

Scalar Positional Markedness and Faithfulness in Harmonic Grammar

Brian Hsu and Karen Jesney
University of Southern California

1 Introduction

Across languages, elements at the edges of prosodic domains are often subject to different phonotactic restrictions than non-edge elements. Flack (2009) identifies two types of pattern. In ‘superset-at-edge’ patterns, a marked structure is permitted at prosodic boundaries of strength x or greater, but is banned elsewhere. In ‘subset-at-edge’ patterns, a marked structure is banned at prosodic boundaries of strength x or greater, but is permitted elsewhere.

Capturing these patterns with the ranked constraints of Optimality Theory (OT; Prince & Smolensky 1993/2004) presents certain challenges. Scalar constraints – like HNUC – cannot capture implicational patterns of repair vs. non-repair in OT, predicting instead that a marked structure will be either categorically allowed or categorically disallowed at all types of prosodic boundaries. Positional constraints indexed to prosodic boundaries allow implicational patterns to be modeled (see *esp.* Flack 2009), but also predict the existence of non-implicational or ‘level-skipping’ patterns.

This paper argues that if constraints are weighted as in Harmonic Grammar (HG; Legendre, Miyata & Smolensky 1990, Smolensky & Legendre 2006), scalar constraints can be successfully applied to this problem. Weighted scalar constraints allow patterns of repair vs. non-repair to be captured, and ensure that an appropriately restrictive typology is generated. This approach thus admits analytical solutions that are not possible given ranked constraints. We follow other HG literature in suggesting that weighted constraints offer new insight into the factors responsible for phonological patterning (see, e.g., Bane & Riggle 2009, Farris-Trimble 2008, Hayes & Wilson 2008, Jesney 2014, to appear, Kimper 2011, Pater 2012, to appear, Potts *et al.* 2010).

The rest of this paper is structured as follows. Section 2 presents data illustrating superset-at-edge and subset-at-edge patterns and previous analyses of these asymmetries using indexed positional constraints in OT. Section 3 clarifies the overgeneration problem inherent to indexed constraints, showing that unattested ‘level-skipping’ patterns are predicted by their interaction. Section 4 presents our proposal for scalar constraints in Harmonic Grammar, and demonstrates how it applies to the cases discussed in §2. Section 5 further compares the OT vs. HG typologies, arguing that only HG with scalar constraints is appropriately restrictive. Section 6 concludes.

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2 Edge-based asymmetries in Optimality Theory

In ‘superset-at-edge’ patterns, greater markedness is permitted at domain boundaries than in domain-medial positions. Axininca Campa (Payne 1981, McCarthy & Prince 1993) provides an example. As the data in (1) shows, in Axininca Campa onsetless syllables are tolerated word-initially, but onsets are required for word-medial syllables. Potential cases of word-medial onsetlessness are repaired through consonant epenthesis.

- (1) Axininca Campa – Onsetless syllables are tolerated in PWd-initial position only (Payne 1981: 108)
- /i-n-koma-i/ → _{PWd}[iŋ.ko.ma.ti] 'he will paddle'
 /i-n-koma-aa-i/ → _{PWd}[iŋ.ko.ma.taa.ti] 'he will paddle again'

Superset-at-edge patterns are commonly analyzed in OT using constraints that disfavor repair in prominent positions like word edges. Positional Faithfulness constraints (Beckman 1998, Casali 1996) relativized to positions of prominence provide a straightforward account. For the case at hand, we can define multiple versions of DEP (McCarthy & Prince 1995), each indexed to apply only when the epenthetic segment is initial within a particular prosodic constituent.

- (2) a. _σ[DEP-INIT – Assign a violation mark to any output segment in initial position of a syllable that lacks an input correspondent.
 b. _{PWd}[DEP-INIT – Assign a violation mark to any output segment in initial position of a prosodic word that lacks an input correspondent.

Superset-at-edge patterns rely on rankings like that in (3). Onset epenthesis is prevented at word boundaries by the ranking _{PWd}[DEP-INIT >> ONSET], while potential word-medial onsetless syllables are repaired by epenthesis due to the ranking ONSET >> _σ[DEP-INIT.

- (3) Only PWd-initial syllables can be onsetless – OT with indexed constraints

/i-N-koma-i/	_{PWd} [DEP-INIT	ONSET	_σ [DEP-INIT
_{PWd} [iŋ.ko.ma.i]		**!	
 _{PWd} [iŋ.ko.ma.ti]		*	*
_{PWd} [tiŋ.ko.ma.i]	*!	*	*
_{PWd} [tiŋ.ko.ma.ti]	*!		**

‘Subset-at-edge’ patterns are essentially the converse of superset-at-edge patterns. In subset-at-edge patterns fewer marked structures are permitted at more prominent boundaries. Guhang Ifugao (Newell 1956, Smith 2002), for instance, tolerates onsetless syllables word-medially but requires onsets in word-initial syllables.

- (4) Guhang Ifugao – Onsetless syllables are tolerated in PWd-medial position only (Newell 1956: 535-538)

a.	[bú.ʉŋ]	‘an Ifugao necklace’	b.	*[u.hup]
	[ma.ŋá.an]	‘remove’		*[iŋ.ŋi]
	[ha.í.tan]	‘whetstone’		*[ad.da.ya]

This type of pattern can be captured in OT by using Positional Markedness constraints (Smith 2002, Flack 2009) that disfavor marked structures at prominent edges. For Guhang Ifugao, the traditional ONSET constraint is given multiple instantiations, each indexed to a distinct prosodic category.

- (5) a. $*_{\sigma}[V]$ – Assign a violation mark to any vowel in initial position of a syllable.
 b. $*_{PWd}[V]$ – Assign a violation mark to any vowel in initial position of a prosodic word.

Given these constraints, the subset-at-edge pattern is generated by the ranking in (6). Onsetless syllables at the PWd edge are repaired by epenthesis due to $*_{PWd}[V] \gg DEP$, while epenthesis into word-medial syllables is prevented by $DEP \gg *_{\sigma}[V]$.

- (6) Only word-initial syllables require onsets – OT with indexed constraints

/a.í.tan/	$*_{PWd}[V]$	DEP	$*_{\sigma}[V]$
$_{PWd}[a.í.tan]$	*!		**
$_{PWd}[a.hí.tan]$	*!	*	*
$_{PWd}[ha.í.tan]$		*	*
$_{PWd}[ha.hí.tan]$		**!	

As discussed in detail by Flack (2009), superset-at-edge and subset-at-edge patterns can also reference higher-level prosodic boundaries. Beyond the PWd boundary effects seen in the examples above, comparable phonotactic restrictions are seen at phrase and utterance edges. For instance, Leti (Hume 1998) permits syllable-final and PWd-final codas, but bans codas in PPh-final position. Phrase-final codas are repaired through metathesis with a preceding vowel.

- (7) Leti – Codas are allowed at the syllable and PWd level, but are repaired in PPh-final position (Hume 1998: 163)

/...urun/	→ [...ur <u>nu</u>] _{PPh}	'beautiful'
/...urun mɔa/	→ [...urun mɔa] _{PPh}	'Moanese breadfruit'
/...mɛsar/	→ [...mɛs <u>r</u> a] _{PPh}	'teacher'
/...mɛsar lavna/	→ [...mɛsar lavna] _{PPh}	'teacher, big'

Selayarese (Mithun & Basri 1986) allows onsetless syllables everywhere except at the beginning of an utterance; underlying onsetless syllables in utterance-initial position undergo glottal stop epenthesis.

- (8) Selayarese – Onsetless syllables are permitted except at Utterance boundaries (Mithun & Basri 1986: 242)

Ut _t [ʔa:pa]	'what?'
Ut _t [ʔinnĩ]	'this'
Ut _t [ʔa:pa innĩ] *Ut _t [ʔa:pa ʔinnĩ]	'what is this?'

This type of variation in the ‘cutoffs’ to which positional repairs are sensitive argues for the indexation of positional constraints to not just the syllable and PWd levels, but to (at least) the PPh and Utterance levels as well (Flack 2009). Accounting for the full range of asymmetries in parallel OT therefore requires a proliferation of indexed constraints that both favor and disfavor the preservation of marked structures at prosodic edges.

3 The overgeneration problem in Optimality Theory

Although indexed positional constraints in OT can successfully generate attested edge-based asymmetries, they also overgenerate, predicting a variety of unattested patterns. The attested patterns described above all observe implicational cutoffs. If a marked structure is permitted at level x but disallowed at level $x + 1$, it will also be disallowed at level $x + 2$, etc. Likewise, if a marked structure is disallowed at level y but permitted at level $y + 1$, it will also be permitted at level $y + 2$. In other words, all of the attested patterns have the basic shape in (9), where the syllable, PWd and PPh levels can be replaced by any set of hierarchically-related prosodic categories.

- (9) Attested hierarchy-respecting patterns – subset- and superset-at-edge
- | | | | |
|----|---------------------------------|----|-------------------------------------|
| a. | PPh ...initial V not allowed | b. | PPh ...initial V allowed |
| | | | |
| | PWd ...initial V not allowed | | PWd ...initial V allowed |
| | | | |
| | σ ...initial V allowed | | σ ...initial V not allowed |

The interaction of indexed positional constraints also predicts the existence of unattested non-implicational, ‘level-skipping’ patterns, however. In such hypothetical patterns a marked element is permitted at one level of prosodic structure even as the same element is prohibited at both higher and lower levels (or vice versa). Two examples are shown in (10).

(10) Unattested level-skipping patterns

<p>a. PPh ...initial <i>V</i> not allowed</p> <p style="margin-left: 40px;"> </p> <p style="margin-left: 40px;">PWd ...initial <i>V</i> allowed</p> <p style="margin-left: 40px;"> </p> <p style="margin-left: 40px;">σ ...initial <i>V</i> not allowed</p>	<p>b. PPh ...initial <i>V</i> allowed</p> <p style="margin-left: 40px;"> </p> <p style="margin-left: 40px;">PWd ...initial <i>V</i> not allowed</p> <p style="margin-left: 40px;"> </p> <p style="margin-left: 40px;">σ ...initial <i>V</i> allowed</p>
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In (10a), onsets are required for all PWd-medial syllables – i.e., syllables in the least prominent position. PWd-initial syllables, for their part, can be onsetless if they are in PPh-medial position (a more prominent position), but must have onsets if they are PPh-initial (the most prominent position). The ban on onsetless syllables effectively ‘skips’ a level, and is not enforced when the relevant syllable is in PPh-medial, PWd-initial position.

In OT this type of pattern is predicted by the constraint ranking illustrated in (11). Here, the two constraints indexed to the PPh level dominate the two constraints indexed to the PWd level, which in turn dominate the two constraints indexed to the syllable level. Crucially, however, the relative ranking of Markedness and Faithfulness differs across levels. While Markedness is ranked above Faithfulness for the constraints indexed to the PPh and syllable, Faithfulness is ranked above Markedness for the constraints indexed to the PWd. The result is a pattern where onsetless syllables are only allowed in PWd-initial position, and then only when that PWd is not initial in a PPh.

(11) a. PPh-initial and PWd-medial syllables must have onsets

/VV/	* _{PPh} [V]	PPh[DEP -INIT]	PWd[DEP -INIT]	* _{PWd} [V]	* _σ [V]	σ[DEP -INIT]
PPh[PWd[V.V]]	*!			*	**	
PPh[PWd[V.CV]]	*!			*	*	*
PPh[PWd[CV.V]]		*	*		*!	*
☞ PPh[PWd[CV.CV]]		*	*			**

b. PPh-medial, PWd-initial syllables can be onsetless

/...VCV/	* _{PPh} [V]	PPh[DEP -INIT]	PWd[DEP -INIT]	* _{PWd} [V]	* _σ [V]	σ[DEP -INIT]
PPh[...PWd[V.V]]				*	**!	
☞ PPh[...PWd[V.CV]]				*	*	
PPh[...PWd[CV.V]]			*!		*	*
PPh[...PWd[CV.CV]]			*!			*

The unattested language in (10b) is a mirror image of the previous case. Here, PWd-medial syllables, the least privileged category, can be onsetless, but PWd-initial syllables, must have onsets unless they are also PPh-initial. This emerges from the constraint

ranking in (12). As in the previous example, the constraints corresponding to higher prosodic boundaries outrank those corresponding to lower ones. However, the relative rankings between the Markedness and Faithfulness constraints indexed to each prosodic level are reversed – $F \gg M$ holds for the constraints indexed to PPh and syllable edges, and $M \gg F$ holds for the constraints indexed to PWd edges.

(12) a. Phrase-initial and PWd-medial syllables can be onsetless

/VV/	PPh[DEP -INIT	* _{PPh} [V	* _{PWd} [V	PWd[DEP -INIT	σ[DEP -INIT	* _σ [V
☞ PPh[PWd[V.V]		*	*			**
PPh[PWd[V.CV]		*	*		*!	*
PPh[PWd[CV.V]	*!			*	*	*
PPh[PWd[CV.CV]	*!			*	**	

b. Phrase-medial, PWd-initial syllables must have onsets

/...VCV/	PPh[DEP -INIT	* _{PPh} [V	* _{PWd} [V	PWd[DEP -INIT	σ[DEP -INIT	* _σ [V
PPh[...PWd[V.V]			*!			**
PPh[...PWd[V.CV]			*!			*
PPh[...PWd[CV.V]				*	*	*!
☞ PPh[...PWd[CV.CV]				*	*	

This overgeneration problem cannot be straightforwardly resolved by positing a fixed ranking or by adopting stringently-related constraints (de Lacy 2002). The languages in (11) and (12) are both consistent with the fixed rankings in (13), where the constraints indexed to higher prosodic categories are strictly ranked above the constraints indexed to lower prosodic categories.

(13) a. $\text{Utterance[DEP-INIT} \gg \text{PPh[DEP-INIT} \gg \text{PWd[DEP-INIT} \gg \text{σ[DEP-INIT}$
 b. $*_{\text{Utterance}}[\text{V} \gg *_{\text{PPh}}[\text{V} \gg *_{\text{PWd}}[\text{V} \gg *_{\text{σ}}[\text{V}$

Stringently-related constraints like those in (14) fare no better. These constraints replicate the effects of the fixed rankings in (13), and inherit the same level-skipping problem.

(14) a. $\geq_{\text{Utterance}}[\text{DEP-INIT}, \geq_{\text{PPh}}[\text{DEP-INIT}, \geq_{\text{PWd}}[\text{DEP-INIT}, \geq_{\text{σ}}[\text{DEP-INIT}$
 b. $*_{\geq_{\text{Utterance}}}[\text{V}, *_{\geq_{\text{PPh}}}[\text{V}, *_{\geq_{\text{PWd}}}[\text{V}, *_{\geq_{\text{σ}}}[\text{V}$

Barring the patterns in (11) and (12) could be achieved by imposing fixed rankings *between* the indexed markedness and faithfulness constraint scales, but this would limit the ability of the grammar to generate the attested contrasts between subset-at-edge and superset-at-edge patterns. Ultimately, then, level-skipping patterns can only be avoided in

parallel OT by imposing a ranking metacondition such that, across the entire set of constraints indexed to positions along some scale, there is at most one reversal in the relative ranking of Faithfulness and Markedness constraints – a condition at odds with the general tenets of Optimality Theory (*cf.* Itô & Mester 1999).

4 Scaling constraints in Harmonic Grammar

This section proposes a Harmonic Grammar account that captures the attested subset-at-edge and superset-at-edge patterns without encountering the overgeneration issues found in OT. In Harmonic Grammar constraints are weighted rather than ranked. As a result, all constraints have the ability to influence which candidate is selected as optimal, regardless of their “basic” strength within the grammar. Even without altering the constraint set, this opens the door to somewhat different analyses than are possible in OT.

The Axininca Campa example from (1) provides an illustration. In this language onsetless syllables are tolerated word-initially, but onsets are required for word-medial syllables. The OT analysis of this data requires that the version of DEP-INITIAL indexed to the PWD dominate ONSET, which in turn dominates the version of DEP-INITIAL indexed to the syllable (3). In HG, however, it is the weighting conditions in (15) that must hold.

- (15) Axininca Campa – HG weighting conditions with indexed constraints
 $w(\text{ONSET}) > w_{\sigma}[\text{DEP-INIT}]$
 $w_{\sigma}[\text{DEP-INIT}] + w_{\text{pWd}}[\text{DEP-INIT}] > w(\text{ONSET})$

The independent weight of $\text{pWd}[\text{DEP-INIT}]$ need not be greater than that of ONSET in HG, but the *summed* weight of $\text{pWd}[\text{DEP-INIT}]$ and $\sigma[\text{DEP-INIT}]$ must be. The weights given in (16) fulfill this requirement, but any weights consistent with the conditions in (15) would derive this pattern. (For an introduction to weighting conditions in HG, see Pater 2009.)

- (16) Only PWD-initial syllables can be onsetless – HG with indexed constraints

/i-N-koma-i/	ONSET $w = 3$	$\text{pWd}[\text{DEP-INIT}]$ $w = 2$	$\sigma[\text{DEP-INIT}]$ $w = 2$	<i>H</i>
$\text{pWd}[\text{ij.ko.ma.i}]$	-2			-6
$\text{pWd}[\text{ij.ko.ma.ti}]$	-1		-1	-5
$\text{pWd}[\text{tij.ko.ma.i}]$	-1	-1	-1	-7
$\text{pWd}[\text{tij.ko.ma.ti}]$		-1	-2	-6

As in OT, indexed constraints in HG overgenerate, wrongly predicting the existence of level-skipping patterns. The weighted constraints of HG offer an alternative, however. Specifically, we argue that there are no distinct indexed positional constraints in HG; instead, constraint violations are scaled according to the prominence of the prosodic boundary at which they occur. The definition of scalar $\text{D}[\text{DEP-INITIAL}]$ proposed here is given in (17). For previous uses of scalar constraints to capture other types of patterns in

Harmonic Grammar, see Coetzee & Kawahara (2013), MacPherson & Hayes (2015), Jesney (2014), Kimper (2011), Pater (2012, to appear).

- (17) Definition: Scalar $_D$ [DEP-INITIAL
 Given a basic constraint weight w ,
 a scale $D = \{0, 1, \dots, n\}$ corresponding to some dimension of prominence,
 and a scaling factor s ,
 For any output segment in the initial position of some domain $d \in D$ that lacks
 an input correspondent,
 Assign a weighted violation score of $w + s(d)$

For the analysis of Axininca Campa, we can consider the prominence scale to be {Syllable, PWd, PPh, Utterance}, and assign $_D$ [DEP-INIT a weight of $w = 2$ and a scaling factor of $s = 2$. With these values, epenthesis at a syllable boundary will incur a scaled weighted violation score of $w + s(\text{Syllable}) = 2 + 2(0) = 2$, while epenthesis at a PWd boundary will incur a scaled weighted violation score of $w + s(\text{PWd}) = 2 + 2(1) = 4$. The tableau below shows the interaction of this constraint with ONSET. The second candidate, which violates ONSET once and $_D$ [DEP-INIT once at the syllable level is selected as optimal; it has a higher Harmony score than candidates that incur more violations of ONSET or incur violations of $_D$ [DEP-INIT at the PWd level.

- (18) Only PWd-initial syllables can be onsetless – HG with scalar constraints

/i-N-koma-i/	ONSET $w = 3$	$_D$ [DEP-INIT $w = 2, s = 2$	H
${}_{PWd}$ [iŋ.ko.ma.i]	-2		-6
${}_{\sigma} {}_{PWd}$ [iŋ.ko.ma.ti]	-1	-1_{σ}	-5
${}_{PWd}$ [tiŋ.ko.ma.i]	-1	-1_{PWd}	-7
${}_{PWd}$ [tiŋ.ko.ma.ti]		$-1_{\sigma}, -1_{PWd}$	-6

The weighting conditions required to generate superset-at-edge patterns like that seen in Axininca Campa are straightforward. The basic weight of the Markedness constraints (ONSET in 18) must be greater than the basic weight of the conflicting Faithfulness constraint ($_D$ [DEP-INITIAL in 18). Additionally, the scaling factor associated with the Faithfulness constraint must be sufficient to allow the value of $w + s(d)$ for the Faithfulness constraint to exceed the weight of the conflicting Markedness constraint at some point in the prosodic hierarchy.

Figure 1 illustrates these conditions graphically for a range of Markedness weights. In each case, the solid line plots the penalty associated with the scaled Faithfulness constraint, and the dashed line plots the penalty associated with the conflicting Markedness constraint. When the Faithfulness penalty is greater than the Markedness penalty, the marked structure is admitted. In Figure 1A, this condition holds at all levels,

and so the marked structure is permitted at all prosodic edges. Figure 1B represents the Axininca Campa case, where the marked structure is permitted at the PWd level and higher. Figure 1C represents the case where the marked structure is permitted at the PPh level and above, and Figure 1D represents the case where the marked structure is admitted only in Utterance-initial position.

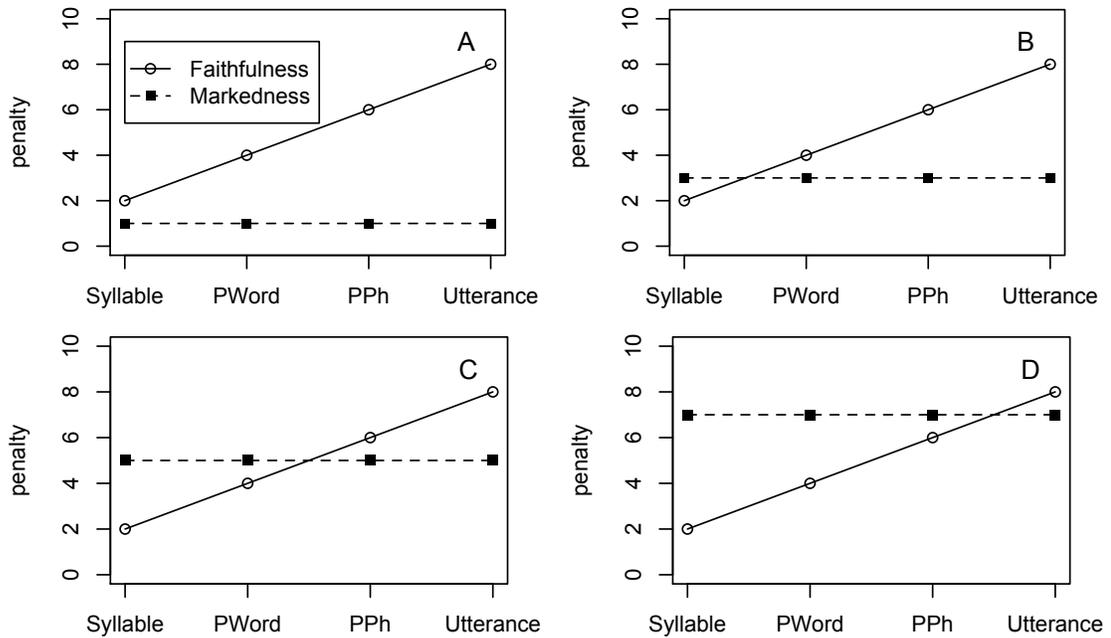


Figure 1: Patterns generated with scaled Faithfulness. In each case, the basic weight of Faithfulness is $w = 2$ and its scaling factor is $s = 2$. In A, the basic weight of Markedness is $w = 1$, in B it is $w = 3$, in C it is $w = 5$, and in D it is $w = 7$.

Subset-at-edge patterns, where fewer marked structures are permitted at more prominent boundaries, can be analyzed by scaling Markedness constraints. In the case of Guhang Ifugao (see 4), onsetless syllables are tolerated word-medially but not in word-initial positions. The relevant Markedness constraint is $*_D[V$, as defined in (19).

- (19) Definition: Scalar $*_D[V$
 Given a basic constraint weight w ,
 a scale $D = \{0, 1, \dots, n\}$ corresponding to some dimension of prominence,
 and a scaling factor s ,
 For any vowel in initial position of a domain $d \in D$,
 Assign a weighted violation score of $w + s(d)$

The prominence scale is again $\{\text{Syllable, PWord, PPh, Utterance}\}$; $*_D[V$ has a weight of $w = 2$ and a scaling factor of $s = 2$. With these values, PWord-medial onsetless syllables incur

a violation score of $w + s(\text{Syllable}) = 2 + 2(0) = 2$, and PWd-initial onsetless syllables incur a violation score of $w + s(\text{PWd}) = 2 + 2(1) = 4$. The tableau below shows the interaction of this constraint with DEP, here given the simple weight of 3.

(20) Only word-initial syllables require onsets – HG with scalar constraints

/a.i.tan/	DEP $w = 3$	* _D [V] $w = 2, s = 2$	<i>H</i>
{PWd} [a.i.tan]		$-1{\sigma}, -1_{\text{PWd}}$	-6
{PWd} [a.hi.tan]	-1	-1{PWd}	-7
{PWd} [ha.i.tan]	-1	-1{σ}	-5
_{PWd} [ha.hi.tan]	-2		-6

The weighting conditions for subset-at-edge patterns are essentially the opposite of those required for superset-at-edge patterns. For subset-at-edge patterns, the basic weight of the Faithfulness constraint must be greater than the basic weight of the conflicting Markedness constraint, and the scaling factor associated with the Markedness constraint must be sufficient to allow the scaled weighted Markedness penalty to overcome the Faithfulness penalty at some point in the prosodic hierarchy. Figure 2 illustrates these patterns graphically, with Figure 2B corresponding to the Guhang Ifugao case.

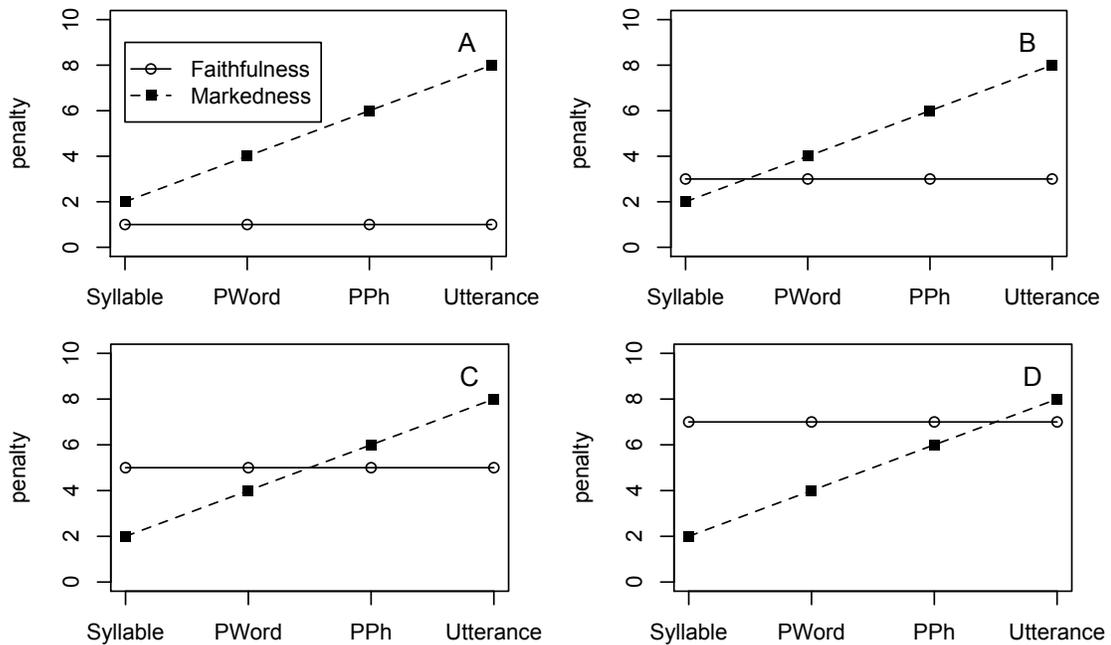


Figure 2: Patterns generated with scaled Markedness. In each case, the basic weight of Markedness is $w = 2$ and its scaling factor is $s = 2$. In A, the basic weight of Faithfulness is $w = 1$, in B it is $w = 3$, in C it is $w = 5$, and in D it is $w = 7$.

The logic remains the same if both Markedness and Faithfulness constraints are scaled. For superset-at-edge patterns (Figure 3A), the basic weight of Markedness must exceed the basic weight of Faithfulness, but Faithfulness must have a greater scaling factor, allowing its scaled violations to overcome those of Markedness at some point in the prosodic hierarchy. For subset-at-edge patterns (Figure 3B), the opposite is true. The basic weight of Faithfulness must exceed the basic weight of Markedness, but Markedness must have a greater scaling factor, allowing the relative strength of the Markedness and Faithfulness penalties to be inverted at some point in the hierarchy. The weighting configurations in Figure 3A and Figure 3B capture the Axininca Campa and Guhang Ifugao patterns, respectively.

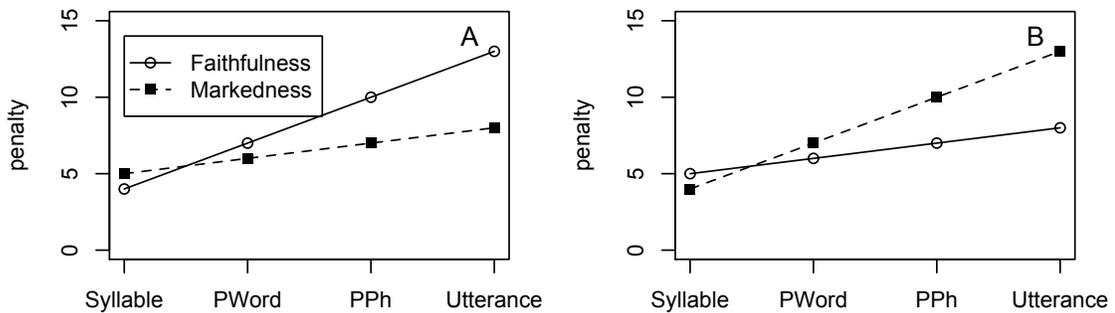


Figure 3: Patterns generated with scaled Markedness and Faithfulness. In A, the basic weight of Faithfulness is $w = 4$ and its scaling factor is $s = 3$; the basic weight of Markedness is $w = 5$ and its scaling factor is $s = 1$. In B the values for Markedness and Faithfulness are reversed.

To summarize, in Harmonic Grammar it is not necessary to include distinct indexed versions of positional markedness and positional faithfulness constraints in order to generate superset-at-edge and subset-at-edge patterns. Instead, generalized positional constraints can be scaled based on the relative prominence of the position in which their violations are incurred, allowing the desired patterns to be modeled using only a simple set of constraints.

5 Comparing OT and HG typologies

Using scalar constraints to capture the attested patterns is not possible in Optimality Theory. The reason is simple. Due to strict domination, in OT constraints can only occupy one position in the hierarchy. If Markedness dominates Faithfulness the marked structure will be allowed nowhere and if Faithfulness dominates Markedness, the marked structure will be allowed in all contexts. The ‘scalar’ aspect of the constraints is effectively ignored when it comes to comparisons of repaired vs. faithful candidates in OT.

At the same time, as discussed in §3, indexed positional constraints predict unattested level-skipping patterns, as there is no way to restrict the number of ranking reversals between the Markedness and Faithfulness constraints indexed to prosodic edges. HG with

scalar constraints does not generate such level-skipping patterns. The reason again is simple. Provided that there is a single scaling factor for each constraint and that consistent scales are used for Markedness and Faithfulness, the relative importance of Markedness and Faithfulness can only be inverted once per prominence scale. In other words, with a given set of weights and scaling factors, the Markedness and Faithfulness penalty lines can only cross once. Level-skipping patterns, in contrast, require two (or more) inversions of relative Markedness vs. Faithfulness importance.

Figure 4 compares the typologies generated with the conflicting constraints ONSET and DEP-INIT, assuming three levels of prominence: the syllable, the PWd and the PPh. As the figure shows, HG with scalar constraints predicts the existence of the hierarchy-respecting patterns a. through f., while excluding unattested level skipping patterns that either allow (*cf.* 11) or disallow (*cf.* 12) onsetless syllables in PWd-initial, PPh-medial syllables only. OT with scalar constraints severely undergenerates, predicting only patterns where onsetlessness is categorically allowed or disallowed. On the other hand, both OT and HG with indexed constraints overgenerate, predicting both hierarchy-respecting and level-skipping patterns.

	/VCV VV/	HG with scalar constraints	OT with scalar constraints	OT & HG with indexed constraints
a.	PPh[PWd[CV.CV] PWd[CV.CV]] ... onsetless never allowed	✓	✓	✓
b.	PPh[PWd[V.CV] PWd[V.V]] ... onsetless allowed everywhere	✓	✓	✓
c.	PPh[PWd[V.CV] PWd[V.CV]] ... onsetless allowed at PPh and PWd	✓	✗	✓
d.	PPh[PWd[V.CV] PWd[CV.CV]] ... onsetless allowed at PPh	✓	✗	✓
e.	PPh[PWd[CV.CV] PWd[V.V]] ... onsetless allowed at medial PWd and σ	✓	✗	✓
f.	PPh[PWd[CV.CV] PWd[CV.V]] ... onsetless allowed at medial σ only	✓	✗	✓
g.	PPh[PWd[CV.CV] PWd[V.CV]] ... onsetless allowed at medial PWd only	✗	✗	✓
h.	PPh[PWd[V.CV] PWd[CV.V]] ... onsetless allowed at PPh and medial σ	✗	✗	✓

Figure 4: A comparison of the typologies generated by HG and OT with scalar constraints and indexed constraints. Patterns a. through f. are attested hierarchy-respecting patterns. Patterns g. and h. are unattested level-skipping patterns.

Ultimately, these patterns are not specific to the interaction of Markedness and Faithfulness constraints. Rather, they are general to any pair of conflicting constraints indexed to the levels of some hierarchy. Conflicting Markedness constraints like *VN, which penalizes an oral vowel followed by a nasal consonant, and * \tilde{v} , which penalizes nasalized vowels, for instance, yield patterns similar to those in Figure 4 if they are scaled to the ends of prosodic domains – i.e., *VN]_D, * \tilde{v}]_D. In HG, if VN sequences are

permitted in PPh-final position but are altered to \tilde{v} in PWD-final position, they will also be altered to \tilde{v} in syllable-final position. Likewise, if VN sequences are disallowed in PPh-final position but are admitted in PWD-final position, they will also be admitted in syllable-final position. Indexed constraints – i.e., $*VN]_{\sigma}$, $*VN]_{PWD}$, $*VN]_{PPh}$, $*\tilde{v}]_{\sigma}$, $*\tilde{v}]_{PWD}$, $*\tilde{v}]_{PPh}$ – overgenerate, allowing level-skipping patterns. Conflicting Faithfulness constraints yield similar patterns, but with respect to the repair type selected in contexts of differing prominence. The typological comparisons are highly general, making consistent predictions across conflicting constraint types.

6 Conclusion

This paper has presented a Harmonic Grammar analysis of the effects of prosodic boundary strength on the application of phonotactic restrictions. We have shown that weighted positional constraints, whose violations are scaled according to the prominence of the boundary at which they occur, correctly account for attested types of edge-sensitivity while avoiding an overgeneration problem that arises with indexed positional constraints in either OT or HG. The paper further affirms that scalar constraints can be successfully applied to a variety of problems in Harmonic Grammar, allowing for analytical solutions that are not possible in Optimality Theory.

We have argued that scalar constraints in a weighted system provide a straightforward means to account for implicational patterns of repair vs. non-repair along some dimension of prominence. This raises the possibility that weighted scalar constraints can be applied in other morpho-phonological domains where implicational process application is observed. For instance, many works in Lexical Phonology have argued that phonological processes can either ‘turn on’ or ‘turn off’ at various levels in the morpho-syntactic derivation. Phonological processes can be triggered or blocked at morphemic boundaries of various strengths, but always in a strictly implicational fashion. A given process cannot apply at non-contiguous stages of the derivation (Bermúdez-Otero 1999, 2011, Kiparsky 1984, Mohanan & Mohanan 1984). As another potential case, Smith (2011) argues that the effect of lexical category on the application of phonotactic restrictions reflects the existence of the privilege hierarchy {Verbs, Adjectives, Nouns}. As with the prosodic boundary cases presented in this paper, the maintenance of a phonological contrast in words of a given lexical category implies that the same contrast will be maintained in all hierarchically superior categories. Future work will determine to what extent these types of morphosyntactically-sensitive patterns, many of which have been previously been claimed to be the result of cyclic derivation, can be profitably modeled in parallel HG with scalar constraints.

References

- Bane, M., & J. Riggle. 2009. The typological consequences of weighted constraints. In *Proc. of CLS 45*, ed. by R. Bochnak, N. Nicola, P. Klecha, J. Urban, A. Lemieux & C. Weaver. Chicago: Chicago Linguistic Society.
- Beckman, J. 1998. *Positional Faithfulness*. PhD dissertation. University of Massachusetts Amherst.
- Bermúdez-Otero, R. 1999. *Constraint Interaction in Language Change: Quantity in English and Germanic*. PhD dissertation. University of Manchester and University of Santiago de Compostela.
- Bermúdez-Otero, R. 2011. Cyclicity. In *The Blackwell Companion to Phonology*, ed. by M. van Oostendorp, C. Ewen, E. Hume & K. Rice. Malden, MA: Wiley-Blackwell.
- Casali, R. 1996. *Resolving Hiatus*. PhD dissertation. UCLA.
- Coetzee, A., & S. Kawahara. Frequency biases in phonological variation. *Natural Language and Linguistic Theory* 31.47-89.
- de Lacy, P. 2002. *The Formal Expression of Markedness*. PhD dissertation. University of Massachusetts Amherst.
- Farris-Trimble, A. 2008. *Cumulative Faithfulness Effects in Phonology*. PhD dissertation. Indiana University.
- Flack, K. 2009. Constraints on onsets and codas of words and phrases. *Phonology* 26.269-302.
- Hayes, B., & C. Wilson. 2008. A Maximum Entropy model of phonotactics and phonotactic learning. *Linguistic Inquiry* 39.379-440.
- Hume, E. 1998. Metathesis in phonological theory: The case of Leti. *Lingua* 104.147-186.
- Itô, J., & A. Mester. 1999. The phonological lexicon. In *Handbook of Japanese Linguistics*, ed. by N. Tsujimura, 62-100. Oxford: Blackwell.
- Jesney, K. 2014. Counterbleed-counterfeeding in Harmonic Grammar. Paper presented at *NELS 45*. Cambridge, MA: MIT.
- Jesney, K. to appear. Positional constraints in Optimality Theory and Harmonic Grammar. In *Harmonic Grammar and Harmonic Serialism*, ed. by J. McCarthy & J. Pater. London: Equinox Press.
- Kiparsky, P. 1984. On the lexical phonology of Icelandic. In *Nordic Prosody II: Papers from a Symposium*, ed. by C.-C. Elert, I. Johansson & E. Strangert. Umeå: University of Umeå.
- Kimper, W. 2011. *Competing Triggers: Transparency and Opacity in Vowel Harmony*. PhD dissertation. University of Massachusetts Amherst.
- Legendre, G., Y. Miyata & P. Smolensky. 1990. Can connectionism contribute to syntax?: Harmonic Grammar, with an application. In *Proc. of CLS 26*, ed. by M. Ziolkowski, M. Noske, & K. Deaton, 237-252. Chicago: Chicago Linguistic Society.
- McPherson, L., & B. Hayes. 2015. Relating application frequency to morphological structure: the case of Tommo So vowel harmony. Ms., Dartmouth College & UCLA.
- McCarthy, J., & A. Prince. 1993. Generalized alignment. *Yearbook of Morphology*.79-153.
- McCarthy, J., & A. Prince. 1995. Faithfulness and reduplicative identity. *Papers in Optimality Theory: University of Massachusetts Occasional Papers* 18.249-384. Amherst, MA: GLSA.
- Mithun, M., & M. Basri. 1986. The Phonology of Selayarese. *Oceanic Linguistics* 25.210-254.
- Mohanan, K.P., & T. Mohanan. 1984. Lexical phonology of the consonant system in Malayalam. *Linguistic Inquiry* 15.575-602.
- Newell, L. 1956. Phonology of the Guhang Ifugao dialect. *Philippine Journal of Science* 85.523-539.
- Pater, J. 2009. Weighted constraints in generative linguistics. *Cognitive Science* 33.999-1035.
- Pater, J. 2012. Serial Harmonic Grammar and Berber syllabification. In *Prosody Matters: Essays in Honor of Elisabeth O. Selkirk*, ed. by T. Borowsky, S. Kawahara, T. Shinya & M. Sugahara, 43-72. London: Equinox Press.
- Pater, J. to appear. Universal Grammar with weighted constraints. In *Harmonic Grammar and Harmonic Serialism*, ed. by J. McCarthy & J. Pater. London: Equinox Press.

- Payne, D. 1981. *The Phonology and Morphology of Axininca Campa*. Arlington, TX: SIL
- Potts, C., J. Pater, K. Jesney, R. Bhatt & M. Becker. 2010. Harmonic grammar with linear programming: from linear systems to linguistic typology. *Phonology* 27.77–117.
- Prince, A., & P. Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Technical Report, Rutgers University and University of Colorado at Boulder, 1993. Revised version published by Blackwell, 2004.
- Smith, J. 2002. *Phonological Augmentation in Prominent Positions*. PhD dissertation. University of Massachusetts Amherst.
- Smith, J. 2011. Category-specific effects. In *The Blackwell Companion to Phonology*, ed. by M. van Oostendorp, C. Ewen, E. Hume & K. Rice. 2439–2463. Malden, MA: Wiley-Blackwell.
- Smolensky, P., & G. Legendre. 2006. *The Harmonic Mind: from Neural Computation to Optimality-Theoretic Grammar*. Cambridge, MA: MIT Press.