deleted.

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[1] While French /ʀ/ and English /r/ have different phonetic realizations, their adaptation patterns in Fon are the same. For ease of exposition they will be represented here with one symbol, /r/.

(2) Fon loanword adaptations (Kenstowicz, 2003)

a. French and English /l/ surface faithfully in the onset

/lam/	[lamu]	'blade'
/dɒlə/[2]	[dala]	'dollar'
/flauə/	[flowa]	'flower'

b. Codas are repaired with epenthesis

/kɔl/	[kɔlu]	'neck'
/dɛlfin/	[dɛlufini]	'name'
/tɥil/	[twilu]	'tile'

c. Onset /ʀ/ is replaced with [l]

/ʀido/	[ʁlido][3]	'curtain'
/byʀo/	[bilo]	'office'
/gʀɛv/	[glevu]	'beach'

d. Coda /ʀ/ is deleted

/gaʀ/	[ga]	'train station'
/saʀdin/	[sadini]	'sardine'
/tɔʀʃ/	[tɔtʃi]	'torch'

[2] Words borrowed from English are taken from a British dialect that deletes word-final [r]. Note that this does not apply to the words 'torch' and 'sardine' in (2d), as Kenstowicz (2003) indicates that they were adapted from the French 'torche' and 'sardine', not the English cognates.

[3] When the source /r/ is in absolute word-initial position, the sequence [ʁl] preserves both the uvular and liquid qualities of the source.

From a rule-based point of view, Fon requires three rules. One rule, Lateralization, adapts all input rhotics as laterals. A second rule, Epenthesis, inserts a vowel after an input coda. A third rule, R-Deletion, deletes all and only coda rhotics. R-Deletion must apply first in order to bleed both Lateralization and Epenthesis; if either of those rules preceded R-Deletion, it would be bled. Thus the rules are in a mutual bleeding order. Additionally, the language exhibits two conspiracies (Kisseberth, 1970; Kiparsky, 1976): one eliminates rhotics with either Lateralization or R-Deletion, and the other repairs codas with either Epenthesis or R-Deletion. The R-Deletion rule overlaps both conspiracies.

An optimality theoretic account requires markedness constraints banning codas and rhotics, and faithfulness constraints militating against deletion, insertion, and change in laterality. The relevant constraints are defined in (3).

(3) Constraints relevant for the Fon CFE

NOCODA: Coda consonants are banned

*R: Rhotic consonants are banned

MAX: Input segments have output correspondents

DEP: Output segments have input correspondents

IDENT[lateral]: Input and output correspondents have the same value for the feature [lateral]

The tableaux in (4) show that the Fon CFE presents a ranking paradox in optimality theory. In (4a) MAX must be ranked above DEP to ensure epenthesis as a repair for the coda, instead of deletion. The tableau in (4b) shows that MAX must be ranked above IDENT[lateral], because an input onset rhotic is adapted as a lateral, rather than being deleted. Finally, (4c) demonstrates the ranking paradox: with MAX ranked above DEP and IDENT[lateral], the tableau chooses candidate b., which has undergone both lateralization and epenthesis. The attested deletion candidate, candidate c., is ruled out by the higher-ranked MAX.

(4) Standard OT fails to account for Fon CFE

a. MAX >> DEP

/kɔl/ 'neck'	NOCODA	*ʀ	MAX	ID[lateral]	DEP
a. kɔl	*!				
b. ☞ kɔlu					*
c. kɔ			*!		

b. MAX >> ID[lateral]

/gʀɛv/ 'beach'	NOCODA	*ʀ	MAX	ID[lateral]	DEP
a. gʀɛv	*!	*			
b. ☞ glɛvu				*	*
c. gɛvu			*!		*

c. Ranking paradox

/gaʀ/ 'train station'	NOCODA	*ʀ	MAX	ID[lateral]	DEP
a. gaʀ	*!	*			
b. ☞ galu				*	*
c. ☜ ga			*!		

Because the Fon CFE presents a ranking paradox, and because the candidate that is incorrectly chosen in the above tableau is one that is multiply-unfaithful, HG presents itself as a possible solution. In the HG account, it is necessary to assign the faithfulness constraints weights such that MAX outweighs both IDENT[lateral] and DEP individually, but the cumulative weight of IDENT[lateral] and DEP outweighs MAX. With such weights, the violation of MAX will trade off for violations of IDENT[lateral] and DEP. Here the markedness constraints are given a weight of 2, reflecting their relatively high ranking in the OT account. MAX has a weight of 1.5, and IDENT[lateral] and DEP each have a weight of 1. The weighting arguments used to arrive at these rankings are shown in (5).

(5) Constraint weightings necessary for Fon

Weighting	Result	
$W_{*R} > W_{ID[lateral]}$	/gʀɛv/	glɛv > gʀɛv
$W_{NoCoda} > W_{Dep}$	/kɔl/	kɔlu > kɔl
$W_{Max} > W_{ID[lateral]}$	/gʀɛv/	glɛv > gɛv
$W_{Max} > W_{Dep}$	/kɔl/	kɔlu > kɔ
$W_{Max} < W_{ID[lateral]} + W_{Dep}$	/gaʀ/	ga > galu

In the tableau in (6a), candidate c., which has undergone deletion of the input coda /l/, has a lower relative harmony than candidate b., which has an epenthesized vowel. In (6b) the input, which has a rhotic in the onset, also has a coda consonant. Candidates b. and c. both repair the coda consonant by means of epenthesis, and so the DEP violations for these candidates cancel one another out. Candidate c., which deletes the rhotic, has a lower harmony than candidate b., in which the rhotic is adapted as a lateral. The tableau in (6c) best illustrates the CFE. In candidate b., the coda rhotic has been repaired with both lateralization and epenthesis. The cumulative harmony of this candidate is -2, as it incurs two violations of constraints that each have a weight of 1. Candidate c., on the other hand, deletes the rhotic, and in one fell swoop eliminates both the coda and the rhotic. The single deletion repairs multiple markedness violations and results in a harmony of -1.5, higher than that of candidate b. In other words, IDENT[lateral] and DEP have ganged up to disallow candidate b.

(6) HG account of Fon CFE

a. $W_{MAX} > W_{DEP}$

/kɔl/ 'neck'	NOCODA w=2	*R w=2	MAX w=1.5	ID[lateral] w=1	DEP w=1	H
a. kɔl	-1					-2
b. ☞ kɔlu					-1	-1
c. kɔ			-1			-1.5

b. $W_{MAX} > W_{ID[lateral]}$

/gʀɛv/ 'beach'	NOCODA w=2	*R w=2	MAX w=1.5	ID[lateral] w=1	DEP w=1	H
a. gʀɛv	-1	-1				-4
b. ☞ glɛvu				-1	-1	-2
c. gɛvu			-1		-1	-2.5

c. $W_{MAX} < W_{ID[lateral]} + W_{DEP}$

/gaʀ/ 'beach'	NoCoda w=2	*ʀ w=2	Max w=1.5	ID[lateral] w=1	Dep w=1	H
a. gaʀ	-1	-1				-4
b. galu				-1	-1	-2
c. ☞ ga			-1			-1.5

Are there other possible explanations for the differential borrowing of /r/ and /l/? Kenstowicz (2003) presents a phonetic approximation argument when he argues that coda /r/ is less perceptually salient than onset /r/. Fon speakers, according to this theory, do not even perceive the coda /r/ in the source language. Kenstowicz's explanation relies on different constraints in the perception and production domains (see also Boersma, 1999; Pater, 2004). The ranking of constraints in the perceptual domain, then, does not allow for perception of coda /r/. As a result, the input to the production domain simply does not include coda /r/ at all. However, this perceptual approximation account leaves several questions unanswered. Kenstowicz does not explain why coda /r/ is not perceived as [l]. With the constraints and ranking he gives for the perceptual domain (Dep-V >> *r/__]σ >> Max-C), a candidate with coda [l] would not violate any constraint and would thus be better perceptually than a candidate which simply deletes the coda. Including a higher-ranked constraint preventing the mapping of /r/ to [l] also is not useful, as onset /r/ is mapped to [l]. The perception-production account does not seem sufficient to account for the different borrowings of /r/ across positions. Instead, we argue that /r/ and /l/ are adapted differently based on the repairs available in Fon. Because the adaptation of coda /r/ would be too unfaithful, the segment is simply deleted.

In this section, we have analyzed a single CFE in the loanword phonology of Fon and argued that an account based on cumulativity is preferable to an account based on misperception. In the next section, we turn to Fula, whose loanword phonology includes three different CFEs. This is interesting because the multiple CFE examples in one language show the dispreference for very unfaithful outputs is not a marginal phenomenon; instead, a language may disprefer outputs that are too unfaithful throughout the phonology.

4.4 Fula

Fula, a Niger-Congo language spoken in West Africa, exhibits a number of CFEs in its adaptation of loanwords from French (Paradis, 1995; Rose, 1999; Paradis and Béland, 2002). Fula's native phonology excludes onset and coda clusters, as well as all voiced fricatives, nasal vowels, and the labio-palatal glide /ɥ/. We will focus on what happens when excluded segments coincide with disallowed syllable structure in borrowed words. The language's loanword adaptations reveal at least two straightforward CFEs, presented in §§4.4.1 and 4.4.2. The loanword phonology also incorporates another set of processes in which the cumulative violation of multiple faithfulness constraints is avoided, but in a manner different from the previous CFEs (§4.4.3).

4.4.1 Fula adaptation of labio-palatal glide clusters

The data in (7) illustrate the adaptation patterns of onset clusters and the labio-palatal glide. When it occurs in words borrowed from French, the labio-palatal glide is typically adapted as [w] (7a); onset clusters in French borrowings are resyllabified with an epenthetic vowel between the two consonants (7b). Note that in the words in (7a), the restriction against onset and coda clusters requires that the word-medial segments be syllabified heterosyllabically. Thus the glide in these words is a singleton onset. The cases in which the labio-palatal glide occurs as the second member of an onset cluster, however, are of particular interest; given individual repairs for the labio-palatal glide and for onset clusters, one might expect the clusters in (7c) to be adapted with both a change in glide place and epenthesis. Instead, the glide is deleted in the output, also eliminating the consonant cluster.

(7) Fula labio-palatal glide clusters (data from Paradis, 1995)

a. /ɥ/ is adapted as [w]

/dəlɥil/	[dilwil]	‘oil’
/minɥi/	[minwi]	‘midnight’

b. Onset clusters are repaired with epenthesis

/bwasɔ̃/	[buwasɔŋ]	‘drink’	/plas/	[palas]	‘place’
/kwafe/	[kuwaːfaːdɛ]	‘coif (one’s hair)’	/traktœr/	[taraktɔr]	‘tractor’
/ljøtnã/	[lijetinaŋ]	‘lieutenant’	/krɛjɔ̃/	[kɛrɛjɔŋ]	‘pencil’

c. /ɥ/ is deleted in onset clusters

/kɥivr/	[kiri]	‘copper’	*[kuwiri]
/kɥizinje/	[kisiŋ^{ŋ}gɛ]	‘cook’	*[kuwisiŋ^{ŋ}gɛ]
/biskɥi/	[biski]	‘biscuit’	*[biskuwi]
/tɥijo/	[tijo]	‘pipe’	*[tiwijo]

From a rule-based perspective, this CFE requires three rules: a rule epenthesizing a vowel between members of a cluster (Epenthesis), a rule changing /ɥ/ to [w] (Glide Backing), and a rule deleting /ɥ/ when it is the second member of an underlying onset cluster (Glide Deletion). In order to achieve the outputs in (7c), the Glide Deletion rule must precede Epenthesis and Glide Backing in a bleeding order. However, if Epenthesis and or Glide Backing preceded Glide Deletion, then Glide Deletion would be bled. The rules are thus in a mutual bleeding relationship. This also is an overlapping conspiracy: two rules are necessary to eliminate the labio-palatal glide, and two rules are necessary to repair consonant clusters. The glide deletion rule serves both ends and is part of both conspiracies.

The constraints necessary to account for this first Fula CFE are given in (8). Markedness constraints banning labio-palatal glides as well as complex syllable margins are required; faithfulness constraints require identity to the feature [back] and ban epenthesis and deletion.

(8) Constraints relevant for Fula CFE1

*ɥ: The glide [ɥ] is banned

*COMPLEX: Onset and coda clusters are banned

DEP: Output segments have input correspondents

MAX: Input segments have output correspondents

IDENT[back]: Input and output correspondents have the same value for the feature [back]

The tableaux in (9) demonstrate that a ranking paradox occurs: it is necessary to rank MAX above IDENT[back] and DEP to allow for the outputs in (7a) and (7b) above, in which glide backing and epenthesis are preferred over deletion (tableaux (9a,b)). On the other hand, MAX must be ranked below at least one of those faithfulness constraints to allow for the outputs in (7c), in which deletion is preferred over the combined backing and epenthesis. The ranking that accounts for the outputs in (7a) and (7b) incorrectly predicts both backing and epenthesis for the outputs in (7c) (tableau (9c)).

(9) Standard OT fails to account for Fula CFE1

a. MAX >> ID[back]

/minɥi/ ‘midnight’	*ɥ	*COMPLEX	MAX	ID[back]	DEP
a. min.ɥi	*!				
b. mi.nwi		*!		*	
c. ☞ min.wi				*	
d. mini			*!		

b. MAX >> DEP

/bwasɔ̃/ ‘drink’	*ɥ	*COMPLEX	MAX	ID[back]	DEP
a. bwasɔŋ		*!			
b. ☞ buwasɔŋ					*
c. basɔŋ			*!		

c. Ranking paradox

/tɥijo/ 'pipe'	*ɥ	*COMPLEX	MAX	ID[back]	DEP
a. tɥijo	*!	*			
b. ☞ tiwijo				*	*
c. ☜ tijo			*!		

We turn next to an account of the Fula borrowings in HG. Weighting arguments are shown in (10). By weighting IDENT[back] and DEP such that each weighs less than MAX, but their combined weight outweighs MAX, it is possible to achieve a grammar in which deletion is preferred over the violation of the other two faithfulness constraints.

(10) Constraint weightings necessary for Fula CFE1

Weighting	Result	
$W_{*ɥ} > W_{ID[back]}$	/minɥi/	minwi > minɥi
$W_{*COMPLEX} > W_{DEP}$	/bwasɔ̃/	buwasɔ̃ > bwasɔ̃
$W_{MAX} > W_{ID[back]}$	/minɥi/	minwi > mini
$W_{MAX} > W_{DEP}$	/bwasɔ̃/	buwasɔ̃ > basɔ̃
$W_{MAX} < W_{ID[back]} + W_{DEP}$	/tɥijo/	tijo > tiwijo

HG tableaux are displayed in (11). In (11a), the greater weighting of MAX in comparison with IDENT[back] means that candidate c., the deletion candidate, has a lower harmony than candidate b., the attested backing candidate. In (11b), the same is true of MAX and DEP: MAX's heavier weight eliminates the deletion candidate in favor of the epenthesis candidate, which has a higher cumulative harmony. In (11c), on the other hand, the deletion candidate only violates DEP, giving it a harmony of -1.5. The competing candidate, which undergoes both epenthesis and backing, has a cumulative harmony of -2. This lower harmony takes the doubly-derived candidate out of competition. Note that for the doubly-marked input 'pipe', both of the relevant competitors, that in which the labio-palatal glide is deleted and that in which both a change in place and epenthesis occur, are unmarked. This weighting of constraints chooses the least unfaithful unmarked output and allows for a grammar in which MAX is only violated if a single deletion can avoid two markedness violations at once. For the singly-marked inputs 'midnight' and 'drink', deletion would eliminate only one marked structure and is thus too costly.

(11) HG account of Fula CFE1

a. $W_{MAX} > W_{ID[back]}$

/minɥi/ 'midnight'	*ɥ w=2	*COMPLEX w=2	MAX w=1.5	ID[back] w=1	DEP w=1	H
a. min.ɥi	-1					-2
b. ☞ min.wi				-1		-1
c. mini			-1			-1.5

b. $W_{MAX} > W_{DEP}$

/bwasɔ̃/ 'drink'	*ɥ w=2	*COMPLEX w=2	MAX w=1.5	ID[back] w=1	DEP w=1	H
a. bwasɔŋ		-1				-2
b. ☞ buwasɔŋ					-1	-1
c. basɔŋ			-1			-1.5

c. $W_{\text{MAX}} < W_{\text{DEP}} + W_{\text{ID[back]}}$

/tɥijo/ 'pipe'	*ɥ w=2	*COMPLEX w=2	MAX w=1.5	ID[back] w=1	DEP w=1	H
a. tɥijo	-1	-1				-4
b. tiwijo				-1	-1	-2
c. ☞ tijo			-1			-1.5

HG can better account for the Fula CFE than standard OT. In the next section we turn to the second Fula CFE, which also deals with the repair of borrowed onset clusters.

4.4.2 Fula adaptation of /vw/ clusters

The second Fula CFE, illustrated in (12), occurs when the voiced fricative /v/ coincides with an onset cluster in borrowed words. The voiced fricative /v/ is always adapted in Fula. In 76.5% of cases, it is adapted as the labio-velar glide [w], while 17.3% of the time it is adapted as [b], and the remaining 6.2% of the time it is adapted as [f] (Paradis and LaCharité, 1997). Each of these adaptation patterns is illustrated in (12a); for the remainder of this section, we will focus on the gliding pattern, as it is most prevalent. Recall that in (7b) above, onset clusters were repaired with an epenthetic vowel. Those examples in which the second member of the onset cluster is a /w/ are repeated in (12b) below. We might expect /vw/ clusters to undergo both the gliding and epenthesis processes exhibited in (12a) and (12b). Instead, the /v/ in these clusters is deleted, as in (12c).[4]

[4] Another potential analysis of these facts is that epenthesis and sonorization would create a [wuw] sequence, which would violate an OCP constraint against labial sonorants in consecutive syllables (thanks to Stuart Davis for pointing out this analysis).

(12) Fula adaptation of /vw/ clusters (data from Paradis, 1995; Paradis and LaCharité, 1997)

a. /v/ is adapted as [w], [b] or [f]

/vɛr/	[wɛːr]	'glass'	/vakɑ̃s/	[wakkas]	'vacation'
/avɔka/	[awɔka]	'lawyer'	/sivil/	[siwil]	'civil'
/avjɔ̃/	[abijɔn]	'airplane'	/livr/	[liːbaːr]	'book'
/vinɛgr/	[binɛːgara]	'vinegar'	/elɛv/	[ɛlɛf]	'student'
/muvmɑ̃/	[mufmaŋ]	'movement'	/televizjɔ̃/	[tɛlɛfisjɔŋ]	'television'

b. Onset clusters are repaired with epenthesis

/bwasɔ̃/	[buwasɔŋ]	'drink'	/kwafe/	[kuwaːfaːdɛ]	'coif (hair)'

c. /v/ is deleted in an onset cluster

/vwaju/	[waju]	'bum'	*[wuwaju]
/vwajaʒ/	[wajaːs]	'trip'	*[wuwajaːs]
/vwatyr/	[watiːri]	'car'	*[wuwatiːri]

This CFE is very similar in structure to the previous example. In both cases, the single segment that makes a structure doubly-marked is deleted, rather than undergoing two adaptation processes. In the first CFE, we saw that the deletion of the second member of the cluster, a glide not in the native Fula inventory, repaired both the glide and the onset cluster. In this CFE, it is the first member of the cluster that is disallowed in Fula's segmental inventory, and so it is this segment that is deleted, also repairing the onset cluster. In rule-based terminology, the same epenthesis rule discussed in §4.4.1 is necessary here. Also necessary is a rule of Gliding, which replaces the voiced fricative /v/ with the glide [w]. Finally, a V-Deletion rule eliminates the segment /v/ when it is found in an onset cluster. Just as above, V-Deletion must apply first to bleed Gliding and Epenthesis, as the earlier application of either of those rules would bleed V-Deletion. The rules are thus in a mutual bleeding relationship.

Just as for the previous CFE, a ranking paradox arises in a standard OT account of this data. Many of the constraints defined in (8) are also relevant for this example. Additional constraints are defined in (13). These include a markedness constraint banning voiced fricatives and a faithfulness constraint requiring identity to the feature [sonorant]. This faithfulness constraint penalizes the adaptation of a fricative as a glide.

(13) Constraints relevant for Fula CFE2

*v: Voiced fricatives are banned

IDENT[sonorant]: Input and output correspondents have the same value for the feature [sonorant]

Once again, standard OT is confronted with a ranking paradox in the analysis of this CFE. In order to achieve the gliding and epenthesis error patterns, both DEP and IDENT[sonorant] must be ranked below MAX, as in the first two tableaux in (14). This ranking, however, incorrectly chooses the doubly-derived candidate in the tableau for ‘bum’, rather than the attested deletion candidate.

(14) Standard OT fails to account for Fula CFE2

a. MAX >> ID[sonorant]

/vɛr/ 'glass'	*v	*COMPLEX	MAX	ID[sonorant]	DEP
a. vɛr	*!				
b. ☞ wɛr				*	
c. ɛr			*!		

b. MAX >> DEP

/bwasɔ̃/ 'drink'	*v	*COMPLEX	MAX	ID[sonorant]	DEP
a. bwasɔ̃		*!			
b. ☞ buwasɔŋ					*
c. basɔŋ			*!		

c. Ranking paradox

/vwaju/ 'bum'	*v	*COMPLEX	MAX	ID[sonorant]	DEP
a. vwaju	*!	*			
b. ☞ wuwaju				*	*
c. ☜ waju			*!		

The cumulative aspect of HG is what enables it to account for this problem. The weighting arguments are given in (15). As long as MAX has a greater weight than either of the other two faithfulness constraints, then a candidate with a single violation of IDENT[sonorant] or DEP will always be chosen over a deletion candidate, as in the first two tableaux in (16). In (16a), the lower weight of IDENT[sonorant] gives candidate b. a higher cumulative harmony than candidate c., the deletion candidate. The tableau for ‘drink’ in (16b) is identical to the one in (11b) and is repeated here as a reminder of the relative weighting of MAX greater than DEP. Because the cumulative weight of IDENT[sonorant] and DEP outweighs MAX, however, deletion is a viable option in only those cases where a single deletion trades off for violations of both IDENT[sonorant] and DEP, as in (16c).

(15) Constraint weightings necessary for Fula CFE2

Weighting	Result	
$W_{*v} > W_{ID[sonorant]}$	/vɛr/	wɛr > vɛr
$W_{*Complex} > W_{Dep}$	/bwasɔ̃/	buwasɔ̃ > bwasɔ̃
$W_{Max} > W_{ID[sonorant]}$	/vɛr/	wɛr > ɛr
$W_{Max} > W_{Dep}$	/bwasɔ̃/	buwasɔ̃ > basɔ̃
$W_{Max} < W_{ID[sonorant]} + W_{Dep}$	/vwaju/	waju > wuwaju

(16) HG account of Fula CFE2

a. $W_{Max} > W_{ID[sonorant]}$

/vɛr/ ‘glass’	*v w=2	*COMPLEX w=2	MAX w=1.5	ID[sonorant] w=1	DEP w=1	H
a. vɛr	-1					-2
b. ☞ wɛr				-1		-1
c. ɛr			-1			-1.5

b. $W_{Max} > W_{Dep}$

/bwasɔ̃/ ‘drink’	*v w=2	*COMPLEX w=2	MAX w=1.5	ID[sonorant] w=1	DEP w=1	H
a. bwasɔ̃		-1				-2
b. ☞ buwasɔŋ					-1	-1
c. basɔŋ			-1			-1.5

c. $W_{MAX} < W_{ID[sonorant]} + W_{DEP}$

/vwaju/ 'bum'	*v w=2	*COMPLEX w=2	MAX w=1.5	ID[sonorant] w=1	DEP w=1	H
a. vwaju	-1	-1				-4
b. wuwaju				-1	-1	-2
c. ☞ waju			-1			-1.5

The preceding two sections have accounted for two similar CFEs in Fula's loanword adaptations. In each of these cases, some structure in the input was doubly-marked because it contained a marked segment embedded in a marked syllabic structure. In each of these examples, we saw that the grammar resorted to deletion only when the other available repair would have violated multiple faithfulness constraints. Segmental deletion was thus used to avoid a multiply-unfaithful output. In the next section, we turn to another case from Fula that involves faithfulness cumulativity, but can be accounted for in standard OT. Nevertheless, it is argued that an HG account captures the cumulative faithfulness generalization more directly.

4.4.3 Fula adaptation of NC sequences

In each of the previous CFEs in this chapter, two markedness constraints were highly weighted, and two processes operated in order to avoid those marked structures. When those processes could combine, however, the language circumvented the multiple processes by deleting the one segment or feature that contributed to the violation of both markedness constraints. When the input only violates a single markedness constraint, but the repair of that marked structure would in turn create another markedness violation, then the input is potentially doubly-marked, as described in Chapter 2. The third Fula example illustrates just such a problem. Fula disallows nasal vowels; when words containing nasal vowels are borrowed from French, the nasal vowel is “unpacked” (Paradis, 1995; Paradis and LaCharité, 1997), that is, realized as a vowel followed by a nasal consonant, as in (17a). In the previous two sections, we saw that Fula repairs complex onsets with epenthesis. The data in (17b) show that complex codas are also repaired with epenthesis. The location of the epenthetic vowel is determined by constraints on what makes a good onset: when the input coda cluster had falling sonority, then epenthesis occurs after the second consonant of the cluster, but when the input coda cluster had rising sonority, epenthesis occurs between the two consonants.

The particularly interesting cases are presented in (17c). In each of these words, the nasal vowel falls before a coda consonant. Remember that Fula allows singleton codas exclusively. The input to each of these words, then, is only singly-marked, because of the nasal vowel. If the nasal vowel were unpacked, however, a coda cluster would be created, which would then have to be repaired with epenthesis. Instead, though, the nasal feature is simply deleted.

(17) Fula nasal consonant sequences (data from Paradis, 1995; Paradis and LaCharité, 1997)

a. Nasal vowels are unpacked

/bãdi/	[ban^{n}di]	‘gangster’	/kãtɔ̃/	[kantɔŋ]	‘canton’
/marɛ̃/	[marɛŋ]	‘sailor’			

b. Coda clusters are repaired with epenthesis

/kard/	[karda]	'card (comb)'	/kart/	[kartal]	'card'
/fɔrs/	[fɔrsɔ]	'force'	/filtr/	[filtir]	'filter'
/mɛtr/	[mɛɛtɛr]	'meter'	/tabl/	[taabal]	'table'

c. Nasal feature is deleted if unpacking would result in coda cluster[5]

/epɔ̃ʒ/	[epɔs]	'sponge'	*[epɔnsɔ]
/balɑ̃s/	[balas]	'scale'	*[balansa]
/dimɑ̃ʃ/	[dimaːs]	'Sunday'	*[dimansa]
/ɛsɑ̃s/	[ɛsaːs]	'gasoline'	*[ɛsansa]
/vakɑ̃s/	[wakkas]	'vacation'	*[wakkansa]
/depɑ̃s/	[deppas]	'expense'	*[deppansa]
/kɔ̃ferɑ̃s/	[kɔŋferas]	'conference'	*[kɔŋferansa]

This data set differs from the others in this chapter in that none of the inputs in (17c) is doubly-marked. Nevertheless, the deletion of the nasal feature only occurs when the alternative repair would incur violations of multiple faithfulness constraints.[6] These cases are potentially doubly-marked, rather than actually doubly-marked. In other words, they are marked in such a way that repairing their marked structure will create a second marked structure. In rule-based terminology, the input only meets the structural

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[5] In one example, the vowel is unpacked and the following coda is deleted: /prɔpagɑ̃d/ [pɔrpagan] 'propaganda' *[pɔrpaganda]. Paradis and LaCharité (1997) argue that this adaptation occurs because the nasal makes a better coda than a stop.

[6] This case is much like that of Child ED13 in Chapter 3. In that example, inputs for words like 'sock' are only singly-marked, but the repair of the marked structure would create another marked structure.

description of a single rule, but that rule feeds a second rule, resulting in an output that has been acted upon by two rules. It is as if the grammar is aware that unpacking of the nasal vowel in these cases would create a coda cluster which would then have to be repaired. In order to avoid the potential double repair, the nasal feature is instead deleted. However, note that deletion of the nasal feature is not the repair for words like those in (17a). That is, nasal-feature deletion only occurs when it avoids the violation of two faithfulness constraints. This resembles the other CFEs, in which segmental or featural deletion was only allowed in those instances in which the alternative repairs would have violated multiple faithfulness constraints.

What is surprising about this example is that standard OT has no problem in accounting for it. The relevant constraints, in addition to those in (8) and (13), are defined in (18). A markedness constraint banning nasal vowels is high-ranked. Two additional faithfulness constraints are also required: MAX[nasal] militates against deletion of the nasal feature[7], and INTEGRITY essentially bans unpacking of the type seen in Fula. In order to avoid confusion between the MAX constraints, we rename the constraint militating against segmental deletion MAXSEG.

(18) Constraints relevant for Fula CFE3

*ṽ: Nasal vowels are banned

MAX[nasal]: Input [nasal] features have output correspondents

INTEGRITY: A single segment in the input has a single correspondent in the output

[7] MAX[nasal] militates against the deletion of a particular feature, even if the segment remains. MAXSEG[nasal], used in Chapter 3, militates against the deletion of an entire nasal segment.

In previous CFEs, we saw that each of two faithfulness constraints had to be ranked below a single MAX constraint, because there were two independent repairs that were preferred over deletion. Here the fact is that each of two faithfulness constraints needs to be ranked below a different MAX constraint. In order for unpacking to be the best repair for the words in (17a), INTEGRITY must be ranked below MAX[nasal], as in the first tableau in (19). The higher-ranked MAX[nasal] thus rules out candidate c., in which the input nasal vowel is realized as an oral vowel. In the words in (17b), on the other hand, vowel epenthesis is the preferred repair for an input coda cluster, rather than deletion of one of the consonants. This means that DEP must be ranked below MAXSEG, as in the second tableau in (19). However, there is no need for DEP to be ranked below MAX[nasal], because the two constraints never conflict—epenthesizing a vowel and deleting a nasal feature are never competing repairs for a single marked structure. Moreover, in the words in (17c), deletion of the nasal feature is actually preferred over the combination of unpacking and epenthesis. This can be achieved with the ranking MAXSEG >> DEP >> MAX[nasal] >> INTEGRITY, as in the third tableau in (19).

(19) Standard OT accounts for Fula CFE3

a. MAX[nasal] >> INTEGRITY

/marɛ̃/ 'sailor'	*ṽ	*COMPLEX	MAXSEG	DEP	MAX[nasal]	INTEGRITY
a. marɛ̃	*!					
b. ☞ marɛŋ						*
c. marɛ					*!	

b. MAXSEG >> DEP

/kard/ 'card'	*ṽ	*COMPLEX	MAXSEG	DEP	MAX[nasal]	INTEGRITY
a. kard		*!				
b. ☞ karda				*		
c. kad			*!			

c. DEP >> MAX[nasal]

/balɑ̃s/ 'scale'	*ṽ	*COMPLEX	MAXSEG	DEP	MAX[nasal]	INTEGRITY
a. balɑ̃s	*!					
b. balans		*!				*
c. balansa				*!		*
d. ☞ balas					*	

Standard OT's ability to account for this CFE is simply an artifact of the processes involved. The fact that there are two deletion processes to consider, segmental deletion and nasal feature deletion, allows us to rank the two constraints against deletion at different points in the hierarchy. The constraint MAXSEG must be highly ranked, as segmental deletion is never the repair in this particular set of processes (though we know from §§4.4.1 and 4.4.2 that MAXSEG must be ranked over DEP, IDENT[sonorant] and IDENT[back]). MAX[nasal], on the other hand, need only be ranked over INTEGRITY, because the nasal deletion and unpacking processes are in competition for the chance to repair the same marked structure. The true test case would be one in which epenthesis and nasal deletion were competing processes, but such a case can never arise, because vowel epenthesis will never be a viable repair for a nasalized vowel. Moreover, there is no common constraint that is violated by both the segmental deletion in candidate c. in the second tableau in (19) and the nasal deletion in candidate d. in the third tableau. If some such constraint did exist, it would have to be ranked above both DEP and INTEGRITY, and then this would look more like a straightforward CFE.

In sum, then, this third Fula data set does represent a CFE, because two independently evidenced repairs, nasal unpacking and epenthesis, cannot occur at the same time; when their joint application would be expected, and only then, a third process, nasal feature deletion, applies. Though OT has no problem accounting for this latter CFE, it is in the HG account that the identity of the CFE is best revealed. This account also shows that HG can account for the same cases that standard OT can account for, as well as those for which standard OT cannot account. The weighting arguments for this CFE are shown in (20). The weighting arguments show that MAX[nasal], as the attested repair for the potentially doubly-marked candidate, must have a lower weight than the sum of the INTEGRITY and DEP constraints, which would be the constraints violated in the unattested doubly-derived repair.

(20) Constraint weightings necessary for Fula CFE3

Weighting	Result	
$W_{*\tilde{v}} > W_{INTEGRITY}$	/marɛ̃/	marɛŋ > marɛ̃
$W_{*COMPLEX} > W_{DEP}$	/kard/	karda > kard
$W_{MAX[nasal]} > W_{INTEGRITY}$	/marɛ̃/	marɛŋ > marɛ
$W_{MAXSEG} > W_{DEP}$	/kard/	karda > kad
$W_{MAX[nasal]} < W_{INTEGRITY} + W_{DEP}$	/balãs/	balas > balansa

The tableaux in (21) illustrate the HG account. In the tableau for ‘sailor’, MAX[nasal] has a weight of 1.5 and INTEGRITY has a weight of 1, thus preferring the unpacked candidate b. over candidate c., in which the nasal feature has been deleted. In the tableau for ‘card’, the weighting of MAXSEG at 1.5 (its weight in (11) and (16) above) and DEP at 1 means that candidate c, which violates MAXSEG, has a lower cumulative harmony than candidate b., which violates DEP. Most importantly, in the tableau for ‘scale’, the candidate that combines violations of INTEGRITY and DEP is eliminated because of their cumulative harmony (-2), and the candidate that only violates MAX[nasal], with a cumulative harmony of -1.5, is selected instead.

(21) HG account of Fula CFE3

a. $W_{\text{MAX[nasal]}} > W_{\text{INTEGRITY}}$

/marɛ̃/ ‘sailor’	*ṽ w=2	*COMP w=2	MAXSEG w=1.5	MAX[nasal] w=1.5	INTEG w=1	DEP w=1	H
a. marɛ̃	-1						-2
b. ☞ marɛŋ					-1		-1
c. marɛ				-1			-1.5

b. $W_{\text{MAXSEG}} > W_{\text{DEP}}$

/kard/ ‘card’	*ṽ w=2	*COMP w=2	MAXSEG w=1.5	MAX[nasal] w=1.5	INTEG w=1	DEP w=1	H
a. kard		-1					-2
b. ☞ karda						-1	-1
c. kad			-1				-1.5

c. $W_{\text{MAX[nasal]}} < W_{\text{INTEGRITY}} + W_{\text{DEP}}$

/balɑ̃s/ 'scale'	*ṽ w=2	*COMP w=2	MAXSEG w=1.5	MAX[nasal] w=1.5	INTEG w=1	DEP w=1	H
a. balɑ̃s	-1						-2
b. balans		-1			-1		-3
c. balansa					-1	-1	-2
d. ☞ balas				-1			-1.5

4.4.4 Fula summary

In the preceding three sections, three different CFEs in Fula were presented. Each of these CFEs involved the combination of a marked segment (a labio-palatal glide, voiced fricative, or nasal vowel) with a disallowed syllabic structure (an onset or coda cluster). Fula's native segmental inventory is quite restricted and consists primarily of unmarked segments. The fact, then, that three different CFEs arise in the language's borrowing of words from French is not too surprising. CFEs occur when there are multiple markedness constraints ranked above multiple faithfulness constraints. In the native grammar, Fula speakers would have no need to demote markedness constraints against front glides, voiced fricatives or nasal vowels, and so the antagonistic faithfulness constraints would have remained low. The summary weighting for all three Fula CFEs is given in (22).

(22) Fula weighting summary

$W_{*ɥ}$, W_{*v}, $W_{*ṽ}$, $W_{*\text{COMPLEX}} >> W_{\text{MAXSEG}} >> W_{\text{DEP}} >> W_{\text{MAX[nasal]}} >> W_{\text{IDENT[back]}}$, $W_{\text{IDENT[sonorant]}}$, $W_{\text{INTEGRITY}}$

There is no evidence that native Fula words have any of the marked segments discussed here (though given richness of the base, we must allow for the possibility). It is only as the result of adaptation from a language with a less restrictive inventory that the CFEs emerge. That is, when Fula speakers adapt words with marked segments and structures, their low-ranked faithfulness constraints become active in determining the best adaptation. In some ways, this might be thought of as an "emergence of the faithful" effect, a name borrowed from the effects known as "emergence of the unmarked" (for a somewhat different definition of this term, see Lee, 1996). In emergence of the unmarked effects, markedness constraints that are so low-ranked that they usually play no decisive role in candidate selection suddenly play an important role when the higher-ranked faithfulness constraints do not apply. Such effects are most common in processes like epenthesis or reduplication, in which there is no underlying representation to which the faithfulness constraints can compare the candidates. In a CFE, on the other hand, there is a set of low-ranked faithfulness constraints that are dominated by markedness constraints in the native grammar. Because the native lexicon presumably has no words with these marked structures, the faithfulness constraints are rarely active. (This assumption does not violate richness of the base; if the language does have inputs with marked structures, they would be modified just as the loanwords are. The lack of any evidence of unfaithfulness, however, implies that the simplest assumption is that the lexicon does not contain words with the relevant marked structures, as would also be predicted by lexicon optimization (Prince and Smolensky, 1993/2004)). These low-ranked faithfulness constraints really only play a role in determining which of two (or more) unmarked, unfaithful outputs should be chosen. This scenario arises frequently in loanword adaptation, as the grammar must make the non-native inputs conform to the native markedness constraints. The faithfulness constraints thus function to choose the most faithful unmarked candidate.

In the next section, we examine a CFE that occurs in the adaptation of English loanwords into Hawaiian. This example is especially interesting because the faithfulness threshold seems to be higher: the Hawaiian speaker discussed here allows adaptations in which one or even two faithfulness constraints may be violated to repair a single marked structure, but disallows the violation of three faithfulness constraints in a single repair.

4.5 Hawaiian

A somewhat more complex example of the cumulative effects of faithfulness constraints comes from the loanword phonology of a Hawaiian speaker discussed by Adler (2006). Speaker 2[8] exhibited a number of interesting patterns in his phonology of words borrowed from English. First, some background on the native language: Hawaiian has no coronal obstruents and no fricatives; there are no codas and no complex syllable margins. Speaker 2 complies with his native grammar in his adaptations of English loanwords. The English coronal stop /t/ merges with the velar stop /k/ in Speaker 2's grammar, as shown in (23a) and (23b). The English coronal fricative /s/ is also borrowed as the velar stop [k] when it appears prevocalically, as in (23c). Syllable-structure violations, both codas and clusters, are repaired with epenthesis, as is shown in (23d).

Interestingly, though Speaker 2 borrows prevocalic /s/ as [k], and though typical syllable structure errors are repaired with epenthesis, an unexpected repair occurs for

[8] Speaker 2 exhibited some variation; however, the patterns described here are robust. This thesis does not attempt to account for any variation.

initial s-clusters. In these clusters, the [s] deletes, as in (23e), rather than being realized as [k] followed by an epenthetic vowel. The same repair occurs for coda /s/, as shown in (23f).

(23) Hawaiian (data from Adler, 2006)

a. English /k/ is borrowed as [k]

[kolopi:]	‘Colby’	[kakəpi:]	‘cockpit’
[ko:linə]	‘corn’	[koinikə]	‘zoink’

b. English /t/ is borrowed as [k]

[kake]	‘task’	[kale:]	‘trade’
[mekikə]	‘mystic’	[keike]	‘taste’

c. English prevocalic /s/ is borrowed as [k][9]

[pelekine]	‘blessing’	[paləkami]	‘balsamic’

d. English syllabic violations are repaired by epenthesis

[kəlapi]	‘clasp’	[kale:]	‘trade’
[ko:linə]	‘corn’	[hapə]	‘half’

e. /s/ is deleted in onset clusters

[pikə]	‘speak’	[kaime]	‘stymie’
[kolə]	‘score’	[lupe]	‘sloop’
[nika]	‘snicker’		

[9] Speaker 2 sometimes borrows English prevocalic /s/ as [h], which can be viewed as a one-step change. In a cluster or a coda, however, /s/ is always deleted.

f. /s/ is deleted in codas

[kali:]	‘crease’	[apəlinə]	‘aspirin’
[wipə]	‘whisper’	[maki]	‘musky’
[pikə]	‘beast’	[wa:pə]	‘wasp’

At first glance, Speaker 2’s adaptation patterns seem unsystematic; deletion and epenthesis are both active syllabic repairs, and the segment /s/ undergoes featural changes in some instances and is deleted in others. Upon closer examination, though, a clear pattern emerges. When a segmental or syllabic repair would involve the violation of three or more faithfulness constraints, deletion is chosen as an alternative. For instance, the change from /s/ to [k] violates two faithfulness constraints, one preserving manner features, the other preserving place features. When the /s/ is in preconsonantal or coda position, however, a third repair, vowel epenthesis, is necessary. This would constitute the violation of three faithfulness constraints; instead, /s/ is deleted in these cases, incurring a violation only of MAX. The violation of MAX trades off for violation of three other faithfulness constraints. Note that it is clear that Speaker 2 allows any combination of repairs that are unfaithful in only one or two ways. The borrowing of prevocalic /s/ as [k] is unfaithful to manner and place; the adaptation of coda /t/ as [k] followed by an epenthetic vowel is unfaithful in both the change in place and the epenthesis. It is just the combination of all three of these faithfulness violations to repair a single ill-formed structure that is disallowed.

A rule-based approach to Speaker 2’s grammar requires four rules. One rule, Velarization, replaces all coronal stops with velars. A second rule, Stopping, requires that all fricatives be realized as stops. This rule feeds the Velarization rule in the case of input /s/.[10] A third rule requires epenthesis in order to fix syllabic violations like onset clusters or codas. And finally, a fourth rule, S-Deletion, deletes input /s/ when it appears as the first member of a cluster or as a coda. This CFE can also be described as a mutual bleeding interaction: S-Deletion bleeds each of the other rules, and if ordered differently, any of the other rules would bleed S-Deletion. Again, a conspiracy is involved—in fact, three conspiracies are at work in this problem. One set of rules conspires to eliminate fricatives, another set of rules conspires to avoid coronal obstruents, and a third set of rules conspires to repair bad syllable structure. It happens to be the case that one rule, S-Deletion, plays a role in all three conspiracies.

Adler formalizes an OT analysis of the Hawaiian loanword adaptations by formulating constraints based on perceptual and articulatory similarity judgments. A more neutral OT account of Speaker 2's loanword phonology involves the markedness and faithfulness constraints in (24). The markedness constraints against coronal obstruents, fricatives, codas, and clusters are all high-ranked in the grammar, as none of them is ever violated. (The constraint against fricatives, *FRIC, and the relevant candidates that would be eliminated by it, will be left out of the following tableaux for reasons of space.) The faithfulness constraints banning insertion and deletion and requiring identity in place and manner are each violated at some point, so they must all rank below the markedness constraints. What is at issue is the relative ranking of faithfulness constraints.

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[10] Alternatively, Velarization and Stopping could be combined into a single rule that requires that all input coronal obstruents be realized as velar stops. Because there is no restriction on how many featural changes can be made by a single rule, it is possible to eliminate both the marked features of /s/, the [coronal] and [+continuant] features, in one rule.

(24) Constraints relevant to Hawaiian CFE

*t: Coronal obstruents are banned

*FRIC: Fricatives are banned

NOCODA (NC): Syllable-final consonants are banned

*COMPLEX: Onset and coda clusters are banned

DEP: Output segments have input correspondents

MAX: Input segments have output correspondents

IDENT[coronal]: Input and output correspondents have the same value for the feature [coronal]

IDENT[continuant]: Input and output correspondents have the same value for the feature [continuant]

The tableaux in (25) show that in standard OT, a ranking paradox between MAX and the other faithfulness constraints emerges. When the input /s/ is prevocalic, as in (25a), a ranking of MAX over DEP, IDENT[coronal] and IDENT[continuant] is necessary to ensure preservation of /s/ as [k]. On the other hand, when the /s/ is not prevocalic, as in (25b), ranking MAX above the other faithfulness constraints results in an output in which the /s/ is incorrectly preserved. The correct generalization about Speaker 2's grammar is that deletion of /s/ is only an available repair when the alternative is an output that violates too many faithfulness constraints. That is, Speaker 2 only deletes /s/ when to preserve it would violate not only IDENT[coronal] and IDENT[continuant], but DEP as well. This, then, is an example of cumulative faithfulness: the cumulative violation of IDENT[coronal], IDENT[continuant] and DEP can be enough to overcome higher-ranked MAX and compel deletion. From another point of view, the Hawaiian example can be thought of as "triply-derived environment blocking." That is, an underlying /k/ is allowed, as is a [k] derived in one step (from /t/, which constitutes a place change) and a [k] derived in two steps (from prevocalic /s/, which constitutes a place and manner change). However, a /k/ derived in three steps (from non-prevocalic /s/, which constitutes a place and manner change as well as the epenthesis necessary to repair the coda violation) is disallowed.

(25) Standard OT fails to account for Hawaiian

a. MAX >> DEP, ID[coronal] and ID[continuant]

/blɛsɪŋ/ 'blessing'	*t	NOCODA	*COMP	MAX	DEP	ID[cor]	ID[cont]
a. blɛsɪŋ	*!	*	*				
b. ☞ pelekine					**	*	*
c. peleine				*!	**		
d. pekine				*!	*	*	*

b. Ranking paradox (DEP, ID[coronal] or ID[continuant] >> MAX necessary to rule out candidate b.)

/spik/ 'speak'	*t	NOCODA	*COMP	MAX	DEP	ID[cor]	ID[cont]
a. spik	*!	*	*				
b. ☞ kəpikə					**	*	*
c. ☜ pikə				*!	*		

HG provides an alternative account of Speaker 2's adaptation pattern. Weighting arguments are given in (26). It is necessary to weight each of the constraints in the above account such that the violation of any one or two of the faithfulness constraints

IDENT[coronal], IDENT[continuant] and DEP will still be outweighed by a single violation of MAX, but the violation of all three of those constraints is enough to overcome MAX. Here the markedness constraints have all been assigned a weight of 3 (reflecting their high ranking in a ranking-based account). MAX has a weight of 2.5, while the other three markedness constraints all have a weight of 1.

(26) Constraint weightings necessary for Hawaiian

Weighting	Result	
$W_{*t} > W_{ID[coronal]}$	/tæsk/	kake > take
$W_{*t} > W_{ID[coronal]}+W_{ID[continuant]}$	/blesiŋ/	pelekine > pelesine
$W_{*COMP} > W_{DEP}$	/klæsp/	kəlapi > klapi
$W_{NoCODA} > W_{DEP}$	/slup/	lupe > lup
$W_{MAX} > W_{ID[coronal]}$	/tæsk/	kake > ake
$W_{MAX} > W_{ID[continuant]}$	/hæf/	hap > ha
$W_{MAX} > W_{DEP}$	/hæf/	hafə > ha
$W_{MAX} > W_{ID[coronal]} + W_{DEP}$	/teist/	keike > kei
$W_{MAX} > W_{ID[continuant]} + W_{DEP}$	/hæf/	hapə > haf
$W_{MAX} > W_{ID[coronal]}+W_{ID[continuant]}$	/blesiŋ/	pelekine > peleine
$W_{MAX} < W_{ID[coronal]} + W_{ID[continuant]} + W_{DEP}$	/spik/	pikə > kəpikə

The tableaux in (27) illustrate the HG account. In (27a), the fully faithful candidate violates all three of the high-weight markedness constraints and has the lowest cumulative harmony. Candidate d., in which all marked structures have been deleted, incurs multiple violations of MAX, whose weight is great enough to eliminate the candidate. Candidate b., in which the input /s/ is realized as a [k], and candidate c., in which the input /s/ is deleted, tie on their violations of DEP, as vowels are epenthesized between the members of the consonant cluster and after the word-final coda. The relevant comparison, then, is between candidate b.'s violations of IDENT[coronal] and IDENT[continuant], and candidate c.'s violation of MAX. Even though candidate b. violates three constraints, its cumulative harmony is higher than that of candidate c., which violates only two, one of which is a much heavier constraint. In (27b), the fully-faithful candidate is again ruled out by the cumulative violation of the high-weight markedness constraint. Candidate d., whose markedness violations were all repaired through deletion, incurs too many violations of MAX. Again, both candidates b. and c. incur violations of DEP because of the epenthesis after the coda, but in this case candidate b., in which the /sp/ cluster is realized as [kəp], incurs an additional violation of DEP because of the cluster repair. This violation, combined with the violations of IDENT[coronal] and IDENT[continuant] incurred by the /s/ → [k] mapping, give candidate b. a cumulative harmony of -4. Candidate c., which avoids the three-step repair by deleting the input /s/, has a harmony of -3.5, just high enough to win.

(27) HG account of Hawaiian

a. $W_{MAX} > W_{ID[coronal]} + W_{ID[continuant]}$

/blɛsɪŋ/ 'blessing'	*t w=3	NC w=3	*COMP w=3	MAX w=2.5	DEP w=1	ID[cor] w=1	ID[cont] w=1	H
a. blɛsɪŋ	-1	-1	-1					-9
b. ☞ pelekine					-2	-1	-1	-4
c. peleine				-1	-2			-4.5
d. lene				-3	-1			-8.5

b. $W_{MAX} < W_{ID[coronal]} + W_{ID[continuant]} + W_{DEP}$

/spik/ 'speak'	*t w=3	NC w=3	*COMP w=3	MAX w=2.5	DEP w=1	ID[cor] w=1	ID[cont] w=1	H
a. spik	-1	-1	-1					-9
b. kəpikə					-2	-1	-1	-4
c. ☞ pikə				-1	-1			-3.5
d. pi				-2				-5

It is important to note that in the above examples, a violation of MAX is only allowed if a single deletion repairs multiple markedness violations. Each of the above inputs includes a variety of marked segments or structures. In the input for 'blessing' in (27a), there is an onset cluster, a prevocalic /s/, and a coda consonant, so the fully-faithful candidate incurs violations of *COMPLEX, *t, and NOCODA. Because of the high ranking of the markedness constraints, each of these marked structures must be repaired. Candidate b., the attested output, repairs both the onset cluster and the coda with epenthesis and changes the prevocalic /s/ to a [k]. This, then, is an interesting example, as the winning output violates DEP (twice), IDENT[coronal] and IDENT[continuant]. It might seem as though this set of violations should be disallowed, given the fact that the repair of a non-prevocalic /s/ by violations of exactly these three constraints is disallowed. If the multiple violations in 'blessing' are treated the same as the multiple violations in 'speak' in (27b), then the deletion candidate should be a better alternative. This is not the case, however. If an input has multiple loci of markedness violations, then any deletion output candidate would have to have multiple loci of deletion. In the word 'blessing', no single deletion can trade off for the violations of DEP, IDENT[coronal], and

IDENT[continuant]. It would take three deletions (as in candidate d.) to eliminate all the markedness violations. Because of the relatively high weight of MAX, these three deletions are not tolerated. Thus candidate b., in which DEP, IDENT[coronal], and IDENT[continuant] are all violated, is the best candidate for this input. This drives home the point that in CFEs, a violation of the higher-weight faithfulness constraint (in this case, MAX) is only allowed if it will remove multiple marked structures, thereby avoiding the violation of multiple other faithfulness constraints. If a violation of MAX only resolves one marked structure, and thus only avoids the violation of one other faithfulness constraint, then the violation of MAX is deemed too costly.

In the tableau for 'speak', the fully-faithful candidate violates exactly the same three markedness constraints that the fully-faithful candidate for 'blessing' violated: *COMPLEX because of the /sp/ cluster, *t because of the /s/, and NOCODA because of the /k/. The "expected" repair, shown in candidate b., involves both epenthesis and the change from /s/ to [k] and would violate DEP (twice, once for the cluster and once for the coda), IDENT[coronal], and IDENT[continuant]. Note that this is also exactly parallel to candidate b. in the tableau for 'blessing', the winning candidate. The crucial difference lies in the locus of violation of each of the faithfulness constraints. By deleting the /s/ in 'speak', candidate c. violates MAX but avoids violations of IDENT[coronal] and IDENT[continuant] as well as one of the DEP violations (the other violation, for epenthesis after the coda /k/, is unrelated). Here, then, deletion is the preferred repair because a single deletion can eliminate multiple marked structures.

A careful observer will have noticed that several of the adaptations in (23) did violate three faithfulness constraints. It is not the case that Speaker 2's grammar disallows all outputs which are triply-unfaithful; some triply-unfaithful outputs are allowed, as in 'blessing' above, because the loci of the faithfulness violations do not intersect. Other triply-unfaithful mappings are allowed even when the loci of violations do intersect, indicating that not all of the low-weight faithfulness constraints have equal weight. An example from (23) is repeated in (28) along with details about which faithfulness constraints are violated.

(28) Some triply-derived repairs allowed

[koinikə] 'zoink'

/z/ → [k] violates IDENT[coronal], IDENT[continuant], IDENT[voice]

Hawaiian does not have any voiced obstruents, so borrowed voiced obstruents must be repaired. In this example, the change from /z/ to [k] violates three identity faithfulness constraints; deletion of the /z/ would avoid these three violations, yet the deletion candidate is not the attested output. The optimal output for a prevocalic /z/ is the same as a prevocalic /s/. This implies that the additional faithfulness violation incurred by the winning candidate for an input /z/, the violation of IDENT[voice], must have a very low weight, so low that the cumulative violation of IDENT[voice], IDENT[coronal], and IDENT[continuant] cannot overcome the weight of MAX. The additional constraints necessary to account for this word and the relevant weighting argument are shown in (29).

(29) Additional constraints for Hawaiian

*VOIOBS: Voiced obstruents are banned

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

Weighting	Result
$W_{*MAX} > [W_{ID[coronal]} + W_{ID[continuant]} + W_{ID[voice]}]$	/zɔɪŋk/ k̲oinikə > oinikə

A tableau for 'zoink' is displayed in (30). Based on the weighting argument above, it is necessary for the combined weight of IDENT[coronal], IDENT[continuant] and IDENT[voice] to be less than the weight of MAX. Given the previously established weights of IDENT[coronal], IDENT[continuant], and MAX, it is simply necessary to give IDENT[voice] a weight lower than 0.5. Here it is shown with a weight of 0.4. This allows the cumulative harmony of candidate b., the winning candidate, to be slightly higher than the cumulative harmony of candidate c., the deletion candidate.

(30) HG account of allowable triply-derived repairs

/zɔɪŋk/ 'zoink'	*t w=3	*VOIOBS w=3	MAX w=2.5	ID[cor] w=1	ID[cont] w=1	ID[voi] w=0.4	H
a. zɔɪŋk	-1	-1					-6
b. ☞ koinikə				-1	-1	-1	-2.4
c. oinikə			-1				-2.5

In sum, Speaker 2's Hawaiian loanword adaptations show cumulative faithfulness effects. In his grammar, deletion is a repair strategy only when it would avoid the violation of multiple other faithfulness constraints whose weight can gang up on the weight of MAX. Otherwise, the relatively high weight of MAX renders it too costly a violation.

4.6 Theoretical implications

The CFEs presented in this chapter raise several theoretical questions. First, we will return to the discussion begun in Chapter 1 about the merits of HG versus LC. Then we will take up the question of why DEP is so frequently a part of CFEs.

4.6.1 Local constraint conjunction versus harmonic grammar

As has been shown throughout this thesis, cumulative faithfulness effects are (almost always) problematic for standard OT precisely because of strict domination. Single violations of the relevant faithfulness constraints are allowed, so those constraints must be low-ranked, but there is no mechanism in place to allow for multiple low-ranked constraints to gang up on a higher-ranked constraint. We have turned to HG as an alternative to OT because one of the ways in which HG differs from OT is that it allows this ganging up effect. However, there is another analytical possibility within OT: local constraint conjunction (e.g., Smolensky, 1995; Kirchner, 1996). LC is an augmentation of standard OT that has been proposed to deal with cumulative effects; two constraints can be conjoined such that violation of both conjuncts results in violation of the higher-ranked conjoined constraint. This allows the grammar to rule out just those structures that are too marked (with the conjunction of two or more markedness constraints) or too unfaithful (with the conjunction of two or more faithfulness constraints). Several valid criticisms of LC have been made, however. The domain of conjunction must be specified, and if the domain is too large, unattested grammars are predicted (e.g., McCarthy, 2003a; Pater, Bhatt and Potts, 2007). For instance, Pater and colleagues (2007) note that the conjunction of NoCoda and *VoicedObstruent within a word can result in a grammar in which initial devoicing occurs only in the case that a word has a coda. This is a typologically unattested pattern. Moreover, the provenance of LC constraints is at issue; there is debate as to whether all constraints are conjoined (recursively or not) as part of Con, or whether Con simply includes a local conjunction operation. These questions make an LC account of cumulativity effects somewhat challenging. This section explores possible LC accounts of some of the CFEs discussed in this chapter and argues that HG is the better alternative.

4.6.1.1 Fula

LC can account for the range of Fula loanword adaptations. In the first Fula CFE, the Glide Backing and Epenthesis processes could each occur individually, but they could not co-occur. By conjoining Ident[back] and Dep and ranking this conjunct above Max, it is possible to eliminate outputs in which both epenthesis and backing have occurred in favor of outputs in which the glide is deleted. The LC constraint is not relevant if both conjuncts are not violated, and so the ranking of Max above the individual conjuncts avoids the deletion candidates in those outputs in which only Ident[back] or Dep is violated. In the second Fula CFE, Gliding and Epenthesis could not co-occur, so the relevant conjunction there would be between Ident[sonorant] and Dep. And in the third CFE, in which Unpacking and Epenthesis could not co-occur, it would be necessary to conjoin INTEGRITY and DEP. Each of these conjunctions presents the same potential problem, so the focus here will be on the first conjunction, that of IDENT[back] and DEP.

When two constraints are conjoined, the domain of conjunction must be specified. The violations of each conjunct must occur within the specified domain for the conjoined constraint to be violated. The domain of conjunction of IDENT[back] and DEP in Fula is an interesting question; the violations of IDENT[back] and DEP in an output like /tɥijo/ → [tiwijo] are not in the same syllable.[11] As Paradis (1995; Paradis and Béland, 2002) does not discuss the foot structure of Fula, the next smallest relevant domain of conjunction is the word. Thus the constraint in (31) conjoins IDENT[back] and DEP within the domain of a word. The tableaux in (32) show that the LC constraint eliminates the unattested doubly-derived output candidate for a word like 'pipe' (32c). In the singly-derived words 'midnight' (32a) and 'drink' (32b), on the other hand, only one of the conjuncts of the constraint is violated, and so the locally conjoined constraint plays no role.

(31) Locally conjoined constraint

IDENT[back]&DEP_W: The conjunction of IDENT[back] and DEP within the domain of a word

[11] This same criticism is also true of the third Fula CFE conjunction. In a candidate like [balansa] for input /balɑ̃s/, the violations of INTEGRITY and DEP are also in separate syllables. This does raise the possibility that conjoined constraints in Fula in general are likely to be conjoined in adjacent syllables or in the word as a whole.

(32) LC account of Fula CFE

a. MAX >> ID[back]

/minɥi/ ‘midnight’	ID[back]&DEP$_w$	*ɥ	*COMP	MAX	ID[back]	DEP
a. min.ɥi		*!				
b. mi.nwi			*!		*	
c. ☞ min.wi					*	
d. mini				*!		

b. MAX >> DEP

/bwasɔ̃/ ‘drink’	ID[back]&DEP$_w$	*ɥ	*COMP	MAX	ID[back]	DEP
a. bwasɔŋ			*!			
b. ☞ buwasɔŋ						*
c. basɔŋ				*!		

c. ID[back]&DEP$_w$ >> MAX

/tɥijo/ ‘pipe’	ID[back]&DEP$_w$	*ɥ	*COMP	MAX	ID[back]	DEP
a. tɥijo		*!	*			
b. tiwijo	*!				*	*
c. ☞ tijo				*		

Though LC and HG can both account for this Fula CFE, they make different predictions about a set of words that occur in French but did not occur in Paradis’ (1995; Paradis and Béland, 2002) description of Fula loanwords. These words have onset clusters and the labio-palatal glide, but the glide does not occur as part of the onset cluster. Words of this structure, presented in (33), are quite common in French, and it is not a stretch to imagine that they may be borrowed into Fula.

(33) French words with unrelated onset clusters and labio-palatal glides

/gradɥe/	‘graduate’	/spiritɥel/	‘spiritual’
/gratɥi/	‘free’	/statɥer/	‘to hand down a ruling’
/prɔdɥi/	‘produce’	/tradɥir/	‘translate’

Because it was necessary to conjoin IDENT[back] and DEP in the domain of a word to account for the Fula CFE, this conjunction also predicts that words in which the glide is not part of the cluster will nevertheless undergo deletion of the glide. This is shown in (34).

(34) LC predicts deletion even when glide is not part of cluster

/gratɥi/ ‘free’	ID[back]&DEP$_w$	*ɥ	*COMP	MAX	ID[back]	DEP
a. grat.ɥi		*!	*			
b. garat.wi	*!				*	*
c. ☞ garati				*		

HG, on the other hand, makes a different prediction. The inputs in (33) each violate two markedness constraints: *COMPLEX and *ɥ. Because these are high-ranked constraints, any successful output must repair both markedness violations. Deletion of the glide only repairs one violation, that of *ɥ. Thus the HG account, given in (35), predicts that when the labio-palatal glide is not part of a cluster, it will be adapted as [w] and the cluster will be repaired with epenthesis. This reinforces the point made earlier: the weighting of constraints necessary to account for CFEs entails that deletion is only an available strategy when it will repair multiple markedness violations at once. If deletion only repairs one markedness violation, and another markedness violation must be repaired with another strategy, deletion becomes too costly.

(35) HG predicts deletion *only* when it repairs multiple markedness violations

/gratɥi/ 'free'	*ɥ w=2	*COMPLEX w=2	MAX w=1.5	ID[back] w=1	DEP w=1	H
a. grat.ɥi	-1	-1				-4
b. ☞ garat.wi				-1	-1	-2
c. garati			-1		-1	-2.5

LC and HG make different predictions in the case of these words whose borrowed forms are not attested; it is thus an empirical question which is correct. It seems likely, however, that the output predicted by HG is the correct one, as it combines two unrelated repairs already found in Fula words. The large domain of the LC constraint makes the unexpected prediction. This has already been noted as a criticism of LC: conjunction in large domains makes the prediction that unrelated or non-local segments may affect one another (McCarthy, 2003a). Restrictions on the domain of conjunction have been proposed (Łubowicz, 2005), and it is the case even in this example that one might think of alternative domains that would not cause unexpected predictions. For instance, we might consider conjoining DEP and IDENT[back] in the domain of adjacent segments, rather than the word. This also raises the question of what is a reasonable domain—do domains have to be prosodic constituents such as syllables, feet, or words, or can they be other local relationships, such as adjacent segments? In any case, HG does not have the domain problem. In the HG account in (11) above, determining the domain of application of any constraint or set of constraints was not necessary. This gives HG an advantage over LC.

4.6.1.2 Hawaiian

In the Hawaiian CFE, it is the co-occurrence of three different processes that is banned. Velarization, Stopping, and Epenthesis are all valid processes individually, and any two of them can be combined, but the combination of all three processes is disallowed. LC can account for this cumulative faithfulness effect, but to do so it is necessary to conjoin three constraints: DEP, IDENT[coronal], and IDENT[continuant]. The constraints can be conjoined within the domain of a syllable. This constraint is defined in (36).

(36) Locally conjoined constraint

LC3: IDENT[coronal]&IDENT[continuant]&DEP_{σ}: The conjunction of IDENT[coronal], IDENT[continuant] and DEP within the domain of a syllable

By conjoining these constraints and ranking them above MAX, it is possible to rule out the triply-derived [k]. Ranking MAX above the other non-conjoined faithfulness constraints, however, preserves the /s/ as [k] in the case that it is prevocalic. The tableaux in (37) show this conjunction. Note that in the tableau for 'blessing' (37a), the winning candidate b. does not violate the LC3 constraint, even though the candidate does violate IDENT[continuant], IDENT[coronal] and DEP. This is because the LC constraint operates solely within the domain of a syllable. The violations of DEP incurred by candidate b. are not in the same syllable as the violations of IDENT[coronal] and IDENT[continuant], and so the LC3 constraint is not violated. This emphasizes the point that the deletion of /s/ is allowed only in the case that it avoids a three-step repair for that segment. Moreover, it is important to see that gratuitous violations of MAX are not allowed. Candidate d. in the tableau for 'speak' (37b) deletes not only the /s/, but also the coda /k/, which avoids any need for either featural change or epenthesis. This candidate, however, incurs a gratuitous violation of MAX, which eliminates it, in spite of the fact that it violates no other constraint.

(37) LC account of Hawaiian CFE

a. MAX >> DEP, ID[coronal], ID[continuant]

/blɛsɪŋ/ 'blessing'	LC3	*t	NC	*COMP	MAX	DEP	ID[cor]	ID[cont]
a. blɛsɪŋ		*!	*	*				
b. ☞ pelekine						**	*	*
c. peleine					*!	**		

b. LC >> MAX

/spik/ 'speak'	LC3	*t	NC	*COMP	MAX	DEP	ID[cor]	ID[cont]
a. spik		*!	*	*				
b. kəpikə	*!					**	*	*
c. ☞ pikə					*	*		
d. pi					**!			

While the LC3 constraint can sufficiently account for the data, it raises broader questions. Is it acceptable to conjoin three constraints? Are locally conjoined constraints part of Con, or are they created as needed by learners? If a triply-conjoined constraint exists in a grammar, do its doubly-conjoined counterparts exist as well? For instance, does Speaker 2's grammar also include the conjunction of IDENT[coronal] and IDENT[continuant], or of DEP and IDENT[coronal], or DEP and IDENT[continuant]? Note that each of these constraints must be ranked below the markedness constraints, because each would be violated by one of Speaker 2's outputs. Moreover, do constraints exist in Con that differ only in their domain of conjunction? For instance, is there also a constraint conjoining IDENT[coronal], IDENT[continuant] and DEP, but within the domain of a word? These questions are not insurmountable; it may be that all possible conjunctions of all constraints exist in Con. If this were the case, though, then even those conjunctions that predict implausible grammars must be assumed.

Though both LC and HG can account for Speaker 2's adaptation patterns, the LC account raises numerous questions about the conjunction of constraints. These questions are not problematic for the HG account, as the constraints do not have to be conjoined.

4.6.1.3 Summary of LC versus HG

The accounts of Fula and Hawaiian showed that both LC and HG can account for cumulative faithfulness effects. However, the conjunction of faithfulness constraints was shown to be subject to at least two of the same criticisms that arise in the discussion of the local conjunction of markedness constraints. First, the domain of conjunction must be specified; when the domain is too large, unlikely grammars are predicted. The domain of conjunction criticism has been discussed by McCarthy (2003a), and restrictions on the domain have been proposed by Łubowicz (2005). Nevertheless, it is unclear whether the domain can be sufficiently restricted, and in any case HG does not share this problem. In LC, if the domain is too large, unattested results may obtain, but in HG, it was shown that with the proper weightings, CFEs were limited to structures whose markedness violations overlap, even without the specification of a domain. It seems, then, that by virtue of not having to specify a domain at all, HG has an advantage over LC.

A second criticism of LC concerns whether conjoined constraints are part of Con or if constraint conjunction is an operation accessible to learners. Smolensky (1995) is silent on this issue. Baković (2000) and Itô and Mester (1998) have argued that locally conjoined constraints are universal, though Baković (2000) does state that conjunction is not recursive, as that would create an infinite number of constraints. This raises a further question: if conjunction is not recursive, how many constraints can be conjoined? It has been shown here that in some cases, three constraints must be conjoined; it is conceivable that there are grammars in which four or more constraints must be conjoined. If these constraints are universal, how many conjoined constraints exist? Moreover, Rice (2006) notes that if locally conjoined constraints are universal, they should play a greater role in grammars than they seem to. On the other hand, Itô and Mester (2003a) and Smolensky (1997) argue that the operation of conjunction is part of Con, but that the locally conjoined constraints themselves are not necessarily universal—in fact, which locally conjoined constraints exist in a language is part of what makes each language different. Each of these arguments has its advantages, but which is the correct assumption is unclear. Again, HG is not plagued with the problem of universality or the provenance of constraints; it is the weighting of constraints that allows for CFEs, and the weighting is exactly what makes each grammar language-specific.

4.6.2 Why so many processes with DEP?

As we examined the five CFEs discussed in this chapter, it became clear that all had something in common: in each case, a marked segment overlapped with a marked syllabic structure. In Fon, the marked rhotic could be replaced with a lateral, and a coda could be preserved by means of epenthesis, but when the marked rhotic coincided with the coda, then it was deleted. This was also true of each of the Fula CFEs: the labio-palatal glide, voiced fricative or nasal vowel all coincided with a cluster of some sort. Finally, in Hawaiian, the marked segment /s/ was preserved as [k], unless it appeared in a bad syllable position, for instance a coda or the first member of a cluster. Is it a coincidence that in each of these cases, the disallowed combination of repairs consists of a segmental repair and a syllabic repair?

Paradis (1995) argues that in loanword adaptation, the amalgamation of a segmental repair and a syllabic repair always exceeds the faithfulness threshold. In each of the cases discussed in this chapter, the syllabic repair was epenthesis. Candidates that violated both DEP and some IDENTITY constraint were eliminated. It is interesting that it seems to be no problem to combine multiple segmental repairs (i.e., IDENTITY violations) in loanword adaptation, though Chapters 2 and 3 showed that such combinations are frequently disallowed in fully-developed languages as well as first language acquisition. In Hawaiian, for instance, the cumulative violation of IDENT[coronal] and IDENT[continuant] has a relatively high harmony, and even the cumulative violation of IDENT[coronal], IDENT[continuant] and IDENT[voice] is allowed. What is it about a violation of DEP that makes it particularly unsuitable to combine with another faithfulness violation?

Thus far in this thesis, we have taken the phrase "too unfaithful" to refer to candidates whose cumulative faithfulness violation is too great. That is, when comparing candidates that are equally unmarked, in each of the CFEs discussed so far, the preferred output is the one that repairs marked structures with the smallest absolute cumulative faithfulness value. One question not directly addressed in this thesis, though, is whether that cumulative faithfulness violation in HG corresponds in some way to speakers' calculations of perceptual similarity. It is possible that the epenthesis of a segment, combined with a featural change, is too perceptually salient to the loanword borrowers. One way of testing this would be to have listeners compare an unfaithful production that has undergone epenthesis and featural change with an unfaithful production that has undergone deletion. For instance, an AXB classification task, in which X corresponds to the faithful production, and A and B each correspond to a different unfaithful production, might get at this question.

In any case, the goal of this thesis is not to determine whether speakers prefer fell-swoop repairs to multiply-unfaithful ones because they are perceptually more similar, or because they are more similar in a more abstract calculation like cumulative faithfulness. That is a question left for future research (though a discussion of some of the relevant data and possible experimental evaluations is provided in Chapter 6). The dispreference for repairs that combine DEP with another faithfulness constraint, however, may prove to be a fertile testing ground for this question.

4.7 Conclusion

This chapter has presented a kind of cumulativity not previously discussed: cumulative faithfulness. Loanword phonology was found to be a rich source for CFEs because in loanword adaptations there are likely to be marked segments or structures that must be repaired by the borrowing phonology. In each of the loanword examples discussed here, deletion applies only when it will eliminate a segment or structure that violates multiple faithfulness constraints. In Fula, the glide [ɥ] is deleted when it coincides with a syllable-structure violation. In Hawaiian, [s] is also deleted when it coincides with a syllable-structure violation. In fact, in many CFEs, a segmental markedness violation coincides with a syllable-structure violation. Deletion of the segment solves both problems.

It was shown that CFEs cannot be accounted for in standard OT. While the local conjunction of faithfulness constraints can solve the problem, the Fula and Hawaiian examples show that the LC account has some undesirable results. Instead, the weighted constraints of HG were invoked. By differentially weighting the faithfulness constraints, we can arrive at a grammar in which single unfaithful mappings are allowed, but candidates that are too unfaithful are eliminated.

CHAPTER 5

ATYPICAL CUMULATIVE FAITHFULNESS EFFECTS

5.1 Introduction

For the most part, the cumulative faithfulness effects (CFEs) in previous chapters were of the type (1f) in the typology from Chapter 1: two low-weight faithfulness constraints ganged up on a third, higher-weight faithfulness constraint. Each of those examples involved three processes in a mutual bleeding relationship, included overlapping conspiracies, and resulted in a ranking paradox in standard optimality theory (OT) (with the one exception from Fula in Chapter 4). In this chapter, we examine three examples that in some way differ from the typical CFE description, yet rely crucially on the notion of cumulative faithfulness. These examples are important because they show that faithfulness cumulativity is active in unexpected ways. For instance, cumulative faithfulness may be the explanation behind the presence of a marked output, does not always have to involve segmental or featural deletion, and may result in an unusual type of chain shift.

In §5.2 we consider Luwanga, in which a faithful (marked) output is chosen over the expected doubly-unfaithful (unmarked) output. This is an example of the CFE type (1e) in Chapter 1. §5.3 examines a CFE in a dialect of Japanese which is unusual both because the CFE processes do not involve deletion and because standard OT can account for it. In §5.4, the chain shift is explored as a type of CFE. A distinction is drawn between a "true" chain shift and a CFE chain shift, which is opaque but must be analyzed as a CFE. A summary and conclusion, revising the diagnostics of a CFE, are given in §5.5.

5.2 Luwanga: Two faithfulness constraints gang up on a markedness constraint

The typology in Chapter 1 included CFEs in which two faithfulness constraints gang up on a markedness constraint. The result in such a case is that a faithful, marked structure surfaces rather than an unmarked, doubly-unfaithful structure. Such an example can be found in Luwanga (Green, 2008), a Bantu language with processes somewhat similar to those described for Kikuyu in Chapter 2.

In Luwanga, voiced and voiceless obstruents do not contrast in surface forms: all post-nasal obstruents are voiced, and elsewhere obstruents are voiceless. Typically in a case of such seeming allophonic variation, a voiceless underlying form would be posited, plus a rule or constraint ranking requiring that obstruents be voiced post-nasally. Nevertheless, Green (2008) makes a compelling argument that Luwanga obstruents do show an underlying voice contrast. The noun class prefix for Class 9 nouns is /iN/ (the nasal assimilates in place to a following consonant). When this prefix is attached to some nouns, the nasal deletes (1a). When the same prefix is attached to other nouns, however, the nasal is retained, and the following obstruent is realized as voiced (1b). Green argues that if all obstruents were voiceless underlyingly, there would be no way to predict when the prefix nasal deletes and when it is retained. On the other hand, if we posit that the nasal prefix deletes before underlyingly voiceless obstruents, and is retained before underlyingly voiced obstruents, then the contrastive behavior is explained. Green also notes that underlyingly voiced obstruents devoice when not post-nasal, as in (1c). This would require a rule demanding that obstruents be realized as voiceless when not post-nasal, or a constraint against voiced obstruents generally. The seemingly allophonic distribution of obstruents, then, is the result of a process of devoicing combined with a process of nasal deletion.

(1) Luwanga (data from Green, 2008)

a. Nasals delete before a voiceless obstruent

/iN+takata/[1]	[itakata]	'chest'
/iN+kweena/	[ikweena]	'crocodile'
/iN+fuko/	[ifuko]	'kidney'
/iN+saxaani/	[isaxaani]	'plate'
/iN+xafuka/	[ixafuka]	'pot'

b. Nasals retained before a voiced obstruent

/iN+duuma/	[induuma]	'yam'
/iN+gato/	[iŋgato]	'sandal'
/iN+bako/	[imbako]	'hoe'
/iN+dʒiri/	[iɲdʒiri]	'warthog'

[1] The underlying representation for non-alternating obstruents cannot be determined. Lexicon optimization (Prince and Smolensky, 1993/2004) argues that the when a single phonetic output could be linked to multiple possible inputs, the input which would result in the fewest faithfulness violations is most harmonic. Lexicon optimization would thus lead us to assume that the input to a non-alternating intervocalic voiceless obstruent is voiceless. In any case, the high ranking of *VOIOBS >> IDENT[voice] would choose a voiceless obstruent in this position even if an underlyingly voiced obstruent were posited.

c. Voiced obstruents are realized as voiceless elsewhere

/axa+duuma/	[axatuuma]	‘small yam’
/axa+gato/	[axakato]	‘small sandal’
/axa+dʒiri/	[axatʃiri]	‘small warthog’

In order to account for this pattern in OT, the constraints shown in (2) are necessary. The markedness constraints are composed such that they will result in a surface allophonic pattern, with one constraint banning voiceless obstruents after nasals, and the other constraint banning voiced obstruents generally. The faithfulness constraints militate against deletion and devoicing. Note that only two faithfulness constraints are necessary, as Luwanga displays processes of devoicing and nasal deletion in this instance.

(2) Constraints relevant for the Luwanga CFE

*NC̥: Sequences of a nasal followed by a voiceless obstruent are banned

*VoiObs: Voiced obstruents are banned

Max: Input segments have output correspondents

Ident[voice]: Input and output correspondents have the same value for the feature [voice]

In order to achieve nasal deletion before an underlyingly voiceless obstruent, *NC̥ must be ranked above Max, as is shown in (3a). Either *VoiObs or Ident[voice] must also be ranked above Max to ensure that deletion, and not voicing, is the repair for an NC̥ sequence. Moreover, the ranking *VoiObs >> Ident[voice] insures that voiced obstruents are devoiced when not post-nasal, as in (3b). Finally, the ranking of *NC̥ above *VoiObs (3c) means that devoicing will never occur post-nasally.

(3) Luwanga in OT

a. *NC̥, *VoiObs >> Max

/iN+takata/ ‘chest’	*NC̥	*VoiObs	ID[voice]	Max
a. intakata	*!			
b. indakata		*!	*	
c. ☞ itakata				*

b. *VoiObs >> ID[voice]

/axa+duuma/ ‘small yam’	*NC̥	*VoiObs	ID[voice]	Max
a. axaduuma		*!		
b. ☞ axatuuma			*	

c. *NC̥ >> *VoiObs

/iN+duuma/ ‘yam’	*NC̥	*VoiObs	ID[voice]	Max
a. ☞ induuma		*		
b. intuuma	*!		*	

Note, however, that the tableau in (3c) left out a relevant candidate—a candidate in which the nasal is deleted and the obstruent is devoiced. With the rankings necessary to account for the other phenomena, this candidate would incorrectly win, even though it is doubly-unfaithful. The problem is that the candidate in which the nasal has deleted and the obstruent is devoiced is maximally unmarked, even though it is also maximally unfaithful. With the markedness constraints high-ranked in the grammar, there is no way to avoid getting the least marked output. This causes a ranking paradox: both faithfulness constraints must be low-ranked in order to get the singly-unfaithful outputs in (3a) and (3b), but with both of the faithfulness constraints low-ranked, there is no way to avoid a doubly-unfaithful output. This unattested result is shown in the tableau in (4).

(4) An unattested prediction

/iN+duuma/ 'yam'	*NC̥	*VoiObs	ID[voice]	Max
a. ☜ induuma		*!		
b. intuuma	*!		*	
c. iduuma		*!		*
d. ☞ ituuma			*	*

Candidate d. in the tableau in (4) is clearly bad from a faithfulness point of view. This resembles a CFE: an intervocalic [t] is allowed when it is underlying (e.g., /axa+takata/ → [axatakata], 'small chest'). An intervocalic [t] is also allowed when it is derived by nasal deletion (1a) or by devoicing (1b). However, an intervocalic [t] is not allowed when it is derived by both nasal deletion and devoicing. What is unusual about this example, as compared to other CFEs, is that no third process intervenes to allow for an unmarked output. For instance, obstruent deletion (resulting in an output like *[inuuma]) might have been used to avoid a marked output. Instead, the language allows an output with a marked segment to survive. The correct output for the input /iNduuma/ is [induuma], which is unmarked with respect to the voicing in the NC cluster but is marked in terms of having a voiced obstruent.

From a rule-based point of view, the Luwanga problem is more straight-forward. One rule, Nasal Deletion, deletes a nasal before a voiceless obstruent, while another rule, Devoicing, devoices all obstruents that are not post-nasal. Neither of these rules would apply to the sequence of a nasal followed by a voiced obstruent, and so such a sequence would remain faithful. Moreover, the two rules would not interact. Thus Luwanga is an exception to the general fact that CFEs involve rules that are in a mutual bleeding relationship. The rule-based account fails to capture the avoidance of double-unfaithfulness present in the OT account. This is because the language avoids doubly-unfaithful outputs not with a fell-swoop process, as we have seen in most previous CFEs, but by simply allowing a marked output to surface only in those cases in which its repair would violate multiple faithfulness constraints.

Green (2008) appeals to local constraint conjunction (LC) to solve the Luwanga ranking paradox. By conjoining MAX and IDENT[voice] in the domain of adjacent segments (defined in (5)) and ranking the conjoined constraint above the markedness constraint *VOIOBS, it is possible to avoid the doubly-derived output and choose the singly-marked output instead. This is shown in the tableau in (6).

(5) LC constraint

MAX&IDENT$[\text{voice}]_{\text{AdjSeg}}$: The conjunction of MAX and IDENT[voice] in adjacent segments

(6) LC account of Luwanga CFE

/iN+duuma/ 'yam'	MAX&IDENT[voice]	*NC̥	*VOIOBS	ID[voice]	MAX
a. ☞ induuma			*		
b. intuuma		*!		*	
c. iduuma			*		*!
d. ituuma	*!			*	*

Can harmonic grammar (HG) also account for this type of CFE? Each of the HG accounts presented thus far has illustrated that it is crucial to assign the weights of the faithfulness constraints such that the weight of one constraint outweighs the individual weights of two others, but that the cumulative weight of those two constraints outweighs the single constraint. In this case, two low-ranked faithfulness constraints need to be weighted in such a way that they can gang up on a higher-weight markedness constraint. The tableaux in (7) illustrate that HG can easily account for Luwanga.

(7) HG account of Luwanga CFE

a. $W_{*VOIOBS} + W_{ID[voice]} > W_{MAX}$

/iN+takata/ 'chest'	*NC̥ w=3	*VOIOBS w=3	ID[voice] w=2	MAX w=2	H
a. intakata	-1				-3
b. indakata		-1	-1		-5
c. ☞ itakata				-1	-2

b. $W_{*VOIOBS} > W_{ID[voice]}$

/axa+duuma/ 'small yam'	*NC̥ w=3	*VOIOBS w=3	ID[voice] w=2	MAX w=2	H
a. axaduuma		-1			-3
b. ☞ axatuuma			-1		-2

c. $W_{*\text{VoiObs}} < W_{\text{ID[voice]}} + W_{\text{Max}}$

/iN+duuma/ 'yam'	*NC̥ w=3	*VoiObs w=3	ID[voice] w=2	Max w=2	H
a. ☞ induuma		-1			-3
b. intuuma	-1		-1		-5
c. iduuma		-1		-1	-5
d. ituuma			-1	-1	-4

The tableau in (7a) shows that the weight of the markedness constraint against nasal+voiceless obstruent sequences must be greater than the weight of the faithfulness constraint militating against deletion. The tableau in (7b) shows another case in which the weight of a markedness constraint (*VoiObs) must be greater than the weight of a faithfulness constraint (Ident[voice]). Most importantly, though, the tableau in (7c) illustrates that the cumulative weight of the two faithfulness constraints is enough to outweigh a single violation of *VoiObs. That is, the marked voiced obstruent can only surface when the alternative is a doubly-unfaithful output. This is similar to the more standard CFEs, when a certain process only surfaces to avoid doubly-unfaithful outputs. Here, rather than a third process, it is a particular marked structure that surfaces. The Luwanga example thus exemplifies another part of the typology of CFEs, illustrating that in some cases, a doubly-unfaithful output is avoided by allowing the marked candidate to surface. This occurs when two faithfulness constraints gang up on a markedness constraint.

In the next section, we turn to a CFE than can be accounted for in standard OT, illustrating that when repair processes cannot compete, ranked constraints are sufficient. Nevertheless, it is argued that an HG account is preferable.

5.3 Shizuoka Japanese: A CFE for which standard OT *can* account

As noted in the previous chapters, standard OT typically cannot account for CFEs because of the ranking paradox that arises among the faithfulness constraints. However, it is the case that in some CFEs (like the third Fula CFE in Chapter 4), the relevant repair processes do not conflict with one another, and so no ranking paradox arises. These cases can be accounted for in standard OT, but their HG accounts are more revealing of the cumulativity effect. One such example arises in Japanese (specifically the older Shizuoka dialect) emphatic adjectives and adverbs (Lombardi, 1998; Itô and Mester, 2003a; for alternative analyses, see Davis and Ueda 2002).

Like a number of languages described in this thesis, Shizuoka Japanese disallows the sequence of a nasal followed by a voiceless obstruent. When this sequence is morphologically derived, the underlyingly voiceless obstruent surfaces as voiced, as in (8a). Voiced geminates are also dispreferred in Shizuoka Japanese; voiceless geminates are common, as in (8b), but voiced geminates do not occur in native words. Each of these two phonological restrictions becomes relevant when considering the emphatic or intensified adjectives and adverbs. This morphological class is derived by the addition of a mora to the base (and, for the adverbs, the addition of the suffix –ri). The question is how the mora is realized. Typically, the mora attaches to the first postvocalic consonant of the word.[2] When that consonant is voiced, the mora is realized as a preceding nasal, homorganic with the consonant, as in (8c). As nasal insertion is allowed before a voiced obstruent, and obstruents undergo post-nasal voicing, it seems possible that the emphatic mora could be realized as a nasal before a voiceless obstruent, which would then be

[2] The only exceptions to this generalization are the cases in which the input already includes a nasal followed by a voiced obstruent. In these words, the mora is realized on the preceding vowel.

realized as voiced. When the consonant is voiceless, however, the mora combines with this consonant to create a geminate, as in (8d). The process of gemination avoids the doubly-derived processes of nasal insertion and voicing. In other words, the sequence of a nasal followed by a voiced obstruent is allowed underlyingly; it can also be derived by nasal insertion or by obstruent voicing. This sequence cannot, however, be derived by both nasal insertion and obstruent voicing, even though nasal insertion would have allowed for consistent realization of the emphatic morpheme. (Note too that another doubly-derived repair is also avoided. Gemination is allowed for the voiceless obstruents, so we might expect that in the case of voiced obstruents, the obstruents would devoice and then geminate. This output could be banned because it is doubly-derived, but Shizuoka Japanese also does not have any active devoicing process, so it is not clear that this repair would be allowed in any case.)

(8) Shizuoka Japanese CFE (data from Davis and Ueda 2002; Itô and Mester 2003b; Lombardi 1998)

a. Post-nasal voicing

/yom+te/	[yonde]	'read'-gerund
/yom+ta/	[yonda]	'read'-past
/yom+tara/	[yondara]	'read'-conditional
/yom+tari/	[yondari]	'read'-nonexhaustive listing
/sin+te/	[ʃinde]	'die'-gerund
/sin+ta/	[ʃinda]	'die'-past
/kam+ta/	[kanda]	'chew'-past
c.f. /mi+ta/	[mita]	'look at'-past

b. Voiced geminates disallowed

[kap.pa]	‘legendary being’	no words like *[kab.ba]
[sek.kan]	‘soap’	no words like *[seg.gan]
[toot.te]	‘passing’	no words like *[tood.de]
[tos.sa]	‘impulsively’	no words like *[toz.za]

c. Emphatic form for voiced obstruents: Mora realized as a nasal consonant

Adverbs

Base	Intensified form	Gloss
[koga]	[koŋgari]	‘brown’
[zabu]	[zamburi]	‘with a splash’
[ʃobo]	[ʃombori]	‘sadly’
[madʒi]	[mandʒiri]	‘a wink of sleep’
[boya]	[bonyari]	‘absently’
[yawa]	[yanwari]	‘gently’
[gena]	[gennari]	‘fed up’
[simi]	[simmiri]	‘calmly’

Adjectives

Base	Emphatic form	Gloss
[nagai]	[naŋgai]	‘long’
[hade]	[hande]	‘showy’
[ozoi]	[onzoi]	‘terrible’
[yowai]	[yonwai]	‘weak’
[hayai]	[hanyai]	‘fast’
[karai]	[kanrai]	‘spicy’
[kanaʃii]	[kannaʃii]	‘sad’
[amai]	[ammai]	‘sweet’

d. Emphatic form for voiceless obstruents: Mora realized through gemination

Adverbs

Base	Intensified form	Gloss
[huku]	[hukkuri]	'plump, puffy'
[gaku]	[gakkuru]	'collapsingly'
[uka]	[ukkari]	'thoughtlessly'
[bata]	[battari]	'with a bang'
[kote]	[kotteri]	'densely'
[koso]	[kossori]	'stealthily'
[biʃi]	[biʃʃiri]	'closely'
[kitʃi]	[kittʃiri]	'tightly'

Adjectives

Base	Emphatic form	Gloss
[ikai]	[ikkai]	'big'
[takai]	[takkai]	'high'
[katai]	[kattai]	'hard'
[kitanai]	[kittanai]	'dirty'
[osoi]	[ossoi]	'slow'
[kusai]	[kussai]	'stinky'
[atsui]	[attsui]	'hot'

This CFE is different from previous ones in that the fell-swoop process, the process by which the doubly-derived output is avoided, is gemination, rather than deletion. Gemination can be viewed as a violation of DEPLINK in OT; a link between an underlying mora and an underlying consonant has been inserted. The other intensifying process, nasal insertion, can be thought of as the insertion of a nasal feature on an underlying mora, a violation of DEP[nasal]. The voicing pattern violates IDENT[voice].

Each of these patterns avoids creating voiced geminates (militated against by the markedness constraint *VOIGEM) and sequences of a nasal followed by a voiceless obstruent (*NC̥). Moreover, a markedness constraint militating against unrealized moras would be necessarily high-ranked; such a constraint (and the candidates eliminated by it) will be left out of the following tableaux. Previously undefined constraints are defined in (9).

(9) Constraints relevant for Shizuoka Japanese CFE

*VOIGEM: Voiced geminates are banned

DEP[nasal]: Output nasal features have input correspondents

DEPLINK: Segments linked to a mora in the output must be linked to a mora in the input

The tableaux in (10) illustrate the fact that OT can, unexpectedly, account for this CFE. Tableau (10a) simply shows that in order to achieve postnasal voicing, the markedness constraint against sequences of a nasal followed by a voiceless consonant must outrank IDENT[voice]. In a typical CFE ranking paradox, we would find that the faithfulness constraint linked to the "specific" process, in this case DEPLINK, would be crucially ranked above both of the other faithfulness constraints, here IDENT[voice] and DEP[nasal]. In this case, though, there is no evidence that DEPLINK needs to be ranked above IDENT[voice]. That is, the individual voicing and gemination processes never compete to repair the same markedness violation in Shizuoka Japanese: gemination cannot repair an NC̥ sequence, and voicing cannot realize an unrealized mora. (Note that when gemination competes with voicing to realize a mora before a voiceless obstruent, the voicing repair is also combined with nasal insertion.) It is thus possible to rank IDENT[voice] above both of the DEP constraints, allowing IDENT[voice] to eliminate not only the devoicing candidate in (10b), but also the doubly-derived output in (10c).

(10) Standard OT can account for Shizuoka Japanese

a. *NC̥ >> ID[voice]

/sin+ta/ 'died'	*VOIGEM	*NC̥	ID[voice]	DEPLINK	DEP[nasal]
a. sinta		*!			
b. ☞ sinda			*		

b. ID[voice] or DEPLINK >> DEP[nasal]

/ozoi+μ/ 'terrible'	*VOIGEM	*NC̥	ID[voice]	DEPLINK	DEP[nasal]
a. ozzoi	*!			*	
b. ossoi			*!	*	
c. ☞ onzoi					*

c. ID[voice] or DEP[nasal] >> DEPLINK

/osoi+μ/ 'slow'	*VOIGEM	*NC̥	ID[voice]	DEPLINK	DEP[nasal]
a. ☞ ossoi				*	
b. onsoi		*!			*
c. onzoi			*!		*

The generalization to make here is that standard OT can account for CFEs only in the case that the "specific" repair never competes with one of the more "general" repairs in the language. If the two repairs never compete, then the faithfulness constraint corresponding to one of the general repairs need not be ranked below the faithfulness constraint corresponding to the special repair. Compare this to the ranking paradox tableaux shown in previous chapters. The fell-swoop constraint must be ranked above the constraints against each of the other independent repairs, because the repair corresponding to the fell-swoop constraint competes with each of the independent repairs. When the repairs cannot compete, as in Shizuoka Japanese, no ranking paradox arises.

Though standard OT can account for this CFE, its analysis in HG emphasizes the fact that cumulative unfaithfulness is disallowed. Tableau (11a) shows the crucial weighting of *NC̥ greater than IDENT[voice]. Recall above the mention that voiced obstruents also could not undergo a doubly-derived repair consisting of devoicing and gemination. This is clear in (11b), in which the doubly-derived candidate b. is ruled out due to its cumulative harmony. In (11c), candidate c., which has undergone both nasal insertion and voicing, has a lower cumulative harmony than the gemination candidate a., and so gemination is used to avoid the doubly-derived repair. In these tableaux, IDENT[voice] is shown with a weighting equal to DEP[nasal]. It would be possible, of course, to assign IDENT[voice] a higher weight, and it could then single-handedly eliminate candidate b. in (11b) and candidate c. in (11c). The HG tableaux, however, show that this is unnecessary—IDENT[voice] always has the help of another constraint in eliminating the doubly-derived outputs. In HG, constraints no longer have to operate alone.

(11) HG account of Shizuoka Japanese CFE

a. $W_{*N\mathring{C}} > W_{\text{IDENT[voice]}}$

/sin+ta/ 'died'	*VOIGEM w=3	*NC̥ w=3	ID[voice] w=1.5	DEP-LINK w=1.5	DEP[nasal] w=1.5	H
a. sinta		-1				-3
b. ☞ sinda			-1			-1.5

b. $W_{\text{IDENT[voice]}} + W_{\text{DEP[link]}} > W_{\text{DEP[nasal]}}$

/ozoi+µ/ 'terrible'	*VOIGEM w=3	*NC̥ w=3	ID[voice] w=1.5	DEP-LINK w=1.5	DEP[nasal] w=1.5	H
a. ozzoi	-1			-1		-4.5
b. ossoi			-1	-1		-3.5
c. ☞ onzoi					-1	-1.5

c. $W_{\text{DEP-LINK}} < W_{\text{IDENT[voice]}} + W_{\text{DEP[nasal]}}$

/osoi+µ/ 'slow'	*VOIGEM w=3	*NC̥ w=3	ID[voice] w=1.5	DEP-LINK w=1.5	DEP[nasal] w=1.5	H
a. ☞ ossoi				-1		-1.5
b. onsoi		-1			-1	-4.5
c. onzoi			-1		-1	-3

The Shizuoka Japanese CFE illustrates that under certain circumstances, standard OT can account for CFEs. This only occurs, though, when the specific repair process cannot compete with one of the general repair processes, eliminating the need for a crucial ranking between the two constraints. In the next section, we turn to another phonological phenomenon in which cumulative faithfulness plays a role: the chain shift.

5.4 Fyem: A chain shift as a type of CFE

CFEs occur when a language allows outputs that are singly-unfaithful, but those singly-unfaithful repairs cannot combine in a doubly-unfaithful output. This general description also characterizes another effect in which cumulative faithfulness plays a role: the chain shift. In a chain shift, input /x/ is realized as [y], while input /y/ is realized as [z]. Importantly, input /x/ cannot be realized as [z], because this mapping is too unfaithful. The primary difference between CFEs and chain shifts is that in a CFE, a third process intervenes to eliminate the marked structure, while in a chain shift, no third process is available, and the marked structure is allowed to survive as long as it is derived. Chain shifts thus present an opacity effect that is absent in other CFEs.

The Niger-Congo language Fyem (Nettle, 1998; Beckman, 2003) is an excellent example of a language with cumulative faithfulness effects that take the form of a chain shift. Fyem has two such effects: one is a standard chain shift, but the other more closely resembles a cross between a chain shift and a CFE, for reasons that will be explained below. These effects occur when Fyem repairs vowel+vowel sequences. Hiatus is not allowed in the language, so vowel sequences that are derived by morphological concatenation are repaired by the creation of either a long vowel or a diphthong. A more drastic repair, like deletion, is apparently unavailable, a fact for which we could account using a high-ranked constraint like MAXMORA. In the following examples, the first vowel always assimilates to the second. It is impossible to tell from (12a-d) whether this is the result of the quality of the second vowel (always a high front vowel) or its position (at the right edge of the word). In (12e), however, it appears that it is the position of the vowel at the right edge of the word, and not its quality, that causes assimilation of the first vowel.

The data in (12a) show backing assimilation: a high vowel assimilates in backness to a following high vowel. The data in (12b) show height assimilation: a mid front vowel assimilates in height to a following high vowel. The data in (12c), however, illustrate the CFE. A mid back vowel assimilates in backness to a following high vowel, but not in height. Even though there is evidence of both height and backness assimilation in the language, they cannot co-occur. This results in the opaque outputs in (12c), in which it appears that height assimilation has underapplied. The data in (12d) show another opacity effect: low vowels partially assimilate in height to a following high vowel. These words illustrate the second underapplication effect, because the low vowel does not fully assimilate. Finally, the data in (12e) simply illustrate the fact that assimilation is regressive, even when the second vowel is a low vowel.[3]

(12) Fyem vowel harmony (data from Nettle, 1998; Beckman, 2003)

a. High vowels assimilate in backness to a following high vowel[4]

/hu+í/ [hʷíí] 'dying'

b. Mid front vowels assimilate in height to a following high vowel

/ɓé+í/ [ɓíí] 'coming'

[3] There are a few cases in Fyem in which progressive assimilation occurs (Nettle, 1998: 44), but the phonological conditioning for these cases is not clear. In general, regressive assimilation appears to be dominant.

[4] When the roundness of a vowel is lost due to assimilation, the feature [round] often persists as rounding on the preceding consonant. This is due to a high-ranked MAX[labial] constraint that will not be discussed here, as it has no bearing on the rest of the assimilation process.

c. Mid back vowels only assimilate in backness, not in height[5]

/so+í/	[sʷéí]	'drinking'	/ɗo+í/	[déí]	'house (FOC)'

d. Low vowels partially assimilate in height[6]

/bʲa+í/	[bʲéi]	'woman (FOC)'	/pitína+í/	[pitínéi]	'Pitina (FOC)'

e. Assimilation is always regressive

/so+á/	[sʷáá]	'drank'

The Fyem assimilation data shows both a true chain shift and what we might call a CFE chain shift. The true chain shift occurs when the low vowel [a] only partially assimilates to a following high vowel, resulting in an output in which it appears that height assimilation has underapplied. This is a true chain shift because there is no other evidence for the raising of [a]. It simply appears that [a] is prevented from changing both its [low] and its [high] features at the same time. The CFE chain shift occurs when the mid back vowel assimilates in backness, but not in height, to a following high vowel. This chain shift resembles a CFE in that there is independent evidence for the two processes of backness assimilation and height assimilation. Each of those processes occurs independently, but apparently the two processes cannot co-occur.

The difference between a true chain shift and a CFE chain shift may best be illustrated by exploring a rule-based account. The true chain shift, whereby /ai/ is realized as [ei] and /ei/ is realized as [ii], involves two rules in a counterfeeding order.

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[5] When the vowels are in the opposite order in the input (e.g., /…i+o/), a different result obtains (Nettle, 1998: 44). This seems to be due at least in part to the fact that only rising diphthongs are allowed in the language, combined with the fact that assimilation tends to be regressive.

[6] Nettle (1998: 12) claims that the low vowel [a] patterns as a front vowel in Fyem.

The first rule, Mid-Vowel Assimilation, requires that a mid vowel assimilate the [+high] feature of a following vowel. The second rule, Low-Vowel Assimilation, requires that a low vowel assimilate the [-low] feature of a following vowel. If Mid-Vowel Assimilation is ordered before Low-Vowel Assimilation, the chain shift results, as is shown in (13a). When the rules apply in the opposite order, as in (13b), a feeding order results instead.

(13) True chain shift rule ordering

a.

UR	/ai/	/ei/
Mid-Vowel Assim.	---	ii
Low-Vowel Assim.	ei	---
PR	[ei]	[ii]

b.

UR	/ai/	/ei/
Low-Vowel Assim.	ei	--
Mid-Vowel Assim.	ii	ii
PR	*[ii]	[ii]

One of the same rules, Mid-Vowel Assimilation, is also necessary to account for the CFE chain shift. The other rule, Backness Assimilation, accounts for the change from /ui/ to [ii] by requiring that a vowel assimilate in backness to a following vowel. These two rules are shown, in both orders, in the derivations in (14).

(14) CFE chain shift rule ordering

a.

UR	/ei/	/ui/	/oi/
Mid-Vowel Assim.	ii	---	ui
Backness Assim.	---	ii	ii
PR	[ii]	[ii]	*[ii]

b.

UR	/ei/	/ui/	/oi/
Backness Assim.	---	ii	ei
Mid-Vowel Assim.	ii	---	ii
PR	[ii]	[ii]	*[ii]

The problem with the derivations in (14) is that there is no order in which the rules produce the correct output for an input like /oi/, in which the two vowels differ in both height and backness. Both derivations produce the fully assimilated output [ii]. The structural descriptions of both Mid-Vowel Assimilation and Backness Assimilation are met by the input /oi/, and Backness Assimilation does not bleed Mid-Vowel Assimilation. Yet only Backness Assimilation should apply. It appears that rule-based phonology, with the assumption that rules be as general as possible, cannot account for CFE chain shifts. The CFE chain shift is also clearly different from the true chain shift shown in (13a). Though both illustrate an underapplication interaction, the underapplication in the true chain shift can be explained with rule ordering. The underapplication in the CFE chain shift seems to be a result of the simple fact that a too-unfaithful output is disallowed.

Standard OT cannot account for chain shifts. The relevant constraints are listed in (15). The markedness constraints inducing harmony are agreement constraints, which require that adjacent vowels agree in the features [high], [back] and [low]. Faithfulness constraints require identity in exactly these features.

(15) Constraints relevant for Fyem[7]

AGREE[high]: Adjacent vowels have the same value for the feature [high]

AGREE[back]: Adjacent vowels have the same value for the feature [back]

AGREE[low]: Adjacent vowels have the same value for the feature [low]

[7] The fact that vowel deletion or consonant epenthesis are not valid repairs for vowels in hiatus indicates that the faithfulness constraints MAX and DEP must also be high-ranked in the language; these constraints and the candidates they eliminate will not be shown in the following tableaux.

IDENT[high]: Input and output correspondents have the same value for the feature [high]

IDENT[back]: Input and output correspondents have the same value for the feature [back]

IDENT[low]: Input and output correspondents have the same value for the feature [low]

The tableaux in (16) illustrate that with the ranking necessary to account for Mid-Vowel Assimilation, Low-Vowel Assimilation, and Backness Assimilation, unattested results are predicted for both opaque outputs. In order to save space, constraints not relevant for a given tableau are left out. In (16a,b,d), then, AGREE[low] and IDENT[low] are not shown, and in (16c) AGREE[back] and IDENT[back] do not appear. The tableau in (16a) shows that in order for Mid-Vowel Assimilation to occur, AGREE[high] must be ranked above IDENT[high]. Likewise, for Backness Assimilation to occur, AGREE[back] must be ranked above IDENT[back], as in (16b). The high ranking of the AGREE constraints, however, particularly AGREE[high], incorrectly eliminates the winning candidates in (16c,d). Even though the true chain shift and the CFE chain shift have different explanations, standard OT fares equally miserably at accounting for them.

(16) Standard OT fails to account for Fyem chain shifts

a. Mid-Vowel Assimilation: AGREE[high] >> ID[high]

/ɓé+í/ 'coming'	AGREE[high]	AGREE[back]	ID[high]	ID[back]
a. ɓeí	*!			
b. ☞ ɓíí			*	

b. Backness Assimilation: AGREE[back] >> ID[back]

/hu+í/ 'dying'	AGREE[high]	AGREE[back]	ID[high]	ID[back]
a. huí		*!		
b. ☞ h^{w}íí				*

c. Low-Vowel Assimilation ranking paradox

/b^{j}a+í/ 'woman (FOC)'	AGREE[high]	AGREE[low]	ID[high]	ID[low]
a. b^{j}ai	*!	*		
b. ☜ b^{j}éi	*!			*
c. ☞ b^{j}ii			*	*

d. Mid-Vowel and Backness Assimilation cannot co-occur

/so+í/ 'drinking'	AGREE[high]	AGREE[back]	ID[high]	ID[back]
a. soí	*!	*		
b. ☜ s^{w}éí	*!			*
c. suí		*!	*	
d. ☞ s^{w}íí			*	*

HG fares no better than standard OT at accounting for chain shifts. The tableaux in (17a) and (17b) illustrate the fact that AGREE[high] and AGREE[back] need to be more heavily weighted than IDENT[high] and IDENT[back], respectively, in order to achieve Mid-Vowel and Backness Assimilation. However, the weighting of AGREE[high] greater than IDENT[high] also eliminates the attested outputs in the chain shift cases, as in (17c,d).

(17) HG fails to account for Fyem chain shifts

a. $W_{\text{AGREE[high]}} > W_{\text{ID[high]}}$

/ɓé+í/ 'coming'	AG[high] w=2	AG[back] w=2	ID[high] w=1.5	ID[back] w=1.5	H
a. ɓeí	-1				-2
b. ☞ ɓíí			-1		-1.5

b. $W_{\text{AGREE[back]}} > W_{\text{ID[back]}}$

/hu+í/ 'dying'	AG[high] w=2	AG[back] w=2	ID[high] w=1.5	ID[back] w=1.5	H
a. huí		-1			-2
b. ☞ hʷíí				-1	-1.5

c. True chain shift weighting paradox

/bʲa+í/ 'woman (FOC)'	AG[high] w=2	AG[back] w=2	ID[high] w=1.5	ID[back] w=1.5	H
a. bʲai	-1	-1			-4
b. ☜ bʲéi	-1			-1	-3.5
c. ☞ bʲii			-1	-1	-3

d. CFE chain shift weighting paradox

/so+í/ 'drinking'	AG[high] w=2	AG[back] w=2	ID[high] w=1.5	ID[back] w=1.5	H
a. soí	-1	-1			-4
b. ☜ sʷéí	-1			-1	-3.5
c. suí		-1	-1		-3.5
d. ☞ sʷíí			-1	-1	-3

HG, like OT, is not equipped to deal with opacity effects. Both are theories of surface representations and lack the intermediate representations that are crucial in explaining opacity effects in rule-based theories. Many modifications for OT have been proposed to account for opacity effects, and LC (Smolensky, 1995; Kirchner, 1996; Łubowicz, 2002), comparative markedness (McCarthy, 2002b), and optimality theory with candidate chains (OT-CC; McCarthy, 2007a) all have been used to account for chain shifts. Likewise, modifications for HG have also been proposed. Here we will examine a modification proposed by Albright, Magri and Michaels (2008) that was originally intended to deal with certain cumulative markedness effects. The authors note that while many children have acquired a marked kind of syllable structure, there are often lags in the acquisition of doubly-marked syllable structures. This kind of effect cannot be accounted for in HG because it produces a weighting paradox (that is, two marked forms are each allowed, requiring faithfulness to be weighted greater than each of two markedness constraints, but the doubly-marked form is disallowed, requiring the opposite weighting). Albright et al. thus propose the Split Additive Model. In this model, the faithfulness and markedness violations of each candidate are summed independently, and the sum with a larger absolute value is used for candidate comparison. In essence, this allows for outputs that violate both a markedness and a faithfulness constraint, that is, the opaque output that results from a chain shift. For instance, in the true chain shift above, the input /ai/ is realized as [ei]. This candidate violates a markedness constraint (AGREE[high]) and a faithfulness constraint (IDENT[low]). In standard HG, there is no weighting that will disallow this marked candidate only when it is also unfaithful. By splitting up the evaluation of markedness and faithfulness constraints, however, the Split

Additive Model allows candidates that are very marked or very unfaithful to be eliminated in favor of candidates that are both a little marked and a little unfaithful.

This model is illustrated in the tableaux in (18). Note that these tableaux look like HG tableaux except for the three right-most columns, the evaluation columns. In a standard HG tableau, the rightmost column is used to sum all the violations of a particular candidate; the candidate with the smallest absolute value wins. In a Split Additive Model tableau, on the other hand, the markedness and faithfulness violations are summed separately, in the columns labeled M and F, respectively. For each candidate, the larger (absolute) value is entered in the total column, labeled T. Candidates are compared based on the value in the T column. When a candidate violates both markedness and faithfulness constraints, the value in the T column will be less than the total sum of violations would have been in a standard HG tableau. Thus in (18a,b), the Split Additive Model evaluation is no different from the standard HG evaluation, because each candidate only violates faithfulness or markedness constraints, never both. In (18c), however, the winning candidate b. violates one markedness and one faithfulness constraint. The markedness constraint has the higher weight, and so its weight (2.5) is entered in the total column. Candidate c., the transparent candidate, violates two faithfulness constraints, the sum of which is entered in the F column and, because the candidate violates no markedness constraints, is also entered in the total column. Thus the duel faithfulness violations outweigh the single markedness violation. It is as if the faithfulness violation incurred by [ei] is irrelevant. The same is true in the tableau for the CFE chain shift in (18d). The opaque candidate, which is identical to the opaque winning candidate in (18c), is able to win because its faithfulness violation is essentially ignored.

(18) The Split Additive Model accounts for both Fyem chain shifts

a. $W_{AGREE[high]} > W_{ID[high]}$

/ɓé+í/ ‘coming’	AG[high] w=2.5	AG[back] w=3	ID[high] w=2	ID[back] w=2	M	F	T
a. ɓeí	-1				-2.5	0	-2.5
b. ☞ ɓíí			-1		0	-2	-2

b. $W_{AGREE[back]} > W_{ID[back]}$

/hu+í/ ‘dying’	AG[high] w=2.5	AG[back] w=3	ID[high] w=2	ID[back] w=2	M	F	T
a. huí		-1			-3	0	-3
b. ☞ h^wíí				-1	0	-2	-2

c. $W_{ID[high]} + W_{ID[low]} > W_{AGREE[high]}$

/b^ja+í/ ‘woman (FOC)’	AG[high] w=2.5	AG[low] w=3	ID[high] w=2	ID[low] w=2	M	F	T
a. b^jai	-1	-1			-5.5	0	-5.5
b. ☞ b^jéi	-1			-1	-2.5	-2	-2.5
c. b^jii			-1	-1	0	-4	-4

d. $W_{ID[high]} + W_{ID[back]} > W_{AGREE[high]}$

/so+í/ ‘drinking’	AG[high] w=2.5	AG[back] w=3	ID[high] w=2	ID[back] w=2	M	F	T
a. soí	-1	-1			-5.5	0	-5.5
b. ☞ s^wéí	-1			-1	-2.5	-2	-2.5
c. suí		-1	-1		-3	-2	-3
d. s^wíí			-1	-1	0	-4	-4

In the CFE chain shift tableau in (18d), compare the two main competitors, the attested candidate b. and the fully assimilated candidate d. Because the Split Additive Model takes the greater of the two cumulative scores, candidate b. is evaluated on the basis of its cumulative markedness score, in which the only markedness constraint violated is AGREE[high]. Candidate d., on the other hand, is evaluated on its cumulative faithfulness score, which is the sum of the weights of IDENT[high] and IDENT[back]. The doubly-unfaithful candidate, which violates two faithfulness constraints, loses to the marked candidate b., which violates a single markedness constraint. Even though this is an unusual case, then, it falls into the CFE typology in a peripheral sense: the losing candidate's two faithfulness violations are ganging up to allow the winning candidate's single markedness violation. In that respect, then, Fyem resembles Luwanga.

The Split Additive Model is a good solution to dealing with chain shifts, but it raises numerous questions. Should all HG tableaux be reanalyzed in this way? If so, it seems that this could cause unexpected results, particularly when an opaque candidate needs to be eliminated, as in a feeding interaction. On the other hand, if splitting the markedness and faithfulness evaluations is only necessary for chain shifts and doubly-marked cases, how is the learner to know when to split the evaluation and when not to? These questions are unresolved. And though standard HG is sufficient to account for the other CFEs in this thesis, split tableaux could also be used, with no modification or only minor modifications to the constraint weights.

5.5 Summary and conclusion

This chapter has described three CFEs that are atypical in some way. In the Luwanga CFE, two faithfulness constraints gang up on a markedness constraint, rather than a third faithfulness constraint. While this CFE is predicted by the typology, it does not fit all the CFE diagnostics described in Chapter 2. In particular, the Luwanga chain shift does not reflect a mutual bleeding relationship in rule-based theory, nor is it comprised of overlapping conspiracies. This is the case because only two rules are necessary to account for Luwanga; instead of a third rule intervening to avoid the doubly-derived output, a marked structure persists only when its correction would violate two faithfulness constraints.

The Shizuoka Japanese CFE is unusual in that standard OT can account for it. This was also true of one of the Fula CFEs in Chapter 4. What the two languages have in common is that in one of the singly-derived cases, the fell-swoop repair and the other available repair cannot compete. In other words, the fell-swoop repair cannot fix one of the markedness violations. When this occurs, it becomes possible to rank the faithfulness constraints such that the fell-swoop constraint is outranked by one of the other faithfulness constraints. The fact that standard OT can account for this CFE, though, does not make it any less an instance of faithfulness cumulativity. In Shizuoka Japanese, as in Fula, an output that violates multiple faithfulness constraints is disallowed, even though each of those faithfulness constraints can be violated independently.

Finally, the CFE chain shift illustrated in Fyem shows that CFEs can lead to opaque outputs. This type of CFE is particularly interesting in that rule-based theories cannot derive the correct output. The opaque output is solely the result of the fact that multiply-unfaithful outputs are disallowed. Thus a single rule applies to the /oi/ vowel sequence, and while that rule creates a marked structure ([ei]), no further unfaithful mapping can occur to repair that structure. Thus the mutual bleeding and overlapping conspiracy diagnostics do not apply here. Moreover, Fyem causes a ranking paradox in HG just as it does in OT. This ranking paradox can be resolved by appealing to the Split Additive Model, in which the cumulative value of markedness constraints and the cumulative value of faithfulness cumulativity are evaluated independently.

These three atypical cases cause us to revise the five diagnostics of a CFE introduced in Chapter 2. The diagnostics are repeated again in (19), with caveats noted.

(19) Five characteristics of a CFE, revised

1. CFEs show the interaction of (at least) three different processes, one of which has more narrowly defined structural description than the others…

   …unless no third fell-swoop process occurs in the language, in which case the avoidance of doubly-unfaithful outputs may result in opacity or in a marked, but faithful, output.

2. The CFE processes are ordered in a mutual bleeding relationship, such that the narrowly defined rule bleeds each of the other rules…

   …unless the CFE is a case in which the faithful, marked output is allowed to surface (in which case no rule is necessary) or is a CFE chain shift (in which case rule ordering cannot account for it).

3. The processes participate in overlapping conspiracies; that is, the narrowly defined rule plays a role in each of (at least) two conspiracies…

   …unless the CFE does not involve more than two rules, as is the case when a faithful, marked output surfaces or when a CFE chain shift occurs.

4. Standard OT typically cannot account for CFEs; a ranking paradox arises (typically among the faithfulness constraints)…

   …unless the "specific" and "general" repairs do not compete to repair the same marked structure.

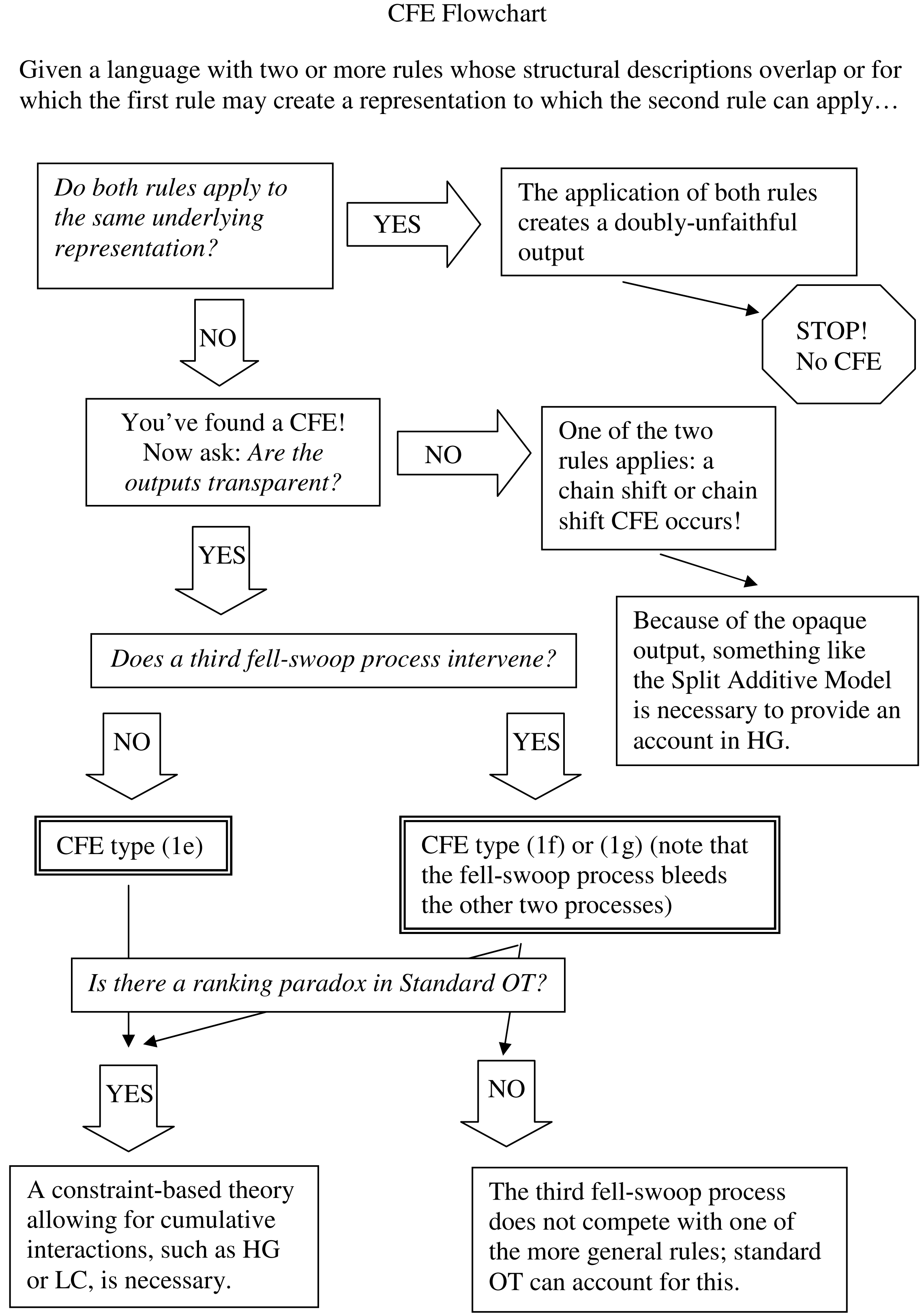
5. A CFE ranking paradox can be resolved by accounts that take advantage of the cumulative effects of constraints, e.g., HG or LC…

   …unless the output is opaque, in which case some addition to HG, like the Split Additive Model, is necessary.

Given that there are so many minor caveats in the revised diagnostics, the diagnostics can also be translated into the flowchart in Figure 1. This flowchart allows us to determine whether a CFE occurs in a language and if so, what type of CFE that is. If two rules with overlapping structural descriptions exist, but they do not apply together, then we have a CFE. The other parts of the flowchart direct us toward the different types of CFE and different possible analyses. If a CFE with opaque outputs occurs, then it must be a CFE chain shift. If no fell-swoop process exists to avoid a doubly-derived output, then we have a CFE of the Luwanga variety, in which a marked, faithful output is preferred to a doubly-unfaithful one. Finally, the existence of a ranking paradox in standard OT determines whether HG is necessary to account for the CFE. Answering each question in the flow chart allows us to fully describe which CFE we have found.

The majority of the CFEs introduced in this thesis can be described with the five unannotated diagnostics from Chapter 2. The annotations shown to be necessary in this chapter describe a small subset of cases. However, the CFEs in this chapter still fall into the typology described in Chapter 1, with the Japanese case being one in which two faithfulness violations gang up on a third faithfulness constraint, while in Luwanga and Fyem, two faithfulness violations gang up on a markedness constraint. This point serves to illustrate that while these CFEs are atypical in some respects, they are still predicted by the typology of logically possible CFEs. In the final chapter, the fourth CFE in the typology in Chapter 1, a case in which multiple violations of a single faithfulness constraint gang up on a markedness constraint, will be discussed, and possible reasons why we found no example to fill this cell will be examined.

Figure 1. CFE flowchart



CHAPTER 6

SOME RESIDUAL ISSUES

6.1 Introduction

The prior five chapters have explored CFEs in the domains of fully developed languages, first language acquisition, and loanword adaptation. This chapter discusses a few remaining issues and questions for further investigation. §6.2 asks a critical question: if languages prefer outputs to be as faithful as possible, why do some languages produce outputs that are multiply unfaithful, for instance in a feeding interaction? In §6.3, the arguments against explaining away CFEs as a matter of misperception are summarized. §6.4 examines the question of whether fell-swoop repairs like deletion are really more faithful than multiply-derived repairs from a constraint-based point of view, and §6.5 considers some experimental findings and possible future experimental directions bearing on the issue of determining whether speakers really prefer fell-swoop repairs like deletion over multiple featural changes in experimental settings. §6.6 raises the question of whether CFEs are opaque or transparent. A summary and conclusion is given in §6.7, where the typology of cumulative interactions from Chapter 1 is revisited.

6.2 Why are some multiply-unfaithful mappings allowed?

The primary goal of this thesis has been to demonstrate, through a variety of examples in a variety of language domains, that when a language has multiple possible ways of creating an unmarked output, the least unfaithful path (measured by cumulative harmony of faithfulness violations) is chosen. This general idea has long been acknowledged in the domain of lexicon optimization (Prince and Smolensky, 1993/2004). Lexicon optimization argues that when a learner is faced with multiple possible inputs for a given output, the learner chooses the input to which the given output is most faithful, thus avoiding extraneous faithfulness violations in the output. That is, given an unmarked output, learners want to be as faithful as possible. Another related idea is that of harmonic ascent (Moreton, 2004). Moreton notes that the only motivation for unfaithfulness is a reduction in markedness. Any unfaithful production must be less marked than the input. Given multiple ways of eliminating markedness, though, it is not unreasonable to think that speakers prefer to do it in the most faithful way possible. Reducing markedness by violating a single faithfulness constraint has the joint advantage of having improved well-formedness at the smallest possible expense.

Given the arguments made in this thesis, however, one vital question remains: If languages prefer to be as faithful as possible, why do feeding and counterbleeding interactions occur, as well as cases in which multiple rules apply in no particular order? In each of these types of interactions, the output is multiply-unfaithful. This section argues that languages resort to multiple unfaithfulness when no fell-swoop repair is available. That is, there is no available repair that would eliminate all the marked structure in a single faithfulness violation. The fact that a given repair is not available is often simply a result of the language's constraint weightings—the faithfulness violation corresponding to the fell-swoop repair carries too heavy a weight. If we define the "most faithful repair" as the repair that has the lowest cumulative harmony with regards to the faithfulness constraints, then this means that in some cases, the multiply-derived repair will be more harmonic and will thus be "more faithful," even though it may violate more constraints.

The rest of this section examines an example of a feeding interaction in another dialect of Greek, a dialect related to that discussed in Chapter 2. Then we go on to examine two possible reasons that feeding interactions that involve deletion processes, which would be expected not to occur, do occur after all.

6.2.1 Another dialect of Greek

Recall the Greek CFE in Chapter 2 (Newton, 1972; Pater, 1996). In that example, adjacent obstruents were required to agree in voice features, and postnasal obstruents were also realized as voiced. However, when a nasal preceded a cluster of two voiceless obstruents, the nasal deleted, rather than triggering a chain of two voicing repairs. This was an example of two violations of a single faithfulness constraint ganging up on another faithfulness constraint. That CFE occurred within word boundaries in all dialects of Greek and across word boundaries in certain dialects, namely Chios, Rhodes, Cyprus, Lesbos, and Samos. In other dialects, however, particularly a set of Peloponnesian dialects, the across-word-boundaries condition actually yields a feeding interaction. We do not attempt to explain here why these Peloponnesian dialects have the CFE within word boundaries but not across word boundaries; clearly constraints that differentiate the two situations are necessary. Here we focus on the across-word-boundaries cases in the Peloponnesian dialects, which differ from the other dialects in having a feeding interaction instead of a CFE. The data in (1) illustrate this case. The data in (1a, b) are repeated from Chapter 2, showing that adjacent obstruents must agree in voice (1a) and that postnasal obstruents are voiced (1b). The data in (1c), however, show that for these particular dialects, the concatenation of a word that ends in a nasal with another word that begins in a voiceless cluster triggers a feeding interaction where postnasal voicing feeds voice assimilation.

(1) Greek feeding interaction

a. Adjacent obstruents agree in voice (all dialects)

[érapsa]	'I sew, aorist'	cf. [rávo]	'I sew'
[ráftis]	'tailor'	cf. [rávo]	'I sew'
[náftis]	'sailor'	cf. [navaɣó]	'I get shipwrecked'
[kurástika]	'I am tired'	cf. [kurázo]	'I tire'
[avɣó]	'egg'	[péfko]	'pine'

b. Postnasal obstruents are voiced (all dialects)

/ton + topo/	[tondopo]	'the place'	cf. [topo]	'place'
[kumbí]	'button'	[émboros]	'merchant'	
[pénde]	'five'	[ándras]	'man'	
[aɲɡ^{j}ía]	'pots'	[siɲɡ^{j}enís]	'relative'	

c. Feeding: across word boundaries (some Peloponnesian dialects)

/ton + psefti/	[tombzéfti]	'the liar'
/ton + kseno/	[toŋgzéno]	'the foreigner'
/tin + tsimba/	[tind^{z}imbáyi]	'he pinches her'

The constraints used for the Greek CFE in Chapter 2 are repeated here in (2). Note that the exact set of constraints used to account for the CFE also accounts for the feeding interaction.

(2) Constraints relevant for the Greek feeding interaction

*NC̥: Sequences of a nasal followed by a voiceless obstruent are banned

AGREE[voice]: Adjacent obstruents that differ in [voice] specification are banned

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

MAX: Input segments have output correspondents

Recall that the OT account of Greek in Chapter 2 was hindered by a ranking paradox. The outputs achieved by the OT account, which were incorrect for the dialects of Greek discussed in Chapter 2, are the outputs attested in Peloponnesian Greek, so we will not repeat those tableaux. More importantly, HG can also account for Peloponnesian Greek. The HG tableaux in (3) illustrate the weighting necessary to achieve the feeding relationship. The high weight of the two markedness constraints effectively rules out any marked candidate. MAX, with a weight of 1.5, outweighs both of the other faithfulness constraints, each of which has a weight of 0.5. Thus in tableaux (3a,b), in which singly-derived repairs are shown, the deletion candidate is ruled out by its violation of MAX, just as it would be in a CFE. The difference between a feeding relationship and a CFE is obvious in tableau (3c), however. The deletion candidate (candidate d.) has a lower cumulative harmony than the feeding candidate c., even though candidate d. violates

IDENT[voice] twice. Thus the greater weighting of MAX eliminates the deletion candidate, which could have served as the fell-swoop repair for the potentially doubly-marked structure /nps/ in the input in (3c). We must also assume that other fell-swoop repairs, like vowel epenthesis, would be eliminated by high-weight constraints. Note that the feeding dialects are identical to the CFE dialects except for the relative weight of MAX and IDENT[voice]. In the CFE dialects of Greek, MAX had a weight of 1.5 and IDENT[voice] a weight of 1, so that two violations of IDENT[voice] summed up to a greater weight than one violation of MAX. In the feeding dialects of Greek, on the other hand, MAX still has a weight of 1.5, but IDENT[voice] has a weight of 0.5, so that two violations of IDENT[voice] is still a smaller cumulative weight than a single violation of MAX. The feeding effect occurs, then, because the language's constraint weighting does not allow for another alternative to eliminate the marked structure.

(3) HG account of Greek feeding interaction

a. $W_{MAX} > W_{IDENT[voice]}$

/rávtis/ 'tailor'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=0.5	H
a. rávtis		-1			-2
b. ☞ ráftis				-1	-0.5
c. rávis			-1		-1.5

b. $W_{MAX} > W_{IDENT[voice]}$

/ton + topo/ 'the place'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=0.5	H
a. tontopo	-1				-2
b. ☞ tondopo				-1	-0.5
c. totopo			-1		-1.5

c. $W_{MAX} > W_{IDENT[voice]} + W_{IDENT[voice]}$

/ton + psefti/ 'the liar'	*NC̥ w=2	AGREE[voice] w=2	MAX w=1.5	ID[voice] w=0.5	H
a. tompsefti	-1				-2
b. tombsefti		-1			-2
c. ☞ tombzefti				-2	-1
d. topsefti			-1		-1.5

The claim here is that languages prefer their outputs to be as faithful as possible, but that sometimes there is no way to avoid multiple unfaithfulness. This occurs when the constraint that may have allowed the grammar to bypass multiple faithfulness violations (i.e., the constraint corresponding to the fell-swoop repair) has too great a weight. This makes a further prediction that feeding interactions in which one of the two processes involves deletion (or some other fell-swoop repair) should not occur, because if deletion is an available repair, it should be the best repair for a multiply-marked input. However, it is clearly the case that feeding interactions in which one of the processes is deletion are attested (these will henceforth be referred to as deletion-feeding interactions). For instance, in Tiberian Hebrew, deletion of syllable-final laryngeal consonants feeds postvocalic spirantization (Idsardi, 1998); similarly, in Javanese, a rule deleting the nasal [n] after [h] feeds an intervocalic h-deletion rule (Lee, 1999, 2007). The question, then, is why do we see deletion-feeding interactions in these languages, rather than fell-swoop deletion? It is argued here that there are two possible reasons why deletion-feeding interactions may occur.

6.2.2 Tuvan: Different types of deletion

The first potential explanation for the existence of deletion-feeding interactions is that the attested singly-derived deletion repair and the unattested fell-swoop repair violate different constraints with different weights. An example in which this may be the case is Tuvan (Harrison, 2000), which has a feeding interaction between an intervocalic velar deletion process and a vowel hiatus resolution process. Velar stops are deleted when they become intervocalic by means of affixation, as in (4a). (4b) shows the hiatus resolution pattern: when two vowels that differ in height are adjacent, the high vowel assimilates to the non-high vowel. The feeding interaction is illustrated in (4c): when the deletion of an intervocalic velar brings together vowels of different heights, hiatus resolution takes place.

(4) Tuvan feeding relationship

a. Intervocalic velar deletion[1]

/ug+u/	uu	‘direction’-3
/sug+u/	suu	‘water’-3
/idik+i/	idii	‘boot(s)’-3
/bilig+i/	bilii	‘knowledge’-3
/urug+u/	uruu	‘daughter’-3
/ada+gan/	adaan	‘name’-past
/egele+geš/	egeleeš	‘begin’-participle

b. Hiatus resolution[2]

/kel+ir/	keer	‘come’-future
/čor+ur/	čoor	‘go’-future
/al+ɨr/	aar	‘take’-CV (auxiliary)

c. Feeding interaction

/ög+ü/	öö	‘yurt’-3
/dag+ɨ/	daa	‘mountain’-3
/biži+geš/	bižeeš	‘write’-CV
/öörü+geš/	ööreeš	‘be joyful’-CV
/udu+gan/	udaan	‘sleep’-Past
/saktɨ+gan/	saktaan	‘remember’-Past

[1] This rule is blocked in non-derived environments, as well as when the loss of the /g/ would render a morpheme unrecoverable (Harrison, 2000). We will not deal with the blocking effects here.

[2] Harrison (2000) provides no examples of hiatus resolution among vowels of different heights that do not also involve deletion, but we assume they do exist. The deletion pattern seen in these data, medial-liquid deletion, is not relevant to the rest of this example.

Harrison (2000) provides an in-depth analysis of this problem in optimality theory (OT); an abridged explanation is given here. The relevant constraints are listed in (5). The markedness constraints ban intervocalic velars and adjacent vowels that differ in height. The faithfulness constraints ban consonantal deletion, as well as deletion of high and non-high features.[3] Because the high vowel always assimilates to the non-high vowel in Tuvan, MAX[non-high] must be high-ranked; it will be left out of the following tableaux, along with the candidates that would be eliminated by it.

(5) Constraints relevant for Tuvan feeding interaction
*VgV: Intervocalic velars are banned
AGREE[height]: Adjacent vowels must agree in height
MAX-C: Input consonants have output correspondents
MAX[non-high]: Input non-high features have output correspondents
MAX[high]: Input high features have output correspondents

The tableaux in (6) illustrate the Tuvan analysis. The high weight of the markedness constraints means that the unmarked, unfaithful candidate will always have a higher harmony value. In (6a), the high weight of *VgV eliminates the faithful candidate, allowing the candidate in which the intervocalic /g/ was deleted to survive. In (6b), the high-weight AGREE[height] eliminates the faithful candidate in which two vowels are in hiatus; the assimilated candidate is preferred, even though it violates MAX[high]. In (6c), the input includes a velar between vowels of differing heights. The faithful candidate fatally violates *VgV, while the candidate in which the intervocalic /g/

[3] Harrison uses the MAX-FEATURE constraints MAX[high] and MAX[non-high] rather than IDENT constraints. If we were to use Ident constraints, we would need IDENT[+high] to take the place of MAX[high] and IDENT[-high] to take the place of MAX[non-high].

has been deleted fatally violates AGREE[height]. Though candidate c. violates two faithfulness constraints, the fact that the sum of those faithfulness constraints is less than the value of either of the markedness constraints means that the doubly-unfaithful candidate is still most harmonic.

(6) HG account of Tuvan feeding interaction

a. $W_{*VgV} > W_{MAX\text{-}C}$

/ug+u/ 'direction'-3	*VgV w=3	AGREE[height] w=3	MAX-C w=1	MAX[high] w=1	H
a. ugu	-1				-3
b. ☞ uu			-1		-1

b. $W_{AGREE[height]} > W_{MAX[high]}$

/čor+ur/ 'go'-Future	*VgV w=3	AGREE[height] w=3	MAX-C w=1	MAX[high] w=1	H
a. čour		-1	-1		-4
b. ☞ čoor			-1	-1	-2

c. W_{*VgV} or $W_{AGREE[height]} > W_{MAX\text{-}C} + W_{MAX[high]}$

/udu+gan/ 'sleep'-Past	*VgV w=3	AGREE[height] w=3	MAX-C w=1	MAX[high] w=1	H
a. udugan	-1				-3
b. uduan		-1			-3
c. ☞ udaan			-1	-1	-2

It is possible, however, to imagine another candidate for the tableau in (6c), one which deletes one of the vowels that could potentially lead to hiatus. This vowel deletion would remove the context for intervocalic velar deletion and the context for hiatus resolution, thus avoiding multiple unfaithful mappings. Such a candidate would incorrectly win under the current constraints and weighting, as is shown in (7), because it would eliminate both marked structures (the marked intervocalic velar in the input, and the potentially-marked vowel-vowel sequence) by violating only a single faithfulness constraint. The velar would no longer be intervocalic, and only one vowel would remain.

(7) Fell-swoop candidate wins

/udu+gan/ 'sleep'-Past	*VgV w=3	AGREE[height] w=3	MAX-C w=1	MAX[high] w=1	H
a. udugan	-1				-3
b. uduan		-1			-3
c. ☜ udaan			-1	-1	-2
d. ☞ udgan				-1	-1

Why, then, does Tuvan allow intervocalic velars to delete, but not allow deletion of a vowel even when it would circumvent the doubly-unfaithful output? Word-medial consonant clusters are allowed in Tuvan (Harrison, 2000), so the problem is not that the deletion candidate creates a new marked structure. Instead, the answer lies in the fact that not all segmental deletions are treated equally. That is, a language may allow a particular type of segment to delete but disallow deletion of other types of segments. Tuvan, it appears, allows for consonantal deletion, but does not allow vowel deletion. Evidence for this also derives from the fact that vowels in hiatus are repaired by assimilation, never deletion. This pattern can be explained with a high-weight constraint preserving input vowels in the output, defined in (8) and illustrated in the tableau in (9). The high weight of MAX-V eliminates candidate d., the fell-swoop candidate, allowing candidate c., the doubly-unfaithful candidate, to win.

(8) Another MAX constraint

MAX-V: Input vowels have output correspondents

(9) Fell-swoop candidate eliminated

/udu+gan/ 'sleep'-Past	*VgV w=3	AGREE[height] w=3	MAX-V w=3	MAX-C w=1	MAX[high] w=1	H
a. udugan	-1					-3
b. uduan		-1				-3
c. ☞ udaan				-1	-1	-2
d. udgan			-1		-1	-4

The Tuvan example shows that one explanation for the fact that deletion-feeding interactions take place is simply that the deletion that would be necessary to eliminate the doubly-marked structure is different from the deletion found in the feeding interaction. If the two types of deletion violate different constraints, then it is possible to arrive at a grammar in which deletion occurs in a feeding interaction, but never as a fell-swoop repair.

6.2.3 Tangale: No fell-swoop repair

The second possible explanation for the existence of deletion-feeding interactions is that there is no possible fell-swoop repair that would eliminate both marked structures. If no single repair can do that, then a multiply-unfaithful repair may still be the most faithful route to unmarkedness. Such an example arises in Tangale, a Chadic language spoken in Nigeria (Kidda, 1985; Kenstowicz, 1994). Tangale has a process of vowel elision: stem-final vowels delete when a consonant-initial suffix follows (10a). In addition, Tangale has a progressive voicing assimilation process: an obstruent must agree in voice quality with the preceding consonant (10b). Vowel elision thus feeds progressive voicing, as in (10c).

(10) Tangale feeding interaction

a. Vowel elision

wudó	'horse'	wud-nó	'my horse'
lútu	'bag'	lút-nó	'my bag'
taga	'shoe'	tag-nó	'my shoe'
duka	'salt'	duk-nó	'my salt'
kagá	'spoon'	kag-nó	'my spoon'

b. Progressive voicing assimilation

bugat-í	'the window'	bugat-kó	'your window'
tugad- í	'the berry'	tugad-gó	'your berry'
aduk-í	'the load'	aduk-kó	'your load'
kúlug-í	'the harp'	kúlug-gó	'your harp'
c.f. loo-í	'the meat'	loo-gó	'your meat'

c. Elision feeds assimilation

wudó	'horse'	wud-gó	'your horse'
lútu	'bag'	lút-kó	'your bag'
taga	'shoe'	tag-gó	'your shoe'
kagá	'spoon'	kag-gó	'your spoon'
duka	'salt'	duk-kó	'your salt'

Relevant constraints are given in (11). The markedness constraint banning a stem vowel followed by a suffix consonant serves as the constraint compelling vowel elision.

Another markedness constraint bans adjacent obstruents that do not agree in voicing. The faithfulness constraints militate against segmental deletion and change in voice.

(11) Constraints relevant for Tangale feeding interaction

*$V_{stem}C_{suffix}$: Stem-final vowels are banned when followed by a suffix

AGREE[voice]: Adjacent obstruents agree in the feature [voice]

MAX: Input segments have output correspondents

IDENT[voice]: Input and output correspondents have the same value for the feature [voice]

The tableaux in (12) illustrate the Tangale feeding interaction. The high weight of *$V_{stem}C_{suffix}$ eliminates the faithful candidate in (12a) in favor of the candidate that has undergone vowel elision. In (12b), the weight of AGREE[voice], which is greater than that of IDENT[voice], eliminates the unassimilated candidate. And the tableau in (12c) shows that even though candidate c. is doubly-unfaithful, it has a higher relative harmony than the faithful candidate, which violates *$V_{stem}C_{suffix}$, or candidate b., in which the vowel has elided but assimilation has not taken place.

(12) HG account of Tangale feeding interaction

a. $W_{*VstemCsuffix} > W_{MAX}$

/lútu+nó/ 'my bag'	*$V_{stem}C_{suffix}$ w=3	AGREE[voice] w=3	MAX w=1	ID[voice] w=1	H
a. lútunó	-1				-3
b. ☞ lútnó			-1		-1

b. $W_{\text{AGREE[voice]}} > W_{\text{ID[voice]}}$ [4]

/bugat+gó/ 'your window'	*V$_{stem}$C$_{suffix}$ w=3	AGREE[voice] w=3	MAX w=1	ID[voice] w=1	H
a. bugatgó		-1			-3
b. ☞ bugatkó				-1	-1

c. $W_{*\text{VstemCsuffix}} > W_{\text{MAX}} + W_{\text{ID[voice]}}$

/lútu+gó/ 'your horse'	*V$_{stem}$C$_{suffix}$ w=3	AGREE[voice] w=3	MAX w=1	ID[voice] w=1	H
a. lútugó	-1				-3
b. lútgó		-1	-1		-4
c. ☞ lútkó			-1	-1	-2

Given that this feeding relationship involves a deletion process, the question is why Tangale does not use deletion as a fell-swoop repair, eliminating the need for two unfaithful processes. The answer is that there is no single deletion that can avoid both markedness violations. The input /lútu+gó/ contains one marked structure (the stem-final vowel before a suffix) and another potentially marked structure (the consonant cluster that would come about as a result of vowel deletion). The deletion of either of the medial consonants [t] or [g] would not eliminate the marked stem-final vowel. Likewise, the deletion of either of the stem vowels creates a consonant cluster sequence that would be required to agree in voicing. There is no single segment that can be deleted in order to avoid another faithfulness violation. In Tangale, then, the combined vowel deletion and voice assimilation repairs really are the most faithful route to unmarkedness—there is no less unfaithful path.

[4] The regressive assimilation candidate [bugadgó], which would be ruled out by a high-weight root faithfulness constraint, is excluded here.

This section has shown that doubly-unfaithful interactions, such as feeding relationships, can still occur even if the general argument is made that languages prefer to choose the most faithful route to unmarkedness. Moreover, in spite of the fact that a language may incorporate deletion as one of multiple processes, it may not always be the case that deletion can be used as a fell-swoop repair. What is particularly interesting about the constraint-based approach to these issues is that because of the universal nature of constraints, fell-swoop processes like deletion (or epenthesis) must be considered in the candidate set. In a traditional rule-based approach to feeding, there would be no reason to raise the question "why does the language not use deletion to avoid multiple unfaithful mappings?" The constraint-based accounts show that we must consider competitors who reduce markedness in a variety of ways. In some languages, the ones this thesis has focused on, a fell-swoop process is used to avoid multiple unfaithful mappings. In other languages, as in Tuvan or Tangale, this is not possible, either because the language only allows the deletion of certain segments (as in Tuvan), or because no single deletion can solve the problem of multiple markedness (as in Tangale).

6.3 Can CFEs be explained by appealing to a misperception account?

The claim made in this thesis is that CFEs occur because speakers disprefer outputs that are too unfaithful to the input. When there are multiple ways to reduce markedness, the most faithful path is chosen. In Chapters 3 and 4, we countered possible arguments that learners simply fail to perceive (or to perceive correctly) the doubly-marked (or potentially doubly-marked) structures, and thus the fell-swoop deletion processes we have noted are simply due to the fact that the sound was never perceived in the first place. Here we return to these arguments, summarizing three reasons why a misperception account of the problem does not hold.

While misperception accounts might be possible for some of the CFEs described herein, they do not suffice to explain all. This is particularly true in the cases in which no deletion takes place. Consider a misperception account of the Japanese CFE, in which a single gemination process avoids the processes of nasal insertion and obstruent voicing. Both nasal insertion and gemination are possible processes to fill an empty mora slot that is present because of the morphology. Because the mora is realized no matter what (i.e., there is no deletion process in this example), a misperception (or perhaps misanalysis of the mora slot) account of this CFE is impossible.

A second argument against a misperception account is in many cases, the deleted sound is a highly salient sound or is in a highly perceptible word position. In the Hawaiian loanword example, for instance, prevocalic /s/ is always preserved (being adapted as [k]), while preconsonantal or word-final /s/ is not. While it is true that the sound /s/ is more confusable preconsonantally than prevocalically (e.g., Redford and Diehl, 1999), implying that prevocalic /s/ is more salient or perceptible than preconsonantal /s/, in general, /s/ is a highly salient segment (Miller and Nicely, 1955), one that might be expected to be perceptually salient in any word position. Moreover, a positional account of adaptation versus deletion is not always possible. For instance, in the first Fula CFE, the labio-palatal glide was adapted when in the first position of a syllable onset, but deleted when in the second position of a syllable onset, even when both of those positions were post-consonantal. That is, the phonetic environment for the two glides is similar, but the adaptation patterns seem to rely on the syllabic analysis of each position. In the second Fula CFE, the sound /v/ was retained in all word positions *except* before the glide [w]. Though it seems likely that the relative perceptibility of [v] differs by word position, the only position in which the sound was deleted was the word-initial (pre-glide) position, a position which is typically considered perceptually salient (e.g., Beckman, 1998; Steriade, 1999). Finally, recall Child ED13's CFE, in which an /s/ which preceded a nonadjacent [k] in the same word was debuccalized, avoiding the stopping and velar assimilation processes. Once again, /s/ is a highly perceptible segment; moreover, there should be no reason why an /s/ is less likely to be perceived when a [k] follows later in the word. The non-local nature of this CFE argues against a misperception account.

Finally, the misperception explanation seems weakest when we consider the CFEs that occur in fully-developed languages. In these languages, like Kikuyu, speakers are assumed not only to perceive the ambient segments, but also to store them in their underlying representations. That is, a Kikuyu speaker who produces the input /n-θɛru/ as [θɛru], which avoids stopping and voicing the post-nasal /θ/, is expected to have both the nasal prefix and the /θ/ stored in her underlying representation. It has been argued that nasal+fricative sequences may cause perceptual difficulties, not least in the listener's analysis of the status of the nasal (Ohala and Ohala, 1993; Ohala and Busà, 1995), and sequences of nasals followed by voiceless fricatives are clearly cross-linguistically marked (e.g., Pater, 1999). Such arguments may account for a diachronic change in /nθ/ clusters, but they have more difficulty accounting for the synchronic alternation.

Speakers of a language like Kikuyu cannot be assumed to misperceive a segment that they correctly represent underlyingly.

In sum, an account based on the simple misperception of the eventually-deleted sounds is not sufficient to account for all the CFEs in this thesis. The account based on degree of faithfulness is preferable. However, exactly what is meant by "degree of unfaithfulness" must be examined in more detail. The next section examines degree of unfaithfulness from a constraint-based point of view, and §6.5 examines degree of unfaithfulness from a more laboratory-based position.

6.4 Is deletion really "more faithful" than multiple feature changes?

Throughout the previous five chapters, the claim has been made that the fell-swoop candidate, which has deleted or epenthesized a single segment or feature, is more faithful than a candidate that has undergone multiple featural changes. This argument defines degree of unfaithfulness by the cumulative weight of the faithfulness violations incurred by a candidate. The fell-swoop candidate violates only a single MAX or DEP constraint, whereas a candidate that has altered multiple features violates multiple IDENT constraints, whose combined weight is greater than that of MAX or DEP. We have been assuming that deletion of segment or featural (or epenthesis of segment or feature) is done in a single step. This runs counter to a set of assumptions made by McCarthy (2007a, 2007b, to appear) in his proposal of Optimality Theory with Candidate Chains (OT-CC). McCarthy claims that a deleted segment violates not only MAX-SEGMENT, but also a number of other MAX[feature] constraints. In OT-CC, candidates are expressed as chains, starting with the fully-faithful candidate and progressing in gradual, harmonically improving steps. Each successive member of the chain must incur only one more faithfulness violation than the previous member, and must be more harmonic than the previous member. McCarthy's argument can be summed up as follows: if features are considered entities in their own rights, rather than attributes of segments (already a controversial claim), then there must be MAX[feature] constraints. If there is a constraint like MAX[place], then a candidate that deletes an entire segment must violate both MAX-SEGMENT and MAX[place]. If a candidate chain has to be gradual, then we must imagine that a deletion candidate must first delete the place feature of a particular segment; only then can the entire segment undergo deletion.

It might be possible to accept McCarthy's claims in the HG accounts of CFEs in this thesis if we made the assumption that the constraints against featural deletion carried such light weights that they did not drastically change the cumulative weight of the candidates, or if we assumed that the weights we have been using for the MAX-SEGMENT constraints in the previous chapters are really shorthand for the cumulative weight of MAX-SEGMENT plus a number of MAX[feature] constraints. However, accepting the argument that deletion candidates violate a number of MAX constraints somehow seems to miss the greater generalization that the languages discussed in this thesis seem to be using deletion to avoid a more unfaithful output.

This thesis, then, makes the alternative claim: segmental deletion candidates only violate a single constraint: MAX-SEGMENT. MAX[feature] constraints may exist[5], and

[5] There is debate over whether both MAX[feature] and IDENT[feature] constraints are necessary (e.g., Lombardi, 1998, 1999, 2001). If we were to exclude MAX[feature] constraints in preference to IDENT[feature] constraints, then it would be necessary to have both IDENT[+feature] and IDENT[-feature] constraints in order to account for an example like Tuvan, in which the change from a high vowel to a non-high vowel is allowed, but the opposite change is not.

have been used here in Chapters 3 and 4, as well as in the account of Tuvan in this chapter. However, we argue that a candidate in which an entire segment has been deleted violates only MAX-SEGMENT, and not the MAX[feature] constraints. MAX[feature] constraints are violated only when an output segment that lacks a given feature stands in correspondence with an input that had that feature. This argument that segmental deletion is a single process is reflected in some strategies of determining similarity computationally; for instance, Levenshtein distance (e.g., Heeringa, 2004) considers featural change to incorporate both deletion and insertion; a single deletion is thus less costly than a featural change. The next question to ask, it seems, is whether speakers' grammars compute similarity/unfaithfulness in a similar way. That is, do speakers judge candidates that have undergone multiple featural change as more unfaithful than deletion candidates? This question will lead us into the next section on experimental examinations of degree of unfaithfulness.

Finally, an important question remains for further research: how exactly do speakers compute degree of unfaithfulness? While we have been assuming this is computed based on the number and weight of faithfulness constraints violated, the possibility remains that speakers use a more complex calculation, perhaps taking into account perceptual or acoustic similarity as well. The next section discusses some possible experimental directions that may help get at this question.

6.5 Possible experimental directions

Though this thesis has not taken an experimental approach to the issue of cumulative faithfulness, at least two questions present themselves that may be best answered experimentally. The first is whether speakers judge a candidate in which multiple featural changes have been made to be more unfaithful than a candidate that has undergone deletion of a segment or a feature. A number of prior studies explore speakers' reactions to stimuli of differing degrees of featural unfaithfulness. From the perceptual point of view, listeners are more likely to confuse (i.e. perceive unfaithfully) segments that differ in few features (Miller and Nicely, 1955). Moreover, when perceiving speech errors (a sort of unfaithfulness-detection), listeners are more likely to hear an error that differs from the target by multiple features than an error that differs from the target by a single feature (Cole, 1973); that is, the more "unfaithful" the production, the more likely the listener is to note its unfaithfulness. Even infants can access the degree of unfaithfulness of productions; Mani and Plunkett (2007) show that 15- and 24-month-old infants are more sensitive to mispronunciations that differ from the target by multiple features than mispronunciations that differ from the target by a single feature. Finally, in a novel way of testing degree of similarity among words, Connine, Blasko and Titone (1993) showed that hearing a nonword that differed from the target by one or two features primed the target; hearing a nonword that differed from the target by four or more features did not prime the target. All of these perceptually-based studies add up to the conclusion that speakers can at least compute degree of unfaithfulness when the comparison is based on the number of featural differences between the target and the production.

None of the above studies, however, explore degree of unfaithfulness outside the realm of featural mismatch. The next step, then, is to compare speakers' reactions to unfaithful productions that involve featural mismatch, segmental or featural deletion, or epenthesis. By manipulating the type of difference (multi-feature differences vs. deletion or vs. epenthesis) as the independent variable, it would be possible to measure speaker's responses (either accuracy or speed, based on either classification or priming tasks) as the dependent variable. From the segmental perspective, for instance, when expecting to hear the word 'noise', which production do speakers judge as more faithful: the multiple-feature change candidate [nɔit] or the segmental deletion candidate [nɔi]? Remember that Amahl's grammar chose the deletion candidate over the doubly-unfaithful candidate. In terms of featural deletion, would speakers judge [kɔk] or [hɔk] to be a more faithful production of 'sock'? These productions correspond to competing candidates in Child ED13's grammar. Of course, the experimenter cannot simply ask subjects "which of these two productions is more faithful?" One way to get at the question would be to use an AXB classification task. In such a task, the listener would hear three stimuli and would be asked to judge whether the middle stimulus (the X stimulus) sounded more similar to the A stimulus or the B stimulus. So, for instance, the listener might hear [nɔit]-[nɔiz]-[nɔi] and be asked to judge whether [nɔiz] was more similar to [nɔit] or [nɔi].

If speakers really are accessing something that approximates degree of unfaithfulness, then the hypothesis is that they would be more likely to judge [nɔiz] as similar to [nɔi] than to [nɔit]. A limitation of this task, however, is that it conflates the notions of perceptual similarity and degree of unfaithfulness, which are not necessarily the same thing. It is possible that listeners would judge a production to be perceptually dissimilar to the target while also recognizing that the stimulus is relatively faithful. This outcome seems like a definite possibility when subjects are asked to compare a deletion candidate, which may be relatively "faithful" to the target, but not very perceptually similar. An alternative way to test this question, then, is in a priming study like the one done by Connine et al. (1993). That is, does the misproduction [nɔi] prime the target /nɔiz/ more than the misproduction [nɔit] does? The production that listeners consider more similar to the target should better prime the target, but the listeners are not asked to make overt perceptual similarity judgments.

The second question that warrants an experimental examination is as follows: when speakers make an unfaithful production, how unfaithful are they likely to be? Inducing unfaithful productions is not an easy task, but a great deal of work has been done on speech errors—that is, accidental unfaithful productions. When speech errors are experimentally induced (e.g., in tongue twisters), speakers are more likely to make errors between segments that differ by smaller numbers of features, and the sound substitutions they make are more likely to differ from the target by a small number of features (Levitt and Healy, 1985). The same finding is true of experimentally elicited child speech errors (Smith, 1990). Naturally produced speech errors follow the same trend: adult speakers are more likely to substitute a sound that differs from the target by one feature than by two, or by two features than by three (van den Broecke and Goldstein, 1980). Unfaithful productions also can occur when speakers are asked to produce words under some stress—for instance, when recalling a list of words from short-term memory. When asked to do such a task, both adults and children were more likely to erroneously recall a word that differed from the target by a small number of features than one that differed from the target by a large number of features (Wickelgren, 1966; Cole, Haber and Sales, 1973; Eimas, 1975). This shows that not only are features stored in short-term memory, but also that speakers are aware enough of featural similarity to attempt to recall and produce words that have similar features to the target. In sum, then, when forced to make unfaithful productions, speakers nevertheless choose to be as faithful as possible. This point has also been made in child acquisition by researchers who note that children avoid even attempting a word that their grammars would produce very unfaithfully (Schwartz and Leonard, 1982; Becker, 2007).

Once again, however, there has not been sufficient examination of the unfaithfulness of a production that includes segmental or featural deletion or epenthesis. Perhaps the best way to get at this issue experimentally is to ask which of two languages is more learnable: a language in which two processes may combine in a single output, or a language in which the possibility of combining two processes is overridden by some third fell-swoop process like deletion. An artificial language learning experiment (or, similarly, a word-game experiment) could be used to explore this question. Artificial language learning experiments have been used to test subjects' constraint rankings or ranking biases (Guest, Dell and Cole, 2000; Tessier, 2006; Finley and Badecker, 2007) and could also be used to examine different weighting relationships among constraints. In such an experiment, the rules or constraint rankings of the artificial language are manipulated as the independent variables, and the learner's ability to learn the language, measured by speed of learning, accuracy on untrained items, or length of retention, are measured as the independent variables. The experiment might be composed as follows: three sets of subjects are each taught a language game in which English words are modified in particular ways (much like teaching subjects a kind of Pig Latin). The choice to use a language game instead of a fully constructed artificial language is simply because to test unfaithfulness, we must be able to make assumptions about a speaker's underlying representations. Having speakers modify productions of English words, then, allows us to assume that those English words are serving as the underlying representation.

All three sets of subjects would be taught two different rules, for instance, the rules of Amahl's grammar. That is, when an /s/ occurred in an English word, it should instead be produced as [t], and when a final voiced stop occurred in an English word, it should instead be devoiced. (Of course, the language game would not be taught in those terms—subjects would be trained over a number of examples and would be forced to make their own generalizations about the rules of the game.) The three sets of subjects would differ, though, in whether a third rule was taught, and what kind of rule that was. Subject group 1 would be taught that when a voiced fricative occurs in a coda, it must undergo both stopping and devoicing (i.e., the English word /nɔiz/ is produced as [nɔit] in these subjects' language game dialect). Subject group 2 would be taught the CFE rule: when the two errors would be expected to combine, instead the sound must be deleted (i.e., /nɔiz/ is produced as [nɔi] in these subjects' language game dialect). Finally, the third group of subjects would be taught the stopping and devoicing rules, but they would not be taught anything about what to do when those rules combined. Instead, the third group would be taught a third completely unrelated rule, perhaps a rule applying to vowels. This third unrelated rule ensures that all subjects learned the same number of rules, but the third group of subjects would not be taught anything about the CFE rule. These subjects would be in the hold-out condition, and would be forced to modify a word like /nɔiz/ without having been explicitly taught what to do. This group's productions would help determine whether there is a bias against producing multiply-unfaithful words.

After training on the language game, all three groups would be tested on a set of trained and untrained words. The test set would include trained words in order to determine whether the subjects had learned the rules of the game. It would also include new words with sounds that had been trained (e.g., a new word with a coda /z/). Finally, the test set would include new words with untrained codas that shared properties with the trained codas, for instance, words with coda /v/. Such a test would be crucial in showing that the subject had learned generalized language rules, rather than specific repairs (e.g., 'delete word-final /z/'). Learning would be measured in a number of ways: whether the subjects actually learned the language game would be determined by accuracy scores on trained words, but the "ease of learning" could also be determined by subjects' accuracy or reaction times for untrained words. Comparing productions on trained versus untrained sounds would allow the researcher to determine whether the subjects had learned a set of rules based on distinctive features, or simply single repairs for marked structures. Based on the findings of this thesis, we would hypothesize that a grammar in which any given output only violates a single faithfulness constraint would be learned fastest and most accurately.

In sum, this thesis has offered a theoretical account of CFEs, showing that a grammar which allows for constraint violations to sum across candidates is superior to a grammar in which the strict ranking of constraints determines the output. Exploring the experimental instantiations of the theoretical explanation is an important next step in determining how speakers organize their grammars and what types of constraint relations (e.g., cumulative vs. strict domination) are most psychologically valid.

6.6 Opaque or transparent?

While CFEs produce transparent outputs and typically involve transparent mutual bleeding rule ordering, they also share some characteristics of opacity effects. In particular, processes are blocked from applying in certain specific environments, i.e., the environment in which another rule would also have to apply. Moreover, standard OT cannot account for CFEs just as it cannot account for opaque outputs. Thus while CFEs would be classified as transparent under traditional views of opacity, in some ways they appear to more closely resemble opacity effects. The question of whether CFEs are opaque or transparent is the final question to be addressed in this chapter.

The standard definition of opacity is given in (14). Case a. is the underapplication case: it looks as though rule P failed to apply even though its structural description was met. Case b. is the overapplication case: it looks as though rule P applied even though its structural description was not met.

(14) Opacity defined (Kiparsky, 1973)

Given a phonological rule P of the form A → B / C__D, P is opaque if there are surface forms

a. A in the environment C__D

b. B derived by P in environments other than C__D

As we have seen in the preceding five chapters, from a rule-based point of view, CFEs are transparent: the necessary rules are in a mutual bleeding order, and the output of the rules is not opaque in the counterfeeding or counterbleeding sense. However, CFEs in many ways resemble another class of opacity effects: grandfather effects and non-derived environment blocking. In a grandfather effect, a marked sound is allowed to surface when underlying, but that same sound cannot be created by a phonological process. Thus the faithful sound is "grandfathered" in while the same sound is disallowed if it is unfaithful. This type of effect is similar to "non-derived environment blocking" (NDEB; Kiparsky, 1976, 1993), in which a rule that eliminates a given marked structure is blocked from applying in a non-derived environment, thus allowing a marked segment or sequence to occur in a non-derived environment while that segment or sequence is modified when it arises in a derived environment. Both of these types of effect are considered opaque by the underapplication subcase: in a grandfather effect, a rule fails to apply when it would create a marked form, and in NDEB, a rule that applies to derived forms fails to apply in non-derived forms. This type of opacity has nothing to do with rule ordering; the lack of process application is the result of some constraint on the grammar disallowing the creation of marked structure. CFEs have some of the same characteristics. In each of the examples considered, a process can apply only insofar as it does not result in too unfaithful an output.

One important difference between grandfather/NDEB effects and CFEs is that in the former, certain segments or structures cannot be derived because they are too marked. In the latter, on the other hand, certain segments or structures cannot be derived because they are too unfaithful. The problem does not lie in the markedness of the structure, then, but in the degree of faithfulness. In any case, CFEs resemble other cases of opacity, in spite of the fact that they produce transparent outputs. Moreover, standard OT cannot account for CFEs, and mechanisms that have traditionally been used to account for cases of opacity, like the local conjunction of faithfulness constraints, are necessary.

Valid arguments exist for each side of the debate. CFEs are always mutual bleeding interactions, which are typically considered transparent because no rule appears to have under- or overapplied in the surface form. The outputs of each of the CFEs discussed here are transparent: for instance in the Kikuyu form [θɛru] ‘bright’, the nasal deletion rule has properly applied, and the surface form does not contain any element that one of the rules should have eliminated. Moreover, CFEs can easily be accounted for with HG, which can account for grandfather effects (Pater, 2006), but no other type of opacity. Finally, CFEs can be analyzed as conspiracies (Kisseberth, 1970; Kiparsky, 1976). Multiple processes are working together to eliminate a single marked output. As conspiracies are transparent by definition (though cf. Dinnsen and Farris-Trimble, 2008a), CFEs must be transparent as well.

On the other hand, CFEs are reminiscent of grandfather/NDEB effects in that a given structure is allowed in some environments but not in others. In a grandfather effect, a rule is blocked if it would create a marked structure. In CFEs, a rule is blocked only in the event that another rule would also have to apply. For instance, in Kikuyu, Voicing and Stopping can each apply individually, but when both would apply together, their application is blocked. In addition, the conjunction of faithfulness constraints can be used to account for CFEs, though the only previous use of such conjunction was to deal with chain shifts, a kind of underapplication opacity.

Intuitively, it seems as though CFEs involve underapplication opacity effects. In Kikuyu, for instance, given an underlying representation like /n-θɛru/ and the Voicing and Stopping rules, it appears that those rules underapply. In fact, they are bled by the Nasal Deletion rule. Bleeding is normally not a type of underapplication, but the bleeding interaction evidenced in CFEs is unusual. In a standard bleeding relationship, there is independent motivation for each of two rules. When the structural description of both rules is met, one rule applies first and the resulting intermediate representation no longer meets the structural description of the second rule. In CFEs, on the other hand, the deletion rule that bleeds the other rules (here n-deletion) is not independently motivated. The only time deletion ever occurs is when it is used to avoid a doubly-unfaithful output. It is as if the phonology is aware that without deletion, the output will be doubly-derived. In order to avoid such unfaithfulness, a deletion rule is invoked. This same deletion rule is never invoked in a singly-derived case, however.

In order to view CFEs as a type of underapplication opacity, we need a way in which a derivation or a process can have access to what the output would be if the process did not apply. That is, we need to be able to make a statement like "Deletion applies only in those cases in which otherwise both of two other rules would have applied." Baković (2007), in presenting a number of overapplication opacity effects that have not previously been discussed, provides just such a mechanism. One of his new opacity effects, which he terms "cross-derivational feeding," occurs when the grammar compares an actual derivation with a counterfactual derivation, that is, a logically possible derivation that is not the attested output. To understand his argument, we will briefly summarize the Lithuanian example he uses. In Lithuanian, an obstruent assimilates in voicing and palatalization to a following obstruent, as in (15a). A second process, Epenthesis, applies when two adjacent obstruents are identical or only differ in terms of voicing or palatalization, as in (15b).

(15) Lithuanian (examples from Baković, 2007)

a. Voicing/palatalization assimilation

at-ko:p^{j}t^{j}i	‘to rise, climb up’
ad-gaut^{j}i	‘to get back’
at^j-p^{j}aut^{j}i	‘to cut off’
ad^j-b^{j}ek^{j}t^{j}i	‘to run up’

b. Epenthesis

at^{j}i-taik^{j}i:t^{j}i	‘to make fit well’
at^{j}i-t^{j}eis^{j}t^{j}i	‘to adjudicate’
at^{j}i-duot^{j}i	‘to give back, return’
at^{j}i-d^{j}et^{j}i	‘to delay, postpone’

Baković claims that the correct analysis for the Epenthesis rule is that it applies only between adjacent identical consonants. Note that in (15b), epenthesis is applying in exactly those cases in which Assimilation otherwise would have created identical adjacent consonants. This “would have” case is known as the counterfactual derivation. In cross-derivational feeding, the counterfactual derivation instead “feeds” the actual derivation. By applying Epenthesis before Assimilation, the grammar can result in outputs that are surface-true (note that in the counterfactual derivation, Assimilation would have created the environment for Epenthesis, resulting in counterbleeding opacity). In short, one rule applies because it can look across derivations and see what the output would have been if a different rule had applied instead. According to Baković, this is a type of overapplication opacity; Epenthesis overapplies to non-identical adjacent consonants if it is fed by the counterfactual derivation.

If we apply the same sort of reasoning to the CFE examples discussed here, we can compare the actual and the counterfactual derivations for Kikuyu. The rules necessary to account for Kikuyu are repeated in (16).

(16) Kikuyu CFE rules

Nasal Deletion: [+nasal] → Ø / ___ [-sonorant, -voice, +continuant]

Voicing: [-sonorant] → [+voice] / [+nasal] ___

Stopping: [+consonantal] → [-continuant] / [+nasal] ___

The Nasal Deletion rule states that nasal segments are deleted in a very specific environment: when they precede a voiceless fricative. The Voicing and Stopping rules are more general, accounting for the realization of other obstruents after nasals. Given these rules, the actual derivation is shown in (17a), with the counterfactual derivation in (17b).

(17) Kikuyu derivations

a. Actual derivation

	/n-θɛru/
Nasal Deletion	θɛru
Voicing	---
Stopping	---
	[θɛru]

b. Counterfactual derivation

	/n-θɛru/
Voicing	n-ðɛru
Stopping	n-dɛru
Nasal Deletion	---
	*[n-dɛru]

Each of these derivations constitutes a bleeding relationship: in (17a), Nasal Deletion bleeds Voicing and Stopping; in (17b), Voicing and/or Stopping bleeds Nasal Deletion. As the rules are written, they are in a special-general relationship. In a special environment, the nasal consonant is deleted; in all other environments, the same nasal causes Stopping or Voicing. If we imagine that an actual derivation could also see the counterfactual derivation, however, we might also imagine a different definition of Nasal Deletion, such that it would apply only when a word's counterfactual derivation would result in multiple unfaithfulness. It is as if the grammar can look at the counterfactual derivation and realize that it would produce a doubly-unfaithful output. When this would occur, n-deletion is invoked to bleed the other rules. In the Baković case, the output of the counterfactual derivation actually feeds the other derivation. Here, it seems simply that the grammar must have access to the counterfactual derivation. The doubly-unfaithful output of the counterfactual derivation informs the grammar that deletion is necessary.

So, are CFEs opaque? The answer to this question is not obvious. They are clearly not opaque in any traditional sense. Nevertheless, they do not completely resemble transparent bleeding interactions either. They might instead be thought of as "opaque bleeding" interactions. Deletion is invoked to force the underapplication of other rules only in the case that the output would have been too unfaithful.

6.7 Conclusion

This thesis had three primary goals: to provide a typology of the previously undiscussed set of phonological phenomena called CFEs, to provide examples of CFEs from a variety of language domains, and to offer an account of them within current phonological theory. The first of these goals is discussed in §6.7.1, while the result of addressing the other goals is discussed in §6.7.2.

6.7.1 Revisiting the typology

In Chapter 1, a tentative typology of cumulative interactions was provided. The table in (18) repeats the portion of the typology that dealt with cumulative faithfulness interactions, with example languages listed.

(18) Typology of CFEs

	Ranking	Result	Example
e.	F1 + F2 > M1	The violations of two faithfulness constraints trade off for the violation of a markedness constraint	Luwanga, Fyem
f.	F2 + F3 > F1	The violations of two faithfulness constraints trade off for the violation of a third faithfulness constraint	Kikuyu, Amahl, Child ED47, Child ED13, Fon, Fula, Hawaiian, Japanese
g.	F2 + F2 > F1	Multiple violations of a single faithfulness constraint trade off for the violation of another faithfulness constraint	Greek (dialects other than Peloponnesian)
h.	F1 + F1 > M1	Multiple violations of a single faithfulness constraint trade off for the violation of a markedness constraint	??

While we found examples of CFE types e., f., and g., we did not find an example of the CFE type h., in which multiple violations of a single faithfulness constraint gang up on a markedness constraint. Why did we not find such an example? To answer this question, we must imagine what this type of CFE would look like. Essentially, we would need an example in which a single violation of a faithfulness constraint is acceptable, but two violations of the same constraint are not. Thus a marked structure is allowed to occur when multiple violations of the same faithfulness constraint would be required to repair it. Another way of thinking about it is that a single violation of a given markedness constraint is repaired, but a word in which the same constraint incurs two violations is not. This basic description sounds strange; a grammar in which a single violation of a markedness constraint is not tolerated, but two violations of that constraint are acceptable, seems problematic. The real question, though, is can HG predict such a strange grammar? If it can, this is problematic, as such a grammar seems from the typology to be unattested. Pater, Bhatt and Potts (2007) and Tesar (2007) discuss just such a hypothetical grammar and the fact that it is predicted by HG. The following example is drawn from their work. We will go on to show that the prediction of such a grammar is marginal and is based on the unusual formulation of a constraint; without this formulation, this grammar is no longer predicted.

Imagine a language in which coda consonants are not acceptable, and so a coda consonant is repaired by deletion. Such a language would require the two constraints listed in (19). The markedness constraint NoCoda bans coda consonants, while Max militates against their deletion. The tableau in (20) illustrates that as long as NoCoda has a greater weight than Max, a single coda consonant will be repaired by deletion.

(19) Constraints necessary for hypothetical grammar

NoCoda: Syllable-final consonants are banned

Max: Input segments have output correspondents

(20) HG account of coda deletion in hypothetical grammar

/bat/	NoCoda w=1.5	Max w=1	H
a. bat	-1		-1.5
b. ☞ ba		-1	-1

What if this hypothetical grammar contained a word with a coda cluster? While a coda cluster intuitively seems even worse than a singleton coda, from the point of view of NoCoda, they are equal. That is, NoCoda is an all-or-nothing constraint: it is violated if any number of syllable-final consonants occurs. Max, on the other hand, is violated by each segment that is deleted. Thus a coda cluster only violates NoCoda once, but the complete repair of that cluster violates Max twice. The tableau in (21) illustrates the result. Note the CFE: a single violation of Max is preferred to a single violation of NoCoda (as in (20)), but when Max is violated multiple times, those violations trade off for a single violation of NoCoda.

(21) HG account of coda cluster in hypothetical grammar

/bant/	NoCoda w=1.5	Max w=1	H
a. ☞ bant	-1		-1.5
b. ban	-1	-1	-2.5
c. ba		-2	-2

In this hypothetical grammar, then, a singleton coda consonant is deleted, but a coda cluster is allowed to remain, as its cumulative harmony is higher than that of the completely unmarked candidate, candidate c. in (21). Moreover, given a different constraint weighting, it is possible to produce a grammar in which one or two coda consonants are repaired by deletion, but a three-element coda cluster is allowed to remain. The tableau in (22) illustrates this second hypothetical grammar. In fact, this effect is infinite: if NoCoda had a weight of 99.5 and Max had a weight of 1, the result would be a grammar in which up to 99 coda consonants in a single syllable are repaired, but a syllable with 100 coda consonants is allowed.

(22) HG account of hypothetical grammar 2

a. A singleton coda is repaired by deletion

/bat/	NoCoda w=2.5	Max w=1	H
a. bat	-1		-2.5
b. ☞ ba		-1	-1

b. A coda cluster with two members is repaired by deletion

/bant/	NoCoda w=2.5	Max w=1	H
a. bant	-1		-2.5
b. ban	-1	-1	-3.5
c. ☞ ba		-2	-2

c. A coda cluster with three members surfaces faithfully

/barnt/	NoCoda w=2.5	Max w=1	H
a. ☞ barnt	-1		-2.5
b. barn	-1	-1	-3.5
c. bar	-1	-2	-4.5
d. ba		-3	-3

A grammar like the hypothetical ones described here is unattested and seems unlikely. The fact that HG can predict such a grammar is problematic. Pater et al. (2007) argue that a possible solution is to re-evaluate the nature of candidate violations. They use a version of OT called Local Harmonic Serialism (LHS), based originally on Harmonic Serialism (McCarthy, 2006, 2007a). In LHS, evaluation is done not in parallel, but serially, such that a markedness constraint assigns candidate violations after each repair. In the example discussed here, the input /bant/ would first be repaired to [bat], which would then be evaluated again by NoCoda and repaired further to [ba].

Another possible solution, noted but dismissed (with no reason given) by Pater et al., is to reformulate the NoCoda constraint such that it is violated once for every consonant in coda position. With such a formulation, it would be impossible to arrive at such a grammar, as is shown in the tableaux in (23).

(23) New formulation of NoCoda solves problem

a. A singleton coda is repaired by deletion

/bat/	NoCoda w=1.5	Max w=1	H
a. bat	-1		-1.5
b. ☞ ba		-1	-1

b. A coda cluster is repaired by deletion

/bant/	NOCODA w=1.5	MAX w=1	H
a. bant	-2		-3
b. ban	-1	-1	-2.5
c. ☞ ba		-2	-2

This reformulation seems like a much simpler solution than appealing to Harmonic Serialism.[6] NOCODA is one of very few all-or-nothing constraints, and intuitively, it does seem that having two coda consonants is worse than having one and should thus receive a greater violation. Note that when constraints that are not all-or-nothing are considered, the CFE discussed above becomes impossible. Imagine, for instance, a language in which voiced obstruents are disallowed (violating *VOIOBS) and are repaired by devoicing (violating IDENT[voice]). The tableaux in (24) illustrate the example. (24a,b) show that if *VOIOBS has a weight greater than that of IDENT[voice], a voiced onset and a voiced coda are each repaired by devoicing. Moreover, the tableau in (24c) shows that even when there are two voiced obstruents in a word, the best repair is to devoice both. This occurs because each of the voiced obstruents incurs its own violation of *VOIOBS. There is no way to weight the constraints such that a single voiced obstruent in a word is repaired, but two voiced obstruents in a word are allowed.

[6] Pater, Bhatt and Potts (2007) do illustrate that LHS also eliminates other problematic grammars predicted by HG that are not specifically relevant to CFEs.

(24) HG account of hypothetical devoicing grammar

a. Voiced onset is repaired by devoicing

/da/	*VOIOBS w=1.5	ID[voice] w=1	H
a. da	-1		-1.5
b. ☞ ta		-1	-1

b. Voiced coda is repaired by devoicing

/ad/	*VOIOBS w=1.5	ID[voice] w=1	H
a. ad	-1		-1.5
b. ☞ at		-1	-1

c. Both voiced onset and voiced coda are repaired by devoicing

/dad/	*VOIOBS w=1.5	ID[voice] w=1	H
a. dad	-2		-3
b. dat	-1	-1	-2.5
c. ☞ tat		-2	-2

A comparison of the tableaux in (20) and (21) to the tableaux in (24) essentially shows that the evaluation of NOCODA as an all-or-nothing constraint is what causes the prediction of the strange grammar in which multiple markedness violations are allowed when single markedness violations are not. If we reformulate NOCODA such that it is violated once by each consonant in a coda, we no longer have this problem. Moreover, the fact that such a grammar would no longer be predicted by HG is a good thing, as it is unattested in any real language. This also explains why the example cell in (18h) is empty; we have not found an example of that type of CFE because it is not possible, even in HG. While it is logically possible to imagine that two violations of a faithfulness constraint might gang up to prefer a single markedness violation, such a grammar is unattested because it cannot actually be predicted in HG.

This thesis, then, has provided examples of the three types of CFEs whose analysis is possible in HG, and has determined that the fourth type of logically possible CFE cannot be produced. It remains to further research to determine whether all of the cumulative markedness effects listed in the typology table in Chapter 1 have possible accounts in HG.

6.7.2 Summing up

Along with providing the typology summarized above, this thesis had two other primary goals. The second goal was to provide examples of CFEs from a number of language domains. The examples of CFEs drawn from fully-developed languages, first language acquisition and loanword adaptation have served to illustrate that, all other things being equal, languages prefer to reduce markedness in the least unfaithful way possible. Frequently the deletion of a segment is a more faithful alternative than either multiple feature changes or the combination of featural change and epenthesis. In some cases, though, the deletion of a feature avoids multiple unfaithful mappings (e.g., Child ED13, Chapter 3), and in other cases, featural epenthesis is the most faithful repair (e.g., Japanese, Chapter 5). There are even languages in which a marked output is preferable to a multiply-unfaithful one (e.g., Luwanga, Chapter 5). In each of these examples, though, multiple faithfulness constraints work together to avoid an output that is excessively unfaithful.

Because they often begin with rankings in which multiple markedness constraints are ranked higher than (or weighted greater than) multiple faithfulness constraints, developing phonologies proved to be a rich source for CFEs. Chapter 3 showed that children sometimes acquire CFEs on the way to fully faithful outputs. Examples came from both normally-developing and phonologically-delayed children, and the HG-GLA (Jesney and Tessier, 2007) was argued to account for the natural emergence and loss of CFEs during the acquisition process. Chapter 4 illustrated CFEs in loanword adaptation. The majority of the loanword CFEs avoided the combination of featural change and epenthesis as a repair for syllable-structure violations, instead choosing segmental deletion as the more faithful repair. It was posited that speakers may take perceptual similarity into account when choosing repair strategies, effectively incorporating perceptual similarity into the "degree of unfaithfulness" calculation. Chapter 4 also illustrated that while the local conjunction of faithfulness constraints can account for CFEs, HG provides a more parsimonious account.

Chapters 2 and 5 provided several examples of CFEs in the morphophonemics of fully-developed languages. These cases supplied evidence that CFEs are not simply a stage in the acquisition of a language; they also function as the final state in some languages. Chapter 5 also introduced the distinction between a "true chain shift" and a "CFE chain shift," both interactions in which the cumulativity of faithfulness constraints plays a role. In a CFE chain shift, though, no rule ordering can account for the outputs; certain outputs are blocked solely because they are too unfaithful, and the marked output is chosen instead. This chapter also rounded out the typology of CFEs, providing an example in which two faithfulness constraints gang up on a single markedness constraint, thus allowing a marked output in favor of a doubly-unfaithful one.

The third goal of the thesis was to provide an account of CFEs within current phonological theory. OT, with its ranked constraints and the principle of strict domination, was shown to be unable to capture the effects that occur when multiple faithfulness constraints gang up on another constraint. While the local conjunction of faithfulness constraints allows OT to account for CFEs, the mechanism of conjunction brings up questions about what kinds of constraints can conjoin, the domain of conjunction, and the provenance of locally conjoined constraints. Harmonic grammar was presented as a viable alternative. HG (or other similar theories of weighted constraints) has already been used by a number of researchers to account for cumulative markedness effects (e.g., Pater, 2006; McClelland, 2007; Tesar, 2007; Coetzee and Pater, to appear), and this thesis extended that use to CFEs. HG provides a numerical measurement for ideas like "more faithful"—the more faithful of two outputs is the one with a better cumulative harmony score across all faithfulness constraints. Finally, HG can account not only for those cases in which multiply-unfaithful outputs are disallowed, but also for cases in which multiply-unfaithful outputs occur because there is no better alternative. With some modification, HG can even account for chain shifts (Albright, Magri and Michaels, 2008).

The findings of this thesis leave the door open for a great deal of future research. Along with the proposals discussed in §6.5 above, the issue of cumulativity should be explored in other linguistic domains, like syntax. And while HG has recently been making a comeback, its relevance must be further tested in the domains of acquisition, variation and opacity.

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Education

Ph.D., Linguistics, Indiana University, 2008
Minors in Speech and Hearing Sciences and Cognitive Psychology
Dissertation: Cumulative faithfulness effects
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M.A., Linguistics, Indiana University, 2005

B.A., Summa cum laude, Xavier University, 2002
English major with minors in French and philosophy

Grants, honors and awards

National Institutes of Health, Predoctoral Fellow, 2003-2008 (NIH-DC00012)

Fred W. Householder Outstanding Graduate Student Paper Award (2004)

Symposium on Research in Child Language Disorders Student Travel Award (2005)

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Graduate and Professional Student Organization Travel Grant (to present at the 29th GLOW Colloquium in Barcelona) (2006)

General research interests

Phonological acquisition, e.g. L1 normal and delayed acquisition and the acquisition patterns of children with disorders; L2 acquisition; parallels between L1 and L2 acquisition; longitudinal change caused by treatment

Phonological theory, particularly constraint-based approaches such as Optimality Theory and Harmonic Grammar; opacity effects

Loanword phonology, particularly opacity effects within loanword adaptation

Publications

Edited volume

Farris-Trimble, A. W. & Dinnsen, D. A. 2008. *Phonological Opacity Effects in Optimality Theory*. Indiana University Working Papers in Linguistics. Bloomington, IN: Indiana University Linguistics Club Publications.

Papers

Dinnsen, D. A. & Farris, A. W. 2006. Constraint conflict: the source of an unusual error pattern. *Clinical Linguistics & Phonetics* 20. 493-499.
Morrisette, M., Farris, A. W. & Gierut, J. A. 2006. Applications of learnability theory. *Advances in Speech Language Pathology* 8: 207-219.
Dinnsen, D. A., Gierut, J. A. & Farris-Trimble, A. W. 2007. Comparative markedness and induced opacity. Indiana University, unpublished manuscript.
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Farris-Trimble, A. W. 2008. Cumulative faithfulness effects: Opaque or transparent? *Phonological Opacity Effects in Optimality Theory. Vol. 6.* Indiana University Working Papers in Linguistics, ed. by A. W. Farris-Trimble and D. A. Dinnsen, 119-145. Bloomington, IN: Indiana University Linguistics Club Publications.
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Dinnsen, D. A. & Farris-Trimble, A. W. In press. Developmental shifts in phonological strength relations. *Phonological Strength*, ed. by K. Nasukawa and P. Backley. New York: Mouton de Gruyter.
Farris-Trimble, A. W. In press. Nothing is better than being unfaithful in multiple ways. CLS 44 Proceedings.

Presentations

Farris, A. W. 2003. Constraints on the Fortis/Lenis Contrast in Ngalakan. Paper presented at the 9th Annual Meeting of the Mid-Continental Workshop on Phonology, Urbana-Champaign, IL, October 29-31.
Dinnsen, D. A. & Farris, A. W. 2004. Grammar continuity and the prominence paradox. Poster presented at the 78th Annual Meeting of the Linguistic Society of America, Boston, MA, January 8-11.

Dinnsen, D. A. & Farris, A. W. 2004. Constraint conflict: the source of an unusual error pattern. Paper presented at the 10th meeting of the International Clinical Phonetics & Linguistics Association, Lafayette, LA, February 25-28.

Farris, A. W. 2004. Loanwords in Fon: A transparent opacity effect. Poster presented at the 10th Annual Meeting of the Mid-Continental Workshop on Phonology, Northwestern University, Chicago, IL, October 28–30.

Farris, A. W. 2005. Chain-shift opacity effects in loanword phonology. Paper presented at the 79th Annual Meeting of the Linguistic Society of America, Oakland, CA, January 6-9.

Farris, A. W. & Gierut, J. A. 2005. Statistical regularities of the input as predictive of phonological acquisition. Poster presented at the Symposium on Research in Child Language Disorders, Madison, WI, June 9-11.

Farris, A. W. 2005. A synergistic explanation of opacity effects in loanword adaptations. Poster presented at the 13th Manchester Phonology Meeting, Manchester, England, May 26-28.

Farris, A. W. 2005. Gapped acquisition of harmonically complete inventories: An analysis of children's cluster acquisition. Paper presented at the 11th Annual Meeting of the Mid-Continental Workshop on Phonology, University of Michigan, Ann Arbor, MI, November 4-6.

Farris, A. W. 2006. Faithfulness to the marked and the acquisition of gapped cluster inventories. Paper presented at the 29th GLOW Colloquium, Barcelona, April 6-8.

Dinnsen, D. A. & Farris, A. W. 2006. Developmental shifts in phonological strength relations. Paper presented at the Workshop on Strength Relations in Phonology, Sendai, Japan, September 5-6.

Farris, A. W. 2007. Doubly-derived environment blocking. Paper presented at the 81st Annual Meeting of the Linguistic Society of America, Anaheim, CA, January 4-7.

Dinnsen, D. A., Gierut, J. A. & Farris, A. W. 2007. An experimental evaluation of comparative markedness. Paper presented at Experimental Approaches to Optimality Theory, Ann Arbor, MI, May 18-20.

Farris-Trimble, A. W. 2007. A typology of s-cluster inventories. Paper presented at the Association of Linguistic Typology VII, Paris, France, September 25-28.

Dinnsen, D. and Farris-Trimble, A. W. 2007. An opacified conspiracy in phonological acquisition. Paper presented at the 13th Annual Mid-Continental Workshop on Phonology, The Ohio State University, Columbus, Ohio, October 26-28.

Farris-Trimble, A. W. 2007. Cumulative faithfulness and Harmonic Grammar. Paper presented at the 13th Annual Mid-Continental Workshop on Phonology, The Ohio State University, Columbus, Ohio, October 26-28.

Farris-Trimble, A. W. 2008. Nothing is better than being unfaithful in multiple ways. Paper presented at the 44th Annual Meeting of the Chicago Linguistic Society, University of Chicago, Chicago, Illinois, April 24-26.

Professional experience and selected service activities

Teaching
- Instructor, L307 Phonology, Indiana University, 2006
- Associate Instructor, L303 Introduction to Linguistic Analysis, Indiana University, 2004, 2005, 2006
- Associate Instructor, L542 Phonological Analysis, Indiana University, 2004, 2005
- Associate Instructor, L642 Advanced Phonology, Indiana University, 2007
- Associate Instructor, L700 Phonological Acquisition, Indiana University, 2008

Service
- Indiana University Linguistics Club, faculty-student liaison, 2003-04
- Indiana University Linguistics Club Publications, management board, 2004-2005
- Referee, Indiana University Linguistics Club Online Working Papers, 2003, 2004
- Referee, *Language Learning*, 2005
- Referee, *Language Acquisition*, 2007
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Membership
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