Harmonic Improvement without Candidate Chains in Chamorro

Aaron Kaplan

This article argues that some ostensible advantages of Optimality Theory with Candidate Chains (OT-CC) over classic OT are actually liabilities. OT-CC correctly predicts that Chamorro umlaut occurs only when trigger and target are adjacent. But OT-CC is incompatible with similar phenomena like Central Venetan metaphony, and attempts to modify OT-CC to produce metaphony impair the theory's handling of umlaut. Classic OT provides a superior approach: constraints grounded in prominence asymmetries produce the umlaut facts, and there is no conflict with analyses of metaphony. This result suggests that despite OT-CC's advancements in treatments of opacity, the theory's machinery remains inadequate in important ways.

Keywords: Optimality Theory, candidate chains, Chamorro, umlaut, Central Veneto, metaphony

1 A Puzzle in Chamorro Umlaut

In Chamorro umlaut (Chung 1983, Conant 1911, Crosswhite 1996, von Preissig 1918, Topping 1968, 1969, 1973, Topping, Ogo, and Dungca 1975), certain prefixes and particles trigger the fronting of root-initial vowels.

(1) a. nána   'mother'   i nǽna   'the mother'
    b. gúmaʔ   'house'   i gímaʔ   'the house'
    c. cúpa   'cigarettes' i cípa   'the cigarettes'
    d. sóŋsuŋ   'village'   i séŋsuŋ 'the village'

Umlaut-triggering morphemes typically contain front vowels themselves, but not all do, and some prefixes and particles with front vowels are not triggers. In the Saipan dialect, canonical umlaut occurs only if the root-initial vowel is stressed.[1] The examples in (1) meet this condition and undergo umlaut, while the forms in (2) show that the lack of root-initial stress precludes umlaut.

(2) a. pulónnun   'triggerfish'   i pulónnun   'the triggerfish'
                                             *i pilónnun, *i pilénnun
    b. mundóŋgu   'cow's stomach'   i mundóŋgu 'the cow's stomach'
                                             *i mindóŋgu, *i mindéŋgu

This unstressed-vowel blocking is unexpected on theoretical grounds. Positional Faithfulness (Beckman 1999) predicts that if anything, stressed vowels (i.e., the prominent units) should resist umlaut, not unstressed vowels.

These facts contrast with superficially similar phenomena in which the spreading feature propagates over a potentially long distance to reach the stressed syllable. This occurs, for example, in Central Venetan metaphony, where high vowels trigger the raising of /e, o/ in a preceding stressed syllable (Walker 2005, 2008, 2010). If the trigger is not adjacent to the stressed syllable, intervening vowels are also raised (except that /ɛ, ɔ, a/ block metaphony; see section 2.2). In procedural terms, [+high] spreads leftward through certain nonlow vowels to the stressed syllable.

(3) a. *No intervening syllables*
        kal-sé-to   'sock (MASC.SG)'   kal-sí-ti   'sock (MASC.PL)'
        kant-é-se   'sing (1PL)'   kant-í-si-mo 'sing (1PL.IMPF.SUBJ)'
        móv-o   'move (1SG)'   múv-i   'move (2SG)'
        kantór   'choir singer (MASC.SG)'   kantúr-i   'choir singer (MASC.PL)'
    b. *An intervening syllable*
        órdeno   'order (1SG)'   úrdini   'order (2SG)'

Optimality Theory with Candidate Chains (OT-CC; McCarthy 2007a,b) has a ready explanation for the patterns in (1) and (2). In this framework, unlike in classic OT (Prince and Smolensky 1993/2004),[2] outputs are produced incrementally (they show ''gradualness''), so that to reach *i pilénnun from /i pulónnun/, we must pass through the intermediate stage i pilónnun. But each step must improve the form's performance on the constraint ranking (''harmonic improvement''), and i pilónnun does not do this: spreading has not reached the stressed syllable, so the constraint responsible for attraction-to-stress remains unsatisfied, and at the same time, a new faithfulness violation is introduced. Since the requisite intermediate step does not show harmonic improvement, the entire derivation is blocked, and umlaut fails. But when stress is root-initial, the first spreading step satisfies the attraction-to-stress constraint. Since /i gúmaʔ/ → i gímaʔ shows harmonic improvement, umlaut is allowed.

This article argues that despite OT-CC's ability to produce the data presented above, this is the wrong approach to take. The same gradualness and harmonic improvement requirements that correctly block umlaut in (2) also incorrectly prevent metaphony in (3b), and revisions to the architecture of OT-CC (Walker 2008, 2010) to account for Central Veneto render the theory incapable of producing Chamorro's umlaut.

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[2] By *classic OT*, I broadly mean versions of OT without candidate chains: the theory put forth by Prince and Smolensky (1993/2004) supplemented with Correspondence Theory (McCarthy and Prince 1995), Alignment (McCarthy and Prince 1993), Positional Faithfulness (Beckman 1999), and so on.

In contrast, a classic OT analysis that takes umlaut to be triggered solely by stress-adjacent prefixes and particles accounts for the umlaut facts while also permitting an analysis of Central Venetan metaphony. This analysis of umlaut is rooted in the observation that umlaut requires an immediately pretonic prefix or particle, which is an especially weak unit in Chamorro: as a nonroot, it is morphologically nonprominent, and immediately pretonic syllables show signs of weakness in the language. Thus, umlaut is a strategy for compensating for these extremely weak elements and can be motivated with a Positional Licensing constraint (Walker 2001, Zoll 1998a,b).

The gradualness and harmonic improvement requirements are central to OT-CC, and at first glance, Chamorro umlaut provides striking confirmation of these devices. But as the analysis presented below shows, we need not take refuge in OT-CC to produce (the appearance of) their effects. If phenomena that seem to reflect these requirements can be derived in classic OT in a principled fashion, a significant argument in favor of OT-CC is undermined. OT-CC offers improvements over classic OT in the treatment of derivational opacity, but in doing so it imposes limitations on operations that hinder analysis of umlaut and metaphony. In contrast, classic OT, with no limitations on operations, offers a more satisfactory treatment of these phenomena. An investigation of umlaut has little to say about opacity itself, but by examining OT-CC's opacity-driving mechanisms in other areas in which they are ostensibly applicable, we can learn more about the suitability of these mechanisms for phonological theory in general and perhaps discover areas for further improvement that opacity itself cannot reveal.

The argument proceeds as follows. Section 2 fleshes out the OT-CC analysis of umlaut sketched above, and section 3 gives the details of Walker's (2008, 2010) modification of OT-CC designed to account for Central Veneto. That proposal, while necessary to produce (3b), undermines OT-CC's account of umlaut. Section 4 develops an analysis of umlaut in classic OT that is compatible with Walker's (2005) approach to metaphony (also in classic OT). Section 5 considers remaining issues, and section 6 contains discussion and conclusions.

2 OT-CC, Umlaut, and Metaphony

2.1 An Analysis of Chamorro Umlaut

In OT-CC, which is related to Harmonic Serialism (Prince and Smolensky 1993/2004), surface forms are produced step by step in a derivational fashion rather than in one fell swoop as in classic OT. Formally speaking, output candidates are *chains*: ordered *n*-tuples that instantiate the initial, intermediate, and final stages in the generation of a surface form. The first member of the chain must always be the most harmonic fully faithful parse of the input—we can add syllabification, and so on, but we cannot incur faithfulness violations on this step. Subsequent steps accumulate changes until the surface form is reached. Chains are further subject to two requirements, *gradualness* and *harmonic improvement*, that are the focus of this article. We will see in this section that these requirements conspire to block umlaut in the forms in (2) but not in (1). A third requirement, *best violation*, is discussed below.

Gradualness essentially requires a candidate chain to make just one change at a time. Formally, each noninitial step retains all the faithfulness violations of its predecessors and adds just one more violation of a ''basic'' faithfulness constraint. In other words, adjacent forms in a

chain must be minimally different,[3] with a monotonic increase in unfaithfulness. To illustrate, (4) presents some potential chains for umlaut.

(4) a.   ⟨i gúmaʔ, i gímaʔ⟩   *(one violation of* IDENT[back]*)*
    b. **⟨i pulónnun, i pilénnun⟩   *(two violations of* IDENT *in one step)*
    c.   ⟨i pulónnun, i pilónnun, i pilénnun⟩   *(one violation of* IDENT *per step)*

Strictly speaking, the initial member of each chain should have no stress since forms like *i gúmaʔ* violate IDENT(stress) and are thus ineligible chain initiators. The chain for *i gímaʔ* is more accurately ⟨i. gu.maʔ, i. gú.maʔ, i. gí.maʔ⟩ (plus additional steps for irrelevant vowel quality alternations, and so on, that I abstract away from; see Chung 1983), with only syllabification added in the first step. Since stress assignment is tangential to the point at hand (in both Chamorro and Central Veneto), I will simplify matters by assuming underlying stress. I will further simplify representations by not showing syllabification.

The chains in (4a) and (4b) each contain two members: the fully faithful form (modulo stress) and the surface form. The former is a well-formed chain in that the second member of the chain incurs just a single additional violation of IDENT compared to its predecessor. The latter is not a well-formed chain since the lone step introduces two violations of IDENT. (I follow McCarthy (2007a,b) in using two asterisks to mark an invalid (rather than merely suboptimal) chain.)

The chain in (4c) is appropriately gradual. Here there are two steps, with [−back] spreading to one new vowel in each step. If we are to attempt to produce umlaut in this form, we must use the chain in (4c) because it is the only gradual option, although we will see shortly that this chain is invalid on other grounds.

The other relevant restriction on chains is harmonic improvement, which requires each non-initial item in a chain to be more harmonic than its immediate predecessor. Construction of a chain proceeds as follows. The most harmonic fully faithful form becomes the first member of the chain. Gen subsequently supplies a set of forms that minimally differ from the fully faithful form as dictated by gradualness. For example, Gen might produce a set of forms that all violate IDENT[back] once, plus a set of forms that violate MAX once. For the IDENT[back]-violating forms, Gen consults Eval and determines which such form is most harmonic. This form becomes the second member of one chain. (This is the best-violation requirement: a chain member that introduces a violation of a faithfulness constraint F must instantiate the most harmonic way of violating F.) The same thing happens with the MAX-violating forms: the most harmonic one becomes the second member of a competing chain. Construction of a chain therefore involves a loop between Gen and Eval, with potential new chain members constantly being checked against the constraint ranking.

Crucially, a form is added to a chain only if it is more harmonic than the immediately preceding member of the chain. If f_{i+1} in a chain ⟨ . . . f_i, f_{i+1}, . . . ⟩ is not more harmonic than f_i, the chain is invalid.

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[3] Exactly what counts as ''minimally different'' is the subject of ongoing research. See McCarthy 2007b.

To determine whether the gradual chains in (4) show harmonic improvement, we must have a constraint ranking. Umlaut is plausibly an attraction-to-stress phenomenon, although I will argue against this position below. Walker (2005) develops Positional Licensing constraints (Walker 2001, Zoll 1998a,b) to account for such phenomena. One family of these constraints requires ''indirect licensing'' of elements in weak positions (codas, unstressed syllables, etc.) by concurrent membership in strong positions (see also Itô 1988, Lombardi 1994, Steriade 1995). In this vein, I adopt the constraint in (5), to be revised below.

(5) LICENSE($[-back]_{prefix}$, $\acute{\sigma}$)
     $[-back]$ in a prefix or particle must be associated with a stressed syllable.

To produce umlaut, this constraint must outrank IDENT[back]. How do the gradual chains in (4) fare against this ranking? Beginning with ⟨i gúmaʔ, i gímaʔ⟩, in the $u \rightarrow i$ change, IDENT[back] is violated, but, as the tableau in (6) shows, this violation buys satisfaction of the higher-ranking constraint. The chain is therefore harmonically improving since the second member of the chain is more harmonic than the first.[4]

(6)	/i gúmaʔ/	LIC($[-back]_{prefix}$, $\acute{\sigma}$)	IDENT[back]
a. i gúmaʔ		*!	
☞ b. i gímaʔ			*

Thus, ⟨i gúmaʔ, i gímaʔ⟩ is a valid chain: it is both gradual and harmonically improving. Before turning to ⟨i pulónnun, i pilónnun, i pilénnun⟩, we should ensure that ⟨i gúmaʔ, i gímaʔ⟩ is not just valid, but also optimal. One way to proceed is to ask whether our existing chain can be lengthened. As (7) shows, adding another spreading step is not harmonically improving and is therefore ruled out. That is, **⟨i gúmaʔ, i gímaʔ, i gímæʔ⟩ is invalid.

(7)	/i gúmaʔ/	LIC($[-back]_{prefix}$, $\acute{\sigma}$)	IDENT[back]
☞ a. i gímaʔ			*
b. i gímæʔ			**!

What about chains that spread [+back] from the root to the stem, producing *u gúmaʔ? Under the current ranking, ⟨i gúmaʔ, u gúmaʔ⟩ is harmonically improving, and in fact would be favored by Positional Faithfulness since *u gúmaʔ preserves the backness of a stressed vowel while i gímaʔ does not.

We can render ⟨i gímaʔ, u gúmaʔ⟩ invalid by splitting IDENT[back] into IDENT[−back] and IDENT[+back] (Pater 1999) and ranking the latter over LICENSE($[-back]_{prefix}$, $\acute{\sigma}$). Now ⟨i gúmaʔ, u gúmaʔ⟩ is not harmonically improving.

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[4] McCarthy (2007b) notes that while OT-CC does not evaluate each member of a chain separately from the rest of the chain, classic OT tableaux like the one in (6) are still useful in assessing harmonic improvement.

(8)

/i gúmaʔ/	Ident[−back]	Lic([−back]$_{prefix}$, σ́)	Ident[+back]
☞ a. i gúmaʔ		*	
b. u gúmaʔ	*!		

Other strategies for satisfying License([−back]$_{prefix}$, σ́) are easily ruled out; for example, deletion of the definite article *i* is blocked by a high-ranking Max.

Finally, consider the chain ⟨i gúmaʔ⟩ with just one member. As (9) shows, it is less harmonic than ⟨i gúmaʔ, i gímaʔ⟩. It therefore appears that the intended winner, ⟨i gúmaʔ, i gímaʔ⟩, is actually the optimal chain under this analysis.

(9)

/i gúmaʔ/	Ident[−back]	Lic([−back]$_{prefix}$, σ́)	Ident[+back]
☞ a. ⟨i gúmaʔ, i gímaʔ⟩			*
b. ⟨i gúmaʔ⟩		*!	

Turning to *i pulónnun*, ⟨i pulónnun, i pilónnun, i pilénnun⟩—the only gradual chain for this form—is not harmonically improving. As (10) shows, the second member of the chain incurs a new violation of Ident[+back] without improving performance on the Licensing constraint relative to the first member of the chain.

(10)

/i pulónnun/	Lic([−back]$_{prefix}$, σ́)	Ident[+back]
☞ a. i pulónnun	*	
b. i pilónnun	*	*!

Consequently, **⟨i pulónnun, i pilónnun, i pilénnun⟩ is invalid because it contains an invalid subchain. Ident[−back] rules out the alternative **⟨i pulónnun, u pulónnun⟩, and other constraints that limit the range of viable License-satisfying strategies in *i gímaʔ* similarly block alternative strategies for *i pulónnun*.

The two conceivable ways of producing umlaut with noninitial stress are ruled out by OT-CC's architecture. OT-CC, then, correctly predicts local spreading (*i gímaʔ*) and prevents long-distance spreading (*i pulónnun*). In contrast, a classic OT analysis that uses the ranking above cannot prevent long-distance umlaut (☺ marks the winner and (☞) marks the correct candidate).

(11)

/i pulónnun/	Lic([−back]$_{prefix}$, σ́)	Ident[+back]
(☞) a. i pulónnun	*!	
b. i pilónnun	*!	*
☺ c. i pilénnun		**

Classic OT permits the fell-swoop mapping /i pulónnun/ → *i pilénnun*, which OT-CC's gradualness blocks. Furthermore, foot structure cannot be called on to limit spreading: both Klein

(2000) and Flemming (1994) argue that Chamorro is a trochaic language, at least in the default case, so with footings such as *i (gíma?)* and *i (nǽna)*, the claim that umlaut is foot-constrained is not tenable. Recall also that Positional Faithfulness is no help here since it would only penalize spreading to stressed syllables and permit spreading through unstressed syllables.

At this point, umlaut appears to be exactly the kind of phenomenon that calls for (constructs like) the gradualness and harmonic improvement restrictions. OT-CC produces umlaut using a member of a well-motivated constraint family, and the local nature of umlaut is an automatic consequence of the theory. OT-CC provides an explanation for the unstressed-vowel blocking effect in that the chains required for long-distance umlaut are either not harmonically improving or not gradual, and therefore ineligible for consideration.[5]

To summarize, OT-CC offers an elegant account of Chamorro umlaut that resolves the ''anti−Positional Faithfulness'' nature of the phenomenon through the gradualness and harmonic improvement requirements. The next section examines Central Venetan metaphony, where OT-CC does not have such an easy time.

2.2 The Incompatibility of Metaphony and OT-CC

Walker (2008, 2010) shows that the same factors that preclude long-distance umlaut in OT-CC also incorrectly rule out metaphony in Central Veneto. I illustrate the point with *úrdini* 'order (2SG)' from (3b). The chain for this form must be ⟨órdeni, órdini, úrdini⟩ because **⟨órdeni, úrdini⟩ is not gradual. Following Walker (2005, 2008, 2010), metaphony is triggered by the constraint in (12).

(12) LICENSE($[+high]_{posttonic}$, σ́)
    [+high] in a posttonic syllable must be associated with a stressed syllable.

As (13) shows, the first step in the gradual chain is not harmonically improving. Just as in (10), long-distance spreading is impossible because the violation of the Licensing constraint is not alleviated by spreading to the intervening unstressed vowel. The subchain **⟨órdeni, órdini, . . . ⟩ is not harmonically improving and is consequently invalid. OT-CC predicts that both umlaut and metaphony should be exclusively local.

(13)

/órdeni/	LIC($[+high]_{posttonic}$, σ́)	IDENT[high]
☺ a. órdeni	*	
(☞) b. órdini	*	*!

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[5] McCarthy (2007a) advances a view of feature spreading in OT-CC in which such operations require two derivational steps. The target of assimilation loses its underlying feature, violating MAX[feature], and a feature on a neighboring segment spreads to that segment, violating NO-SPREAD[feature]. The results of this section are preserved under this interpretation: *i gíma?* comes from the chain ⟨i gúma?, i gᵱma?, i gíma?⟩: spreading to the stressed vowel satisfies Licensing and creates ᵱ, a high vowel specified as both [−back] and [+back], and then the [+back] feature of that vowel is removed to satisfy constraints against multiple or conflicting feature specifications on a segment. But **⟨i pulónnun, i pᵱlónnun, . . . ⟩ does not satisfy LICENSE($[−back]_{prefix}$, σ́). It is not harmonically improving and is still ruled

Replacing LICENSE([+high]_{posttonic}, σ́) with a gradient Alignment (McCarthy and Prince 1993) constraint would render this chain harmonically improving. If the constraint requires [+high] to be aligned with the stressed syllable, ⟨órdeni, órdini, . . . ⟩ is harmonically improving because the second member incurs just one violation of Alignment (counting by syllables) to its predecessor's two. Thus, long-distance spreading can proceed step by step, with each step removing one Alignment violation.

Unfortunately, this approach predicts that when the stressed vowel is an ineligible target for spreading, [+high] will spread as close to the stressed syllable as possible so as to minimize Alignment violations. The relevant test cases involve /ε, ɔ, a/, which block metaphony. When the stressed syllable contains one of these vowels, neither it nor the intervening vowels undergo metaphony. Likewise, when /ε, ɔ, a/ fall between the trigger and the stressed syllable, metaphony is blocked (Walker 2008, 2010).

(14) *Stressed vowels ineligible for raising*

gát-o	'cat (MASC.SG)'		gát-i	'cat (MASC.PL)'
			*gút-i	
ángol-o	'angle (MASC.SG)'		ángol-i	'angle (MASC.PL)'
			*ángul-i	
áxen-o	'donkey (MASC.SG)'		áxen-i	'donkey (MASC.PL)'
			*áxin-i	
pérseg-o	'peach (fruit) (MASC.SG)'		pérseg-i	'peach (fruit) (MASC.PL)'
			*pérsig-i	

(15) *Intervening ineligible vowels*

la(v)ór-a-v-a   'worked, was working (1SG.IMPF.IND)'
la(v)ór-a-v-i   'worked, was working (2SG.IMPF.IND)'   *la(v)úr-a-v-i*

The Alignment approach would favor the chain *⟨ángol-o, ángul-i⟩, for example, which is harmonically improving because it reduces Alignment violations. The Licensing analysis correctly predicts no spreading at all here because spreading to the intervening syllable and no farther does not eliminate the Licensing violation. (Also, McCarthy (2003) argues against gradient Alignment constraints on a variety of empirical grounds, and other researchers have argued that gradient Alignment is excessively powerful (Eisner 1997, Potts and Pullum 2003).)

Walker (2008) also rules out an approach whereby the final vowel's [+high] feature is copied onto the stressed vowel in one step, skipping the intervening vowel so as to satisfy Licensing immediately (16a). In a subsequent step (16b), the feature is also copied onto the intervening vowel to satisfy a constraint against the gapped configuration in (16a). Under this analysis, OT-CC incorrectly predicts that when the intervening vowel is ineligible for raising, metaphony can skip over that vowel—the derivation will stop at (16a) and simply refrain from undertaking the step in (16b). As (15) shows, this does not happen.

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out. Reversing the order of events is no help: deleting the target vowel's [back] feature before spreading (i.e., **⟨i pulónnun, i pIlónnun, i pilónnun, . . . ⟩) still doesn't satisfy Licensing and involves apparently unmotivated feature deletion.

(16) a. ú r d e n i
         | |
       [+hi]$_i$ [+hi]$_i$

   b. ú r d i n i
       | | |
     [+hi]$_i$ [+hi]$_i$ [+hi]$_i$

Walker points out a way to reconcile OT-CC with the facts of metaphony by altering the gradualness requirement. Her revision of gradualness, which no longer bans the harmonically improving chain ⟨órdeni, úrdini⟩, is the topic of the next section, where we will see that in modifying OT-CC to account for metaphony—as we must do if OT-CC is to be a viable theory—we ruin its elegant account of umlaut.

3 A Revision of the Gradualness Requirement

The reason OT-CC, as formulated by McCarthy (2007b), cannot account for long-distance metaphony is that the gradualness requirement (which I will call *strict gradualness*) prevents the grammar from considering the only available harmonically improving chain, namely, ⟨órdeni, úrdini⟩. To correct this problem, Walker (2008) develops a modified version of the gradualness requirement that I will call *relaxed gradualness*. The essence of the proposal is that an element in a candidate chain may incur multiple new violations of a single basic faithfulness constraint if all of these violations are necessary to improve markedness at a single locus. The restrictions on multiple violations in one step (they must all be violations of the same faithfulness constraint and in service of markedness reduction at just one point) preserve OT-CC's functionality in other domains that need not concern us here.

Under relaxed gradualness, ⟨órdeni, úrdini⟩ is now permissible despite two new violations of IDENT[high] in one step because both violations are necessary to remove the final vowel's violation of LICENSE([+high]$_{posttonic}$, ́σ). That is, the final vowel is the locus of the Licensing violation, and incurring multiple IDENT violations at once to repair that violation is allowed. OT-CC can now produce long-distance metaphony. The tableau in (17) confirms that ⟨órdeni, úrdini⟩ is harmonically improving and superior to **⟨órdeni, órdini⟩, which is still not harmonically improving.

(17)

/órdeni/	LICENSE([+high]$_{posttonic}$, ́σ)	IDENT[high]
a. órdeni	*!	
b. órdini	*!	*
☞ c. úrdini		**

Unfortunately, relaxed gradualness also permits ⟨i pulónnun, i pilénnun⟩ for Chamorro, with two violations of IDENT[+back] incurred in one step so as to satisfy LICENSE([−back]$_{prefix}$, ́σ). OT-CC now incorrectly predicts umlaut since *i pilénnun is more harmonic than *i pulónnun*.

(18)

/i pulónnun/	Lɪᴄ([−back]$_{prefix}$, ǿ)	Iᴅᴇɴᴛ[+back]
(☞) a. i pulónnun	*!	
b. i pilónnun	*!	*
☺ c. i pilénnun		**

The problem is that under relaxed gradualness, we need not include the illicit subchain **⟨i pulónnun, i pilónnun⟩ in our attempt to produce *i pilénnun*. Relaxed gradualness permits harmonically improving fell-swoop chains that are necessary for Central Veneto but toxic for Chamorro.

In modifying the theory so as to account for metaphony, we have eliminated any advantage OT-CC had over classic OT in an analysis of umlaut. It appears that under the analyses developed so far, OT-CC can account for either umlaut or metaphony, but not both. This result does not reveal a fatal flaw in Walker's relaxed-gradualness proposal (which seems entirely warranted given the facts of Central Veneto) so much as it exposes a drawback to the OT-CC framework as a whole. Both gradual and fell-swoop phenomena exist, so the OT-CC effort to achieve analytical elegance by restricting the range of possible derivations along this dimension is too inflexible.

One solution to the impasse is to allow a choice between the two kinds of gradualness. Strict gradualness is available to Chamorro and the results of section 2.1 are preserved, but the relaxed-gradualness analysis of Central Veneto is also permitted. Such a move would weaken OT-CC considerably and introduces its own problems.[6] It essentially makes two versions of Gen available, which is at odds with the intended universality of certain OT constructs like Gen and Con. Such a choice between versions of Gen would also exclude the possibility that a single language could exhibit both Chamorro-like and Central Veneto–like processes. I know of no specific examples of this sort, but such a language does not seem implausible.

The solution I propose in the following section is that we return to classic OT, where metaphony can be produced with Lɪᴄᴇɴꜱᴇ([+high]$_{posttonic}$, ǿ). To account for umlaut, we simply need a constraint other than Lɪᴄᴇɴꜱᴇ([−back]$_{prefix}$, ǿ), one that takes stress to be the trigger of umlaut rather than the target. This constraint will motivate umlaut in exactly the right contexts, so we have no need for OT-CC's restrictions to explain the distribution of umlaut.

4 Classic OT: Stress as the Trigger of Umlaut

In this section, I present an analysis of umlaut in classic OT that relies on a new Positional Licensing constraint, namely, one that requires *only immediately pretonic* [−back] features to be associated with the root.[7] The crucial observation behind this analysis is that umlaut occurs when the underlying host of the spreading [−back] feature meets two conditions: it must be both (a) in a prefix or particle (henceforth, simply *prefix*) and (b) immediately pretonic (henceforth, *pretonic*). Both properties are loci of weakness in Chamorro.

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[6] Thanks to an anonymous reviewer for helpful discussion of these issues.

[7] For alternative OT analyses of umlaut, see Crosswhite 1996 and Klein 2000; and for a critique of these approaches, see Kaplan 2008b.

Prefixes, and affixes more generally, are morphologically weak compared to roots. Roots are ''prominent positions which license more contrasts than other non-prominent positions'' (Urbanczyk 2006:194; see also Beckman 1999, Kaplan 2008a, McCarthy and Prince 1995, Steriade 1995).

Some umlaut triggers are uncontroversially prefixes, and the particles that trigger umlaut share relevant properties with them. They are function morphemes, and, as clitics, they are not phonologically independent units. With respect to the definite morpheme in particular, Chung (1983:50) observes that ''*i* gives no evidence of being a separate phonological word, despite the fact that it is traditionally written as such.'' It therefore seems safe to treat these particles as prefixes for present purposes. Thus, the source of spreading in umlaut is morphologically weak.

Pretonic syllables also show evidence of weakness in Chamorro. Stress clash is generally tolerated in the language: *mínèŋkanuʔ* 'abounding in food', *ǽdòmmuʔ* 'to punch one another', *kéʔùcan* 'to be about to rain'. But the syllable immediately before primary stress cannot bear stress. Illustrating this fact requires examining the language's prosodic and morphological systems.

Stress in Chamorro falls on the penult by default, though there are many lexical exceptions with stress in other positions. All suffixes, however, relocate primary stress to the penultimate syllable. When this happens, the primary stress in the unsuffixed form is preserved as secondary stress.[8]

(19) swéddu   'salary'   swèddunmámi   'our (EXCL) salary'
      inéŋnuluʔ   'peeping'   inèŋnulóʔna   'his peeping'
      mímantìka   'abounding in fat'   mìmantikána   'more abounding in fat'

Chung (1983) accounts for this with the cycle. On the first cycle, the bare stem receives primary stress (e.g., *swéddu*). On the next cycle, when the suffix is added, a new primary stress is placed on the penult, and old stresses are demoted (*swèddunmámi*). However, cyclic secondary stress fails to appear when it would immediately precede primary stress.

(20) swéddu   'salary'   sweddómmu   'your (SG) salary'
      nána   'mother'   nanáhu   'my mother'
      gúmaʔ   'house'   gumáʔmu   'my house'
      gúmaʔ   'house'   i gumáʔna   'his house'
      sáŋan   'to say'   saŋáni   'to say to'
      finalágu   'running'   finalagúna   'his running'
      bapót   'ship'   bàpotníha   'their ship'
      magágu   'clothes'   màgagúna   'his clothes'

It appears that Chamorro actively avoids prominence on (immediately) pretonic syllables. We might think of this as an effort to ensure that stressed syllables contrast as much as possible with surrounding (and specifically preceding) syllables. Rachel Walker (pers. comm.) suggests

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[8] Chamorro also has rhythmic secondary stress, which appears on alternating syllables to the left of primary stress. I ignore that complication for the moment but return to it below.

that destressing creates a sharp rise in intensity, and so on, at the onset of primary stress compared to the more gradual rise that a ὸσ́ sequence would entail. This makes the locus of primary stress more easily recoverable. In any case, it is clear that pretonic syllables represent a prominence trough in Chamorro.[9]

Weakening of both immediately and nonimmediately pretonic vowels is well attested cross-linguistically. In Irish, ''a short vowel immediately before the accented syllable may be elided'' (Ó Siadhail 1989:23). In Chi-Mwi:ni, syllables to the left of the phrasal antepenultimate syllable (or the penult if it is heavy) are shortened (Kenstowicz and Kisseberth 1977): *nuːmba* 'house' → *numbaːŋkʰuɬu* 'large house'. Selkirk's (1986) interpretation of this fact is that the antepenultimate syllable is stressed, and vowels to its left are reduced. (It should be noted, however, that Kisseberth and Abasheikh (1974) show that accent does not always fall on the syllable that must bear stress for the analysis to work.)

Similarly, Nevins and Vaux (2008), citing personal communication with José Olímpio Magalhães, characterize the optional raising of pretonic (immediate or not) vowels in Brazilian Portuguese as vowel reduction. One consequence of the optional nature of raising is that vowels farther away from the stressed syllable raise only if all the vowels closer to stress also raise. That is, reduction of the immediately pretonic vowel is a prerequisite for the reduction of other vowels, suggesting that the immediately pretonic syllable is especially weak.

Finally, various Italian dialects have reduction and harmony phenomena that specifically target vowels to the (not necessarily immediate) left of stress (Maiden 1995). For example, in some dialects, /o/ raises to *u* in just this position.

Chamorro umlaut, therefore, exhibits a ''worst of the worst'' effect (Padgett 2002, Smolensky 2006). While nonprominence is permitted in the language (we see prefixes and pretonic syllables, after all), positions at which these dimensions of weakness converge—pretonic prefixes—are subject to special conditions in that their [−back] features must seek special licensing. We can capture this with a new Positional Licensing constraint.

(21) LICENSE([−back]$_{pretonic}$, *Root*)
     [−back] in a pretonic syllable must be associated with the root.

This constraint addresses both dimensions of weakness in that it requires prosodically weak elements to be in a morphologically strong position. It is violated only by a [−back] feature that appears (exclusively) in a pretonic affix. If the [−back] feature is not pretonic, it is obviously not subject to the constraint. If it is not in an affix (i.e., if it is in a root), it automatically satisfies the constraint.

LICENSE([−back]$_{pretonic}$, Root) requires a fundamental shift in our view of umlaut. Stress now becomes the trigger for spreading, not the target. Whether or not umlaut is motivated depends on the position of stress, and the Licensing constraint requires association with the root, not the

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[9] An anonymous reviewer suggests that rather than revealing a weakness in pretonic syllables, (20) shows that Chamorro simply distinguishes secondary-primary clash from primary-secondary clash, banning the former. I do not think these interpretations are incompatible. My only aim here is to show that Chamorro actively targets pretonic syllables for weakening, whether through clash avoidance or some other mechanism.

stressed syllable. Of course, the stressed syllable ends up as the de facto target because it's the nearest root syllable in umlaut contexts, but this is merely a coincidence. From this perspective, umlaut is not an attraction-to-stress phenomenon like metaphony, although it still belongs in the broader category of attraction to prominence.

LICENSE([−back]$_{pretonic}$, Root) does not distinguish prefixes from suffixes, yet umlaut only occurs with prefixes. This may not be problematic in practice because a pretonic suffix syllable appears to be impossible in Chamorro. Since all suffixes create penultimate primary stress, a pretonic suffix syllable would have to occur in a word with either a trisyllabic suffix or a three-syllable sequence of suffixes. To my knowledge, no such configurations exist. It would also be simple to modify the constraint so that it requires pretonic [−back] features to be linked to a root-plus-suffix morphological unit, like the ''macrostem'' common to Bantu verbal morphology.

With LICENSE([−back]$_{pretonic}$, Root) in place, umlaut is now motivated in classic OT only when stress is root-initial. As (22) shows, umlaut is still produced in *i gíma?*.

(22)

/i gúma?/	LIC([−back]$_{pretonic}$, Root)	IDENT[+back]
a. i gúma?	*!	
☞ b. i gíma?		*
c. i gímæ?		**!

Complete faithfulness is ruled out by the Licensing constraint, and spreading to just the root-initial syllable is the least costly way of satisfying Licensing. Other constraints mentioned above, such as IDENT[−back], rule out alternative strategies like regressive spreading.

In contrast, umlaut is not produced when stress is not root-initial.

(23)

/i pulónnun/	LIC([−back]$_{pretonic}$, Root)	IDENT[+back]
☞ a. i pulónnun		
b. i pilónnun		*!
c. i pilénnun		*!*

This time, the fully faithful candidate does not violate LICENSE([−back]$_{pretonic}$, Root): the pretonic syllable is already part of the root, and the prefix syllable is not pretonic. Spreading in this case only introduces gratuitous violations of IDENT. With LICENSE([−back]$_{pretonic}$, Root), we have derived the appearance of the harmonic improvement and gradualness requirements without recourse to OT-CC. It appears that umlaut occurs only when each step in the spreading process improves the form's harmony, but this is due to the specific demands of LICENSE([−back]$_{pretonic}$, Root) rather than to OT-CC's harmonic improvement restriction.

As a final example, consider (24). Here, umlaut fails despite the presence of an immediately pretonic front vowel. As in (23), the reason is that the faithful form already satisfies LICENSE ([−back]$_{pretonic}$, Root), this time because the pretonic [−back] feature is already contained within the root. Thus, only prefixes are umlaut triggers.

(24)

/mìmantiká-ɲa/	LIC([−back]$_{pretonic}$, Root)	IDENT[+back]
☞ a. mìmantikáɲa		
b. mìmantikǽɲa		*!

Since we have produced umlaut in a theory that allows fell-swoop candidates, a straightforward account of metaphony is also available. LICENSE([+high]$_{posttonic}$, σ́) is still at our disposal, so Walker's (2005) analysis in classic OT remains viable. The effect of this constraint is shown in (17); though that tableau was intended to show part of an OT-CC evaluation, it serves equally well as a classic OT tableau.

Nothing stops us from importing LICENSE([−back]$_{pretonic}$, Root) into an OT-CC account of umlaut with relaxed gradualness. Such a move would allow OT-CC analyses of both umlaut and metaphony. The chain ⟨i pulónnun, i pilénnun⟩, which is permitted by relaxed gradualness, is not harmonically improving under the LICENSE([−back]$_{pretonic}$, Root) analysis, as an examination of (23) reveals. We can adopt Walker's (2008) analysis of Central Veneto with relaxed gradualness without putting the analysis of umlaut in peril.

At this point, though, the ''candidate chains'' part of the theory does no work. Umlaut is prevented in *i pulónnun* not by gradualness and harmonic improvement, but by the nature of the umlaut-inducing constraint. The seemingly inherent advantage OT-CC had over classic OT in an analysis of umlaut is gone: both now rely on the same formalism to restrict spreading. Moreover, the original impetus behind relaxed gradualness is the need to circumvent OT-CC's strict gradualness requirement to produce metaphony. The OT-CC analyses of umlaut and metaphony judiciously avoid the unique formal mechanisms that the theory provides. There is no reason to use OT-CC at all at this point: the restrictions central to OT-CC have become at best formal annoyances (under relaxed gradualness) and at worst analytical impediments (under strict gradualness).

Of course, this result has no bearing on the ability of OT-CC to account for derivational opacity, which was the original motivation for gradualness and harmonic improvement. Nonetheless, if these requirements constitute the correct approach to opacity, their effects should be visible and of use in other parts of the grammar. Instead, what we see in the case at hand is that the mechanisms of OT-CC must be weakened and avoided to such an extent that phenomena that seem to support OT-CC must receive treatments that do not invoke OT-CC's machinery after all. Umlaut is not alone in this regard: since relaxed gradualness is necessary to accommodate metaphony, failure to spread to a nonlocal target (as in nasal spreading in Vimeu Picard (José and Auger 2004, McCarthy 2006)) can never be attributed to gradualness and harmonic improvement, even though that is exactly the kind of spreading those constructs are designed to block. OT-CC still has an advantage over classic OT in the realm of opacity, but the current analysis suggests that OT-CC's particular approach to opacity may not be the best one in that its applicability to other domains of phonology is suspect.

A potential concern is the apparent complexity of LICENSE([−back]$_{pretonic}$, Root), which references both prosodic and morphological information. But this constraint uses only independently verifiable prominence asymmetries, and it conforms to the template for Positional Licensing

constraints established by work such as Walker 2005: it identifies the element subject to licensing ([−back]), the conditions under which it must be licensed (pretonicity), and the licenser (the root). Furthermore, LICENSE([−back]$_{\text{pretonic}}$, Root) need not be taken as an atomic constraint. It is possible to construct it from two prominence hierarchies, one stating that affixes are weaker than roots, and the other encoding the fact that pretonic syllables are the prosodically weakest positions in Chamorro (Kaplan 2008b,c). As the issue is tangential to the topic at hand, I will not discuss the details here.

Unlike the OT-CC analysis of umlaut, the classic OT analysis attributes umlaut's behavior entirely to independent cognitive, perceptual, and acoustic considerations. Thus, this section reinforces the conclusion of other research (e.g., Archangeli and Pulleyblank 1994, Flemming 2002, Hayes 2004, Kaplan 2010, Kirchner 1998, Ní Chiosáin and Padgett 1997, Padgett 2003, Pater 1999, Steriade 1994) that a phonetically informed theory is more satisfactory than one that relies solely on abstract formal machinery (e.g., Hale and Reiss 2000). The current investigation suggests that a phonetically informed theory not only provides insight into phenomena's motivations, but also offers better empirical coverage.

To summarize this section, while we saw above that OT-CC encounters difficulty accounting for both Chamorro's umlaut and Central Venetan metaphony under the assumption that both are attraction-to-stress phenomena, classic OT easily accounts for both processes once umlaut is correctly identified as an attraction-to-root phenomenon. The constraints derived from this overhaul are also available to OT-CC, but once they are adopted, the theoretical machinery specific to OT-CC no longer plays a role in the analysis. This leads to the undesirable conclusion that while OT-CC offers machinery with potential applicability to a range of phenomena, that apparatus's actual utility is apparently confined to opacity. Umlaut at first looked tailor-made for OT-CC, but achieving more comprehensive coverage requires eliminating the very properties that made the theory appealing in the first place.

5 Remaining Issues

The analysis of umlaut developed here covers only the central properties of the phenomenon.[10] Other aspects of umlaut are tangential to the point at hand but ultimately deserve closer scrutiny. For example, cyclic secondary stress optionally triggers umlaut:[11] *i gímaʔníha~i gùmaʔníha* 'their house' (from the root *gúmaʔ* 'house'). Interestingly, this holds also for vowels whose stress has been deleted because of the clash prohibition: *i cúpáɲa~i cipáɲa* 'his cigarettes' (from the root *cúpa* 'cigarettes'). But rhythmic secondary stress, which appears (roughly) on alternating syllables to the left of primary stress, does not permit umlaut: *i pùtamunéda* 'the wallet' (**i pìtamunéda*). Both Chung (1983) and Crosswhite (1996) appeal to transderivational relationships and capitalize on the fact that umlaut-triggering vowels without primary stress correspond to vowels in related output forms that do bear primary stress. Alternatively, within the framework employed above, we might adopt LICENSE([−back]$_{\text{pre-}\acute{\sigma}}$, Root) to motivate umlaut with secondary

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[10] I am grateful to an anonymous reviewer for raising many of the questions addressed in this section.

[11] This optionality is confined to the Saipan dialect, according to Chung (1983). Other dialects obligatorily exhibit umlaut here.

stress. Ranking this constraint variably (e.g., Anttila 1997) with respect to IDENT[−back] will produce the optionality of this sort of umlaut. Couched within a stratal OT analysis of the sort developed for Chamorro in Kaplan 2008b, LICENSE([−back]$_{\text{pre-}\acute{\sigma}}$, Root) can motivate umlaut after cyclic secondary stress is assigned but before clash resolution and rhythmic stress assignment.

Furthermore, some prefixes without front vowels trigger umlaut (*dónniʔ* 'hot pepper', *faʔ-dénniʔ* 'to make hot sauce'), and some prefixes with front vowels do not: *túngoʔ* 'to know', *kéʔ-tùngoʔ* 'try to know', *kéʔ-tíngoʔ (from Klein 2000:108; the root-initial cyclic secondary stress should permit umlaut here). Various approaches to each kind of prefix are possible. For example, *faʔ-* may come with a floating [−back] feature (Kaplan 2008b). As for *kéʔ-*type prefixes, a lexically indexed Alignment constraint (Pater 2007) can prevent spreading of their [−back] features. Alternatively, under the stratal approach taken in Kaplan 2008b, *kéʔ-* might be affixed after umlaut occurs (though this would require other modifications, as the analysis's only postumlaut level is postlexical). It is also tempting to capitalize on the fact that *kéʔ-* attracts primary stress and is thus not weak and needs no licensing. In fact, the other front-voweled prefix provided by Klein (2000) that does not trigger umlaut is *ǽ-* 'each other', also with primary stress. But Chung (1983) states that *mí-* 'abounding in' is an umlaut trigger, so primary stress is not a perfect predictor of trigger status. (Notice also that the Licensing analysis requires spreading for all pretonic prefixes, whether stressed or not.)

The analyses of umlaut and metaphony require different loci (pretonic and posttonic syllables, respectively) to be weak, and since the analyses require different Licensing constraints, they are not as unified as one might hope. Both phenomena are produced by Positional Licensing constraints, but it would be desirable to have a more developed theory of weakness. Ideally, the same LICENSE WEAK-F constraint would motivate both umlaut and metaphony, with the nature of the weak position, the licenser, and the feature that spreads being predictable from other properties of the languages. Clearly, the theory of Positional Licensing is not yet at this stage, and getting there may require information (such as phonetic details of each language's weak positions) that is not currently available.

Similarly, neither analysis has an explanation for the cooccurrence in each language of weakness in a particular position and a high-ranking Licensing constraint that targets that position. Such a coincidence would ideally follow from the LICENSE WEAK-F theory, but there is currently no formal indication that Central Veneto with Chamorro's Licensing constraint (or vice versa) would be at all unusual. (And perhaps it isn't unusual: presumably there are many loci of weakness in each language, but they are not all subject to Licensing requirements.)

6 Conclusion

OT-CC addresses several shortcomings of classic OT by reintroducing stepwise derivations. Supporting this framework requires identifying phenomena that need OT-CC's derivationally oriented constructs such as gradualness and harmonic improvement. Chamorro umlaut and Central Venetan metaphony present an interesting contrast in this regard. Umlaut seems to be just the sort of phenomenon OT-CC was designed for, while Central Veneto is incompatible with (the original version of) OT-CC, and modifying OT-CC to produce metaphony damages the simple account

of umlaut. In other words, taking a wider typological view reveals that OT-CC's simple account of umlaut does not rest on a sound footing.

I have argued in this article that umlaut is best understood not as an attraction-to-stress phenomenon, but as spreading to the root under the right stress conditions. Viewed in this way, the facts of umlaut no longer favor OT-CC: the lack of long-distance umlaut is a consequence not of gradual spreading's failure to obey harmonic improvement, but of the absence of the necessary umlaut-triggering conditions. License([−back]$_{pretonic}$, Root), which is a functionally grounded member of the well-motivated family of Positional Licensing constraints, produces a pattern that appears to reflect OT-CC's derivational restrictions without actually imposing that theory's machinery. Harmonic improvement and gradualness are epiphenomena.

OT-CC's principal aim is to achieve an understanding of derivational opacity in a parallel framework. The present study does not address this issue at all, and in light of classic OT's well-documented problems with derivational opacity, OT-CC may ultimately prove the preferable theory. The argument, then, is not that derivational restrictions are unnecessary in phonological theory, but that OT-CC's particular implementation of such constructs is deficient in an important respect. In this sense, the current investigation is less about classic OT versus OT-CC than it is about the kinds of restrictions theoretical frameworks can fruitfully impose upon operations; classic OT and OT-CC simply represent extreme positions on this issue. Since classic OT can generate the appearance of gradualness and harmonic improvement, OT-CC's advantages may not be as great as an initial comparison suggests. While derivational opacity seems to require greater power to regulate operations, umlaut and metaphony point toward less power. If derivation-like properties are necessary to account for opacity—whether or not it involves OT(-CC) specifically—they must be designed in a way that is compatible with both long-distance and strictly local feature spreading.

Nor do I mean to suggest that OT-CC cannot account for umlaut and metaphony simultaneously—it can, as noted above. But doing so requires diluting OT-CC's unique properties and invoking additional machinery that does the work that those unique properties were intended to do. This is surely not a desirable state of affairs. Descriptive adequacy is only one desideratum, and the fact that OT-CC can account for umlaut and metaphony does not mean that those accounts are satisfactory.

References

Anttila, Arto. 1997. Deriving variation from grammar. In *Variation, change and phonological theory*, ed. by Frans Hinskens, Roeland van Hout, and W. Leo Wetzels, 35–68. Philadelphia: John Benjamins.

Archangeli, Diana, and Douglas Pulleyblank. 1994. *Grounded Phonology*. Cambridge, MA: MIT Press.

Beckman, Jill N. 1999. *Positional Faithfulness*. New York: Garland.

Chung, Sandra. 1983. Transderivational relationships in Chamorro phonology. *Language* 59:35–66.

Conant, Carlos Everett. 1911. Consonant changes and vowel harmony in Chamorro. *Anthropos* 6:136–146.

Crosswhite, Katherine. 1996. Base-derivative correspondences in Chamorro. In *UCLA working papers in phonology 93*, ed. by Chai-Shune Hsu, 57–85. Los Angeles: UCLA Graduate Linguistics Circle.

Eisner, Jason. 1997. What constraints should OT allow? Handout from paper presented at the annual meeting of the Linguistic Society of America, Chicago, 4 January. Rutgers Optimality Archive 204. Available at http://roa.rutgers.edu.

Flemming, Edward S. 1994. The role of metrical structure in segmental rules. In *NELS 24*, ed. by Mercè
    Gonzàlez, 97–110. Amherst: University of Massachusetts, Graduate Linguistic Student Association.
Flemming, Edward S. 2002. *Auditory representations in phonology*. New York: Routledge.
Hale, Mark, and Charles Reiss. 2000. ''Substance abuse'' and ''dysfunctionalism'': Current trends in phonol-
    ogy. *Linguistic Inquiry* 31:157–169.
Hayes, Bruce. 2004. Phonetically driven phonology: The role of Optimality Theory and inductive grounding.
    In *Optimality Theory in phonology*, ed. by John J. McCarthy, 290–309. Malden, MA: Blackwell.
Itô, Junko. 1988. *Syllable theory in prosodic phonology*. New York: Garland.
José, Brian, and Julie Auger. 2004. (Final) nasalization as an alternative to (final) devoicing: The case of
    Vimeu Picard. In *Indiana University Linguistics Club working papers online, vol. 4*, ed. by Brian
    José and Ken de Jong. Available at http://www.indiana.edu/~iulcwp.
Kaplan, Aaron. 2008a. Licensing and noniterative harmony in Lango. In *NELS 37*, ed. by Emily Elfner and
    Martin Walkow, 1:311–322. Amherst: University of Massachusetts, Graduate Linguistic Student
    Association.
Kaplan, Aaron. 2008b. Noniterativity is an emergent property of grammar. Doctoral dissertation, University
    of California, Santa Cruz.
Kaplan, Aaron. 2008c. Stress is the trigger of Chamorro umlaut. In *Proceedings of the 2007 Mid-America
    Linguistics Conference*, ed. by Emily Tummons and Stephanie Lux, 135–149. Kansas Working
    Papers in Linguistics 30. Available at https://kuscholarworks.ku.edu/dspace/handle/1808/276.
Kaplan, Abby. 2010. Phonology shaped by phonetics: The case of intervocalic lenition. Doctoral dissertation,
    University of California, Santa Cruz.
Kenstowicz, Michael, and Charles Kisseberth. 1977. *Topics in phonological theory*. New York: Academic
    Press.
Kirchner, Robert. 1998. An effort-based approach to consonant lenition. Doctoral dissertation, UCLA, Los
    Angeles, CA. Available at http://roa.rutgers.edu.
Kisseberth, Charles W., and Mohammad Imam Abasheikh. 1974. Vowel length in Chi-Mwi:ni—a case
    study of the role of grammar in phonology. In *Papers from the Parasession on Natural Phonology*,
    ed. by Anthony Bruck, Robert Allen Fox, and Michael W. La Galy, 193–209. Chicago: University
    of Chicago, Chicago Linguistic Society.
Klein, Thomas B. 2000. *''Umlaut'' in Optimality Theory: A comparative analysis of German and Chamorro*.
    Tübingen: Niemeyer.
Lombardi, Linda. 1994. *Laryngeal features and laryngeal neutralization*. New York: Garland.
Maiden, Martin. 1995. Evidence from the Italian dialects for the internal structure of prosodic domains. In
    Linguistic theory in the Romance languages, ed. by John Charles Smith and Martin Maiden, 115–131.
    Amsterdam: John Benjamins.
McCarthy, John. 2003. OT constraints are categorical. *Phonology* 20:75–138.
McCarthy, John. 2006. Restraint of analysis. In *Wondering at the natural fecundity of things: Essays in
    honor of Alan Prince*, ed. by Eric Bakovic, Junko Ito, and John McCarthy, 213–239. Santa Cruz:
    University of California, Linguistics Research Center.
McCarthy, John. 2007a. Slouching toward optimality: Coda reduction in OT-CC. *Phonological Studies
    (Journal of the Phonological Society of Japan)* 7:89–104.
McCarthy, John. 2007b. *Hidden generalizations: Phonological opacity in Optimality Theory*. London:
    Equinox.
McCarthy, John, and Alan Prince. 1993. Generalized Alignment. In *Yearbook of morphology*, ed. by Geert
    Booij and Jaap van Marle, 79–153. Dordrecht: Kluwer.
McCarthy, John, and Alan Prince. 1995. Faithfulness and reduplicative identity. In *University of Massachu-
    setts occasional papers in linguistics 18: Papers in Optimality Theory*, ed. by Jill Beckman, Laura
    Walsh Dickey, and Suzanne Urbanczyk, 149–348. Amherst: University of Massachusetts, Graduate
    Linguistic Student Association.

Nevins, Andrew, and Bert Vaux. 2008. Introduction: The division of labor between rules, representations, and constraints in phonological theory. In *Rules, constraints, and phonological phenomena*, ed. by Bert Vaux and Andrew Nevins, 1–19. Oxford: Oxford University Press.

Ní Chiosáin, Máire, and Jaye Padgett. 1997. Markedness, segment realisation, and locality in spreading. Technical Report LRC-97-01, Linguistics Research Center, University of California, Santa Cruz.

Ó Siadhail, Mícheál. 1989. *Modern Irish: Grammatical structure and dialectal variation*. New York: Cambridge University Press.

Padgett, Jaye. 2002. Constraint conjunction versus grounded constraint subhierarchies in Optimality Theory. Ms., University of California, Santa Cruz.

Padgett, Jaye. 2003. Contrast and post-velar fronting in Russian. *Natural Language and Linguistic Theory* 21:39–87.

Pater, Joe. 1999. Austronesian nasal substitution and other NC effects. In *The prosody-morphology interface*, ed. by René Kager, Harry van der Hulst, and Wim Zonneveld, 310–343. Cambridge: Cambridge University Press.

Pater, Joe. 2007. The locus of exceptionality: Morpheme-specific phonology as constraint indexation. In *University of Massachusetts occasional papers in linguistics 32: Papers in Optimality Theory III*, ed. by Leah Bateman, Michael O'Keefe, Ehren Reilly, and Adam Werle, 259–296. Amherst: University of Massachusetts, Graduate Linguistic Student Association.

Potts, Christopher, and Geoffrey K. Pullum. 2003. Model theory and the content of OT constraints. *Phonology* 19:361–393.

von Preissig, Edward Ritter. 1918. *Dictionary and grammar of the Chamorro language of the island of Guam*. Washington, DC: Government Printing Office.

Prince, Alan, and Paul Smolensky. 1993/2004. Optimality Theory: Constraint interaction in generative grammar. Ms., Rutgers University, New Brunswick, and University of Colorado, Boulder. Published, Malden, MA: Blackwell (2004).

Selkirk, Elisabeth. 1986. On derived domains in sentence phonology. *Phonology* 3:371–405.

Smolensky, Paul. 2006. Optimality in phonology II: Harmonic completeness, local constraint conjunction, and feature domain markedness. In *The harmonic mind: From neural computation to optimality-theoretic grammar*, ed. by Paul Smolensky and Géraldine Legendre, 2:27–160. Cambridge, MA: MIT Press.

Steriade, Donca. 1994. Licensing by cue. Ms., UCLA, Los Angeles, CA.

Steriade, Donca. 1995. Underspecification and markedness. In *Handbook of phonological theory*, ed. by John Goldsmith, 114–174. Oxford: Blackwell.

Topping, Donald M. 1968. Chamorro vowel harmony. *Oceanic Linguistics* 7:67–79.

Topping, Donald M. 1969. *Spoken Chamorro: An intensive language course with grammatical notes and glossary*. Honolulu: University of Hawaii Press.

Topping, Donald M. 1973. *Chamorro reference grammar*. Honolulu: University of Hawaii Press.

Topping, Donald M., Pedro M. Ogo, and Bernadita C. Dungca. 1975. *Chamorro-English dictionary*. Honolulu: University of Hawaii Press.

Urbanczyk, Suzanne. 2006. Reduplicative form and the root-affix asymmetry. *Natural Language and Linguistic Theory* 24:179–240.

Walker, Rachel. 2001. Positional markedness in vowel harmony. In *Proceedings of HILP 5*, ed. by Caroline Féry, Antony Dubach Green, and Ruben van de Vijver, 212–232. Linguistics in Potsdam 12. Potsdam: University of Potsdam, Institute of Linguistics.

Walker, Rachel. 2005. Weak triggers in vowel harmony. *Natural Language and Linguistic Theory* 23:917–989.

Walker, Rachel. 2008. Gradualness and fell-swoop derivations. Handout from talk presented at the University of California, Santa Cruz, Alumni Conference, 13 September.

Walker, Rachel. 2010. Nonmyopic harmony and the nature of derivations. *Linguistic Inquiry* 41:169–179.

Zoll, Cheryl. 1998a. *Parsing below the segment in a constraint-based framework.* Stanford, CA: CSLI
    Publications.
Zoll, Cheryl. 1998b. Positional asymmetries and licensing. Ms., MIT, Cambridge, MA. Rutgers Optimality
    Archive ROA-282. Available at http://roa.rutgers.edu.

Department of Linguistics
Languages and Communication Building
255 South Central Campus Drive, Room 2300
University of Utah
Salt Lake City, UT 84112

aaron.kaplan@utah.edu