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Weighted Scalar Constraints and Implicational Process Application

Brian Hsu and Karen Jesney
University of Southern California
hsub@usc.edu; jesney@usc.edu

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1. Introduction

Languages show implicational blocking and triggering patterns at different types of prosodic and/or morphosyntactic boundaries.

Implicational blocking:
→ If a markedness-reducing process is blocked at boundaries of strength *x*, then it is also blocked at boundaries of strength *x* + 1

Implicational triggering:
→ If a markedness-reducing process is triggered at boundaries of strength *x*, then it is also triggered at boundaries of strength *x* + 1

(1) a. Implicational blocking

A	*... process blocked*
|	
B	*... process blocked*
|	
C	*... marked structure repaired*

b. Implicational triggering

A	*... process triggered*
|	
B	*... process triggered*
|	
C	*... marked structure permitted*

Prosodic boundaries (Flack 2009):
- 'Superset at edge' → A marked structure is permitted at prosodic boundaries of strength *x* or greater, but is banned (repaired) elsewhere.
- 'Subset at edge' → A marked structure is banned (repaired) at prosodic boundaries of strength *x* or greater, but is permitted elsewhere.

Morphosyntactic boundaries (Kiparsky 1984; Mohanan & Mohanan 1984; Bermúdez-Otero 1999):
- A markedness-reducing process is blocked at morphosyntactic boundaries of strength *x* or greater, so that more marked structures are permitted at stronger junctures.
- A markedness-reducing process is triggered at morphosyntactic boundaries of strength *x* or greater, so that fewer marked structures are permitted at stronger junctions.

Capturing these patterns in Optimality Theory (Prince & Smolensky 1993/2004) presents challenges:
- Scalar constraints – like HNUC – cannot capture implicational patterns of repair vs. non-repair.
- Indexed positional constraints overgenerate, predicting both implicational and non-implicational patterns.

Claim: If constraints are **weighted** as in Harmonic Grammar (HG; Legendre, Miyata & Smolensky 1990; Smolensky & Legendre 2006; see also Goldsmith 2003), **scalar constraints** can be successfully applied to this problem.

- Patterns of repair vs. non-repair are captured.
- Implicational patterns are predicted, while avoiding the overgeneralization of indexed constraints.
- HG allows for analytical solutions that are not possible given ranked constraints (*cf.* Farris-Trimble 2008; Hayes & Wilson 2008; Jesney 2014, to appear; Kimper 2011; Pater 2012, to appear; Potts *et al.* 2010)

Structure of the talk:

§2 Implicational blocking and triggering
§3 The challenge for Optimality Theory
§4 Scaling constraints in Harmonic Grammar
§5 Comparing typologies
§6 Conclusion

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2. Implicational blocking and triggering

Generally-attested patterns:

(2) a. Implicational blocking

A *... process blocked*
|
B *... process blocked*
|
C *... marked structure repaired*

b. Implicational triggering

A *... process triggered*
|
B *... process triggered*
|
C *... marked structure permitted*

Implicational blocking:

(3) Axininca Campa (Payne 1981, McCarthy & Prince 1993) tolerates onsetless syllables word-initially, but requires onsets for word-medial syllables.

/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'

Markedness-reducing process → consonant epenthesis

- Prosodic interpretation: Process is triggered at syllable boundaries, but blocked at PWd boundaries.
- Morphosyntactic interpretation: Process is triggered at affix boundaries, but blocked at grammatical word boundaries.

Crucially, blocking of the repair at word boundaries implies non-repair at all greater boundaries (i.e., phrase and utterance) as well.

Implicational triggering:

(4) English went through a series of stages where ŋg]$_\sigma$ sequences were systematically repaired to ŋ]$_\sigma$ at different morphosyntactic boundaries (Borowsky 1993; Garrett & Blevins 2009; Bermúdez-Otero 2011).

		elong+ate	prolong#er	prolong##it	prolong||	
Stage	0	ŋg	ŋg	ŋg	ŋg	… structure permitted at all boundaries
	1	ŋg	ŋg	ŋg	ŋ	… repair triggered at word boundary
	2	ŋg	ŋg	ŋ	ŋ	… repair triggered at > clitic boundary
	3	ŋg	ŋ	ŋ	ŋ	… repair triggered at > level 2 suffix boundary

Markedness-reducing process → cluster reduction (g-deletion)

- Morphosyntactic interpretation: Process is triggered at relatively stronger morphosyntactic boundaries

For each stage, triggering of the repair at some boundary implies repair at all greater boundaries.

Bermúdez-Otero (2011): These patterns are **opaque**. The motivation for deletion of /g/ is non-apparent once a vowel-initial suffix / clitic is added.

- Russian Doll Theorem: "Let there be the nested cyclic domains $_\gamma$[… $_\beta$[… $_\alpha$[…] …] …]. If a phonological process is opaque in β because its domain is α, then *p* is opaque in γ."

3. The challenge for Optimality Theory

Individual implicational patterns can be readily captured in parallel OT using **indexed constraints** that apply in morpho-phonologically defined contexts (Benua 1997; Beckman 1998; Itô and Mester 1999; Pater 2000; Smith 2002; Hsu 2014).

Axininca Campa **implicational blocking** with indexed faithfulness constraints (Beckman 1998, Casali 1996):

(5) a. $_{\sigma}$[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.

(6) *Only PWd-initial syllables can be onsetless*: $_{PWd}$[DEP-INIT >> ONSET >> $_{\sigma}$[DEP-INIT

/i-N-koma-i/	$_{PWd}$[DEP-INIT	ONSET	$_{\sigma}$[DEP-INIT
$_{PWd}$[iŋ.ko.ma.i]		**!	
☞ $_{PWd}$[iŋ.ko.ma.t̲i]		*	*
$_{PWd}$[t̲iŋ.ko.ma.i]	*!	*	*
$_{PWd}$[t̲iŋ.ko.ma.t̲i]	*!		**

English stage 2 **implicational triggering** with indexed markedness constraints (Smith 2002; Flack 2009):

(7) a. *ŋg# – Assign a violation mark to any [ŋg] sequence at a stem-level 2 suffix boundary
b. *ŋg## – Assign a violation mark to any [ŋg] sequence at a stem-clitic boundary

(8) [ŋg] *sequences are permitted below the stem-clitic boundary*: *ŋg## >> FAITH >> *ŋg#

/proloŋg#er/	*ŋg##	FAITH	*ŋg#
☞ proloŋg#er			*
proloŋ#er		*!	
/proloŋg##it/	*ŋg##	FAITH	*ŋg#
proloŋg##it	*!		
☞ proloŋ##it		*	

Accounting for these patterns in parallel OT requires a proliferation of **indexed constraints,** corresponding to a variety of (morpho-)phonological domains.

The problem: These patterns are strictly **implicational**. Non-implicational patterns do not seem to be attested.

(9) Non-implicational patterns (unattested)

a.
A *... marked structure repaired*
|
B *... process blocked*
|
C *... marked structure repaired*

b.
A *... marked structure permitted*
|
B *... process triggered*
|
C *... marked structure permitted*

The interaction of indexed markedness and indexed faithfulness in OT predicts **non-implicational patterns**.

Example: PWd-medial syllables and PPh-initial syllables must have onsets, but PWd-initial syllables in PPh-medial position can be onsetless.

- Problematic ranking: *$_{PPh}$[V >> $_{PPh}$[DEP-INIT, $_{PWd}$[DEP-INIT >> *$_{PWd}$[V, *$_{\sigma}$[V >> $_{\sigma}$[DEP-INIT
- Breaking down the rankings:
  PPh edge ranking: *$_{PPh}$[V >> $_{PPh}$[DEP-INIT (M >> F)
  PWd edge ranking: $_{PWd}$[DEP-INIT >> *$_{PWd}$[V (F >> M)
  Syllable onset ranking: *$_{\sigma}$[V >> $_{\sigma}$[DEP-INIT (M >> F)

(10) a. *Phrase-initial and PWd-medial syllables must have onsets*

/VV/	*$_{PPh}$[V	$_{PPh}$[DEP-INIT	$_{PWd}$[DEP-INIT	*$_{PWd}$[V	*$_{\sigma}$[V	$_{\sigma}$[DEP-INIT
$_{PPh}$[$_{PWd}$[V.V]	*!			*	**	
$_{PPh}$[$_{PWd}$[V.CV]	*!			*	*	*
$_{PPh}$[$_{PWd}$[CV.V]		*	*		*!	*
☞ $_{PPh}$[$_{PWd}$[CV.CV]		*	*			**

b. *Phrase-medial, PWd-initial syllables can be onsetless*

/...VCV/	*$_{PPh}$[V	$_{PPh}$[DEP-INIT	$_{PWd}$[DEP-INIT	*$_{PWd}$[V	*$_{\sigma}$[V	$_{\sigma}$[DEP-INIT
$_{PPh}$[...$_{PWd}$[V.V]				*	**!	
☞ $_{PPh}$[...$_{PWd}$[V.CV]				*	*	
$_{PPh}$[...$_{PWd}$[CV.V]			*!		*	*
$_{PPh}$[...$_{PWd}$[CV.CV]			*!			*

Fixed rankings in a parallel framework cannot resolve this issue.

- The problematic example in (10) is consistent with fixed rankings where:
  $_{PPh}$[DEP-INIT >> $_{PWd}$[DEP-INIT >> $_{\sigma}$[DEP-INIT *and*
  *$_{PPh}$[V >> *$_{PWd}$[V >> *$_{\sigma}$[V

Stringently-defined constraints (de Lacy 2002) in a parallel framework also cannot resolve this issue.

- Stringently-defined faithfulness constraints: $_{\geq PPh}$[DEP-INIT, $_{\geq PWd}$[DEP-INIT, $_{\geq\sigma}$[DEP-INIT
- Stringently-defined markedness constraints: *$_{\geq PPh}$[V, *$_{\geq PWd}$[V, *$_{\geq\sigma}$[V

Stratal OT (Bermúdez-Otero 1999, Kiparsky 2000, Kiparsky 2008) predicts **implicational patterns** using only simple constraints, if words / prosodic structure are built gradually.

(11) *ŋg]$_{\sigma}$ – Assign a violation mark to any [ŋg] sequence in coda position

(12) Stem level (M >> F):

/proloŋg # er/	*ŋg]$_{\sigma}$	FAITH
☞ proloŋ.ger		
proloŋ.er		*!

M >> F ranking is irrelevant because the context for application of the process does not exist

(13) Stem level (M >> F):

/proloŋg/	*ŋg]$_{\sigma}$	FAITH
proloŋg	*	
☞ proloŋ		*!

Word level (F >> M):

/proloŋ ## it/	FAITH	*ŋg]$_{\sigma}$
proloŋ.git	*!	
☞ proloŋ.it		

M >> F ranking at the stem level triggers g-deletion

This can not "undone" even with a F >> M ranking at the word level.

Result: Apparent overapplication of g-deletion

4. Scaling constraints in Harmonic Grammar

In Harmonic Grammar (Legendre, Miyata & Smolensky 1990, Smolensky & Legendre 2006), constraints are **weighted** rather than ranked.

- **Consequence:** Regardless of its "basic" weight, each constraint can influence which candidate is selected as optimal.

(14) Axininca Campa (Payne 1981, McCarthy & Prince 1993) tolerates onsetless syllables word-initially, but requires onsets for word-medial syllables.

/i-N-koma-i/ → [iŋ.ko.ma.t̲i] 'he will paddle'
/i-N-koma-aa-i/ → [iŋ.ko.ma.t̲aa.t̲i] 'he will paddle again'

To illustrate with indexed constraints in HG, only PWd-initial syllables will be onsetless provided that the following weighting conditions hold:

- w(ONSET) > w($_{\sigma}$[DEP-INIT)
- w($_{\sigma}$[DEP-INIT) + w($_{PWd}$[DEP-INIT) > w(ONSET)

(15) *Only PWd-initial syllables can be onsetless*

/i-N-koma-i/	ONSET $w = 3$	$_{PWd}$[DEP-INIT $w = 2$	$_{\sigma}$[DEP-INIT $w = 2$	*H*
$_{PWd}$[iŋ.ko.ma.i]	–2			–6
☞ $_{PWd}$[iŋ.ko.ma.t̲i]	–1		–1	–5
$_{PWd}$[t̲iŋ.ko.ma.i]	–1	–1	–1	–7
$_{PWd}$[t̲iŋ.ko.ma.t̲i]		–1	–2	–6

But: Indexed constraints in HG overgenerate as they do in OT. Non-implicational patterns are wrongly predicted.

Proposal: There are no distinct positional constraints in HG. Instead, constraint violations are **scaled** to the prominence of the edge at which they occur.

Some previous uses of weighted scalar constraints:

- Kimper (2011) – scaling based on locality and properties of triggers / targets in vowel harmony
- McPherson & Hayes (2015) – scaling based on morphosyntactic distance between triggers and targets in vowel harmony
- Pater (2012) – scaling based on nucleic sonority to model Berber syllabification
- Pater (to appear) – scaling based on weight and sonority to model compatibility with stress
- Coetzee & Kawahara (2013) – scaling based on lexical frequency
- Jesney (2014) – scaling based on sonority cline to model syllable contact effects
- Flemming (2001), Cho (2011), McAllister Byun (2011), Ryan (2011) – scaling based on real phonetic values

Here: Scaling based on the strength of the associated boundary

(16) *Scaled $_{D}$[DEP-INIT*
Given a basic constraint weight w,
a scale $D = \{0, 1, \ldots n\}$ 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 $\boldsymbol{w + s(d)}$

Example: Weight $w = 2$
Prominence scale = {Syllable, PWd, PPh, Utterance}
Scaling factor $s = 2$

epenthesis at a syllable boundary: $_{D}$[DEP-INIT violation of $w + s$(Syllable) = 2 + 2(0) = 2
epenthesis at a word boundary: $_{D}$[DEP-INIT violation of $w + s$(PWd) = 2 + 2(1) = 4

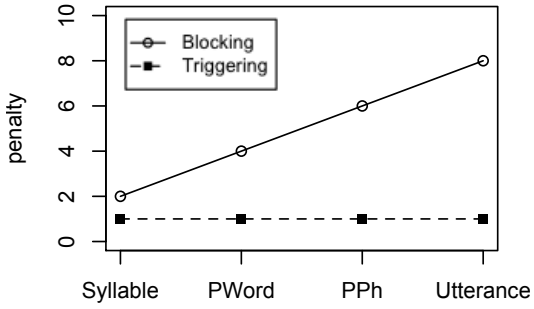
(17) *Only PWd-initial syllables can be onsetless*

/i-N-koma-i/	ONSET *w* = 3	$_{D}$[DEP-INIT *w* = 2, *s* = 2	*H*
$_{PWd}$[iŋ.ko.ma.i]	–2		–6
☞ $_{PWd}$[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

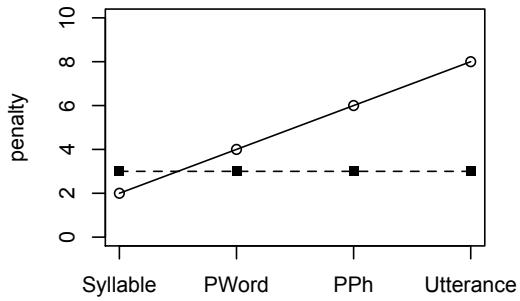
Implicational blocking – weighting conditions:

- The basic weight of the constraint favouring markedness reduction is greater than the basic weight of the conflicting blocking constraint.
- The marked structure becomes allowed – i.e., the markedness-reducing process is blocked – at all levels of prominence where $w + s(d)$ for the blocking constraint exceeds the weight of Markedness.

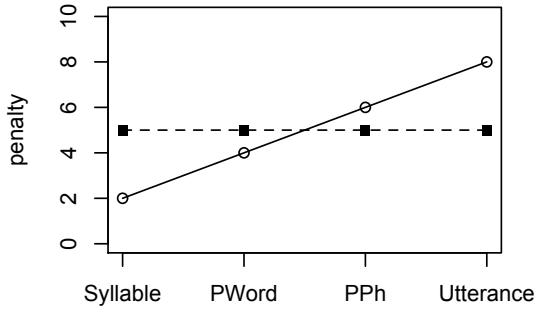
(18) a. Repair blocked everywhere
Markedness w = 1
Faithfulness w = 2, *s* = 2



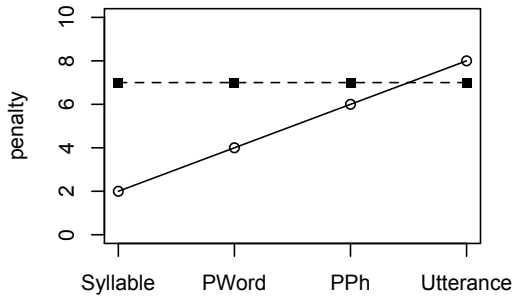
b. Repair blocked at PWd edge and up
Markedness w = 3
Faithfulness w = 2, *s* = 2



c. Repair blocked at PPh edge and up
Markedness w = 5
Faithfulness w = 2, *s* = 2



d. Repair blocked at Utterance edge only
Markedness w = 7
Faithfulness w = 2, *s* = 2



Implicational triggering: fewer marked structures are permitted at more prominent boundaries.

(19) English stage 2:
elong+ate → elo[ŋg]ate
prolong#er → prolo[ŋg]er
prolong##it → prolo[ŋ] it
prolong‖ → prolo[ŋ]

		elong+ate	prolong#er	prolong##it	prolong‖
Stage	0	ŋg	ŋg	ŋg	ŋg
	1	ŋg	ŋg	ŋg	ŋ
	2	ŋg	ŋg	ŋ	ŋ
	3	ŋg	ŋ	ŋ	ŋ

- The triggering constraint, rather than the blocking constraint, must be scaled.

(20) *Scaled *ŋg]$_{D}$*
Given a basic constraint weight *w*,
a scale {0, 1, … *n*} corresponding to some dimension of prominence,
and a scaling factor *s,*
For any vowel in initial position of domain $d \in D$,
Assign a weighted violation score of $\boldsymbol{w + s(d)}$

Example: Weight $w = 2$
Prominence scale = {level 1 suffix, level 2 suffix, clitic, word}
Scaling factor $s = 2$

[ŋg] at level 2 suffix boundary: *ŋg]$_D$ violation of $w + s$(level 2) = 2 + 2(1) = 4
[ŋg] at clitic boundary: *ŋg]$_D$ violation of $w + s$(clitic) = 2 + 2(2) = 6

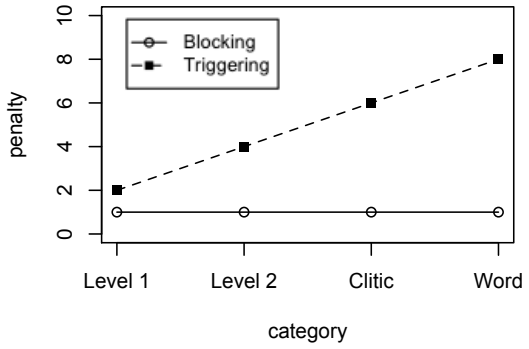
(21) *Stem-clitic boundaries trigger deletion; level 2 suffix boundaries do not*

/proloŋg#er/	MAX-C $w = 5$	*ŋg]$_D$ $w = 2, s = 2$	*H*
☞ proloŋg#er		-1_{level2}	–4
proloŋ#er	–1		–5
/proloŋg##it/	MAX-C	*ŋg]$_D$	
proloŋg##it		-1_{clitic}	–6
☞ proloŋ##it	–1		–5

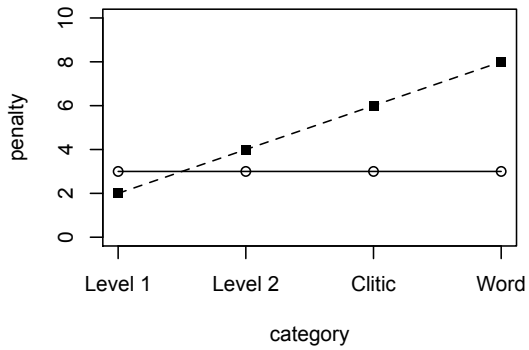
Implicational triggering – weighting conditions:

- The basic weight of the constraint disfavouring the markedness-reducing process is greater than the basic weight of the conflicting triggering constraint.
- The marked structure becomes disallowed – i.e., the markedness-reducing process is triggered – at all levels of prominence where $w + s(d)$ for the triggering constraint exceeds the weight of the constraint favouring faithfulness.

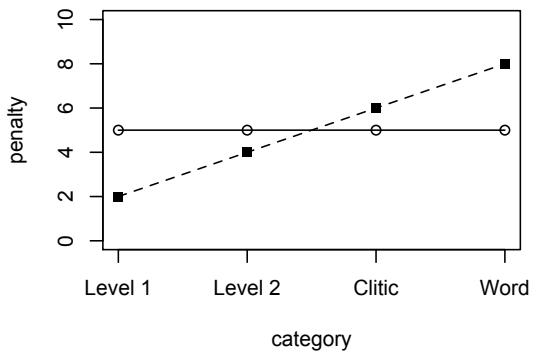
(22) a. Repair triggered at all boundaries
Markedness $w = 2, s = 2$
Faithfulness $w = 1$



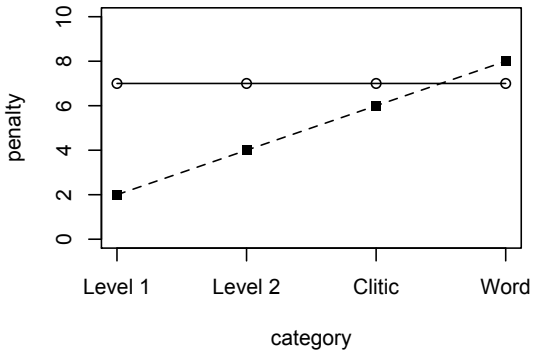
b. Repair triggered at level 2 boundaries and up
Markedness $w = 2, s = 2$
Faithfulness $w = 3$



c. Repair triggered at clitic boundaries and up
Markedness $w = 2, s = 2$
Faithfulness $w = 5$



d. Repair triggered at word boundaries and up
Markedness $w = 2, s = 2$
Faithfulness $w = 7$



If multiple constraints are scaled, the logic remains the same.

Implicational blocking – weighting conditions with both constraints scaled:

- The basic weight of the triggering constraint is greater than the basic weight of the conflicting blocking constraint.
- The blocking constraint has a greater scaling factor, allowing the penalty for repair to exceed the penalty for blocking the process above some level of prominence.

(23) *Only PWd-initial syllables can be onsetless*

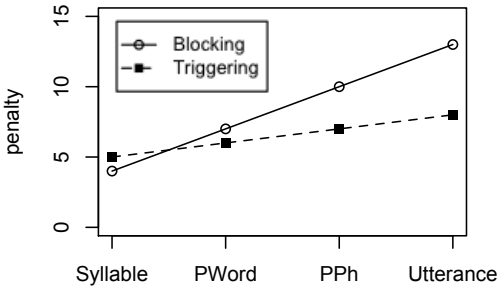
/i-N-koma-i/	$*_D$[V $w = 5,\ s = 1$	$_D$[DEP-INIT $w = 4, s = 3$	*H*
$_{PWd}$[iŋ.ko.ma.i]	$-1_{\sigma,}-1_{PWd}$		–11
☞ $_{PWd}$[iŋ.ko.ma.ti]	-1_{PWd}	-1_{σ}	–10
$_{PWd}$[tiŋ.ko.ma.i]	-1_{σ}	-1_{PWd}	–12
$_{PWd}$[tiŋ.ko.ma.ti]		$-1_{\sigma,}-1_{PWd}$	–11

Implicational triggering – weighting conditions with both constraints scaled:

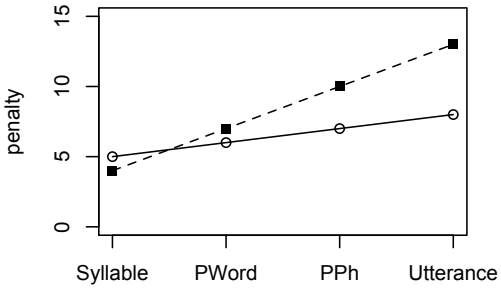
- The basic weight of the blocking constraint is greater than the basic weight of the conflicting constraint favouring markedness reduction.
- The triggering constraint has a greater scaling factor, allowing the penalty for non-repair to exceed the penalty for repair above some level of prominence.

(24) *Patterns with multiple constraints scaled*

a. Implicational blocking



b. Implicational triggering



5. Comparing typologies

Summary: In Harmonic Grammar it is not necessary to include distinct indexed versions for positional markedness and faithfulness constraints. Instead, constraints can be scaled based on the relative prominence of the position in which their violations are incurred.

Scalar constraints **cannot** achieve the effect of driving repair vs. non-repair in Optimality Theory.

- Why not? In parallel OT constraints can only occupy one position in the hierarchy. If M >> F, the marked structure will be allowed in no context. If F >> M, the marked structure will be allowed in all contexts.

Indexed positional markedness and faithfulness constraints predict unattested non-implicational patterns (see §3).

In HG with scalar constraints, non-implicational patterns cannot be generated.

- Why not? The relative importance of conflicting constraints can only be inverted once per prominence scale – i.e., the penalty lines only cross once.
- Non-implicational patterns rely on two (or more) inversions of relative importance for blocking vs. triggering constraints.

(25) *Typological comparison: OT vs. HG*

/VCV VV/	HG with scalar constraints	OT with scalar constraints	OT & HG with indexed constraints	
PPh[PWd[CV.CV] PWd[CV.CV]] *... onsetless never allowed*	✓	✓	✓	*hierarchy-respecting patterns ... attested*
PPh[PWd[**V**.CV] PWd[**V**.**V**]] *... onsetless allowed everywhere*	✓	✓	✓	
PPh[PWd[**V**.CV] PWd[**V**.CV]] *... onsetless allowed at PPh and PWd*	✓	✗	✓	
PPh[PWd[**V**.CV] PWd[CV.CV]] *... onsetless allowed at PPh*	✓	✗	✓	
PPh[PWd[CV.CV] PWd[**V**.**V**]] *... onsetless allowed at medial PWd and σ*	✓	✗	✓	
PPh[PWd[CV.CV] PWd[CV.**V**]] *... onsetless allowed at medial σ only*	✓	✗	✓	
PPh[PWd[**V**.CV] PWd[CV.**V**]] *... onsetless allowed at PPh and medial σ*	✗	✗	✓	*level-skipping ... not attested*
PPh[PWd[CV.CV] PWd[**V**.CV]] *... onsetless allowed at medial PWd only*	✗	✗	✓	

6. Conclusion

Scalar constraints can be successfully applied to a variety of problems in HG – allowing for analytical solutions that are not possible in Optimality Theory.

- Weighted scalar constraints naturally account for **implicational patterns of repair vs. non-repair** along some dimension of prominence.
- HG constraints scaled to levels of prosodic or mopho-syntactic prominence predict attested implicational patterns of process application.

Scalar constraints in HG can be extended to account for implicational process application in other domains, such as lexical category effects.

- Smith (2011): Given a hierarchy of phonological privilege by lexical category (i.e., N>A>V), avoidance of contrast neutralization within words of a given category implies preservation of the same contrast in all higher (or lower) categories of the hierarchy.
- Such patterns do not clearly lend themselves to accounts framed in terms of cyclic derivations.

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