Harmonic Bounding in (Noisy) Harmonic Grammar*

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1 Introduction

- Eastern Andalusian: regressive ATR harmony optionally targets unstressed vowels:

(1)	a.	*cómetelos*	kɔ́me̱te̱lɔ ~ kɔ́mɛ̱tɛ̱lɔ	‘eat them (for you)!’
	b.	*momentos*	mo̱mɛ́ntɔ ~ mɔ̱mɛ́ntɔ	‘instants’

- Analyses exist for OT (Jiménez & Lloret 2007, Lloret 2018, Lloret & Jiménez 2009, Walker 2011), but not Harmonic Grammar (e.g. Legendre et al. 1990).
- **Problem 1:** The constraints used for OT fail in HG.
- **Problem 2:** HG provides different ways of producing optionality.
- Solutions to one problem influence the other, and they hinge on harmonic bounding.
- Common claim: some outputs in optionality are harmonically bounded (Kaplan 2011, Kimper 2011a, Riggle & Wilson 2005, Vaux 2008).
- Most versions of Noisy Harmonic Grammar produce harmonically bounded outputs.
  - NHG (NHG; e.g. Hayes 2017, Jesney 2007): stochastic evaluation of candidates within Harmonic Grammar.
- <u>Argument 1</u>: NHG accounts for Eastern Andalusian only when it cannot access harmonically bounded candidates.
  - If NHG admits desired harmonically bounded candidates, it admits undesired ones, too.

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- Therefore, the constraint set must not render any licit output harmonically bounded.
- Argument 2: we need positive constraints (e.g. Kimper 2011b) that reward compliance instead of penalizing non-compliance.
  - Only with positive constraints are all of Eastern Andalusian's surface forms non-harmonically bounded.
- Taken together: optionality has implications for phonology more generally.
- Two case studies:
  - Eastern Andalusian harmony: NHG must not have access to harmonically bounded candidates.
  - Pima reduplication: NHG succeeds even without access to harmonically bounded candidates.

2 Eastern Andalusian Harmony

- Word-final /s/ deletes ("/s/-aspiration") and the adjacent vowel becomes lax, triggering harmony (data from Jiménez & Lloret 2007, Lloret 2018, Lloret & Jiménez 2009).
- The stressed vowel always harmonizes:

(2)	a.	*tesis*	tɛ́sɪ	'thesis'
	b.	*tienes*	tjɛ́nɛ	'you have'
	c.	*nenes*	nɛ́nɛ	'babies'
	d.	*monos*	mɔ́nɔ	'monkeys'
	e.	*lejos*	lɛ́hɔ	'far'
	f.	*pesos*	pɛ́sɔ	'weights'
	g.	*bocas*	bɔ́kæ̞	'mouths'

- Other post-tonic vowels optionally harmonize in "lockstep" (Hayes 2017):

(3)	a.	*treboles*	trɛ́βolɛ ∼ trɛ́βɔlɛ	'clovers'
	b.	*cómetelos*	kɔ́metelɔ ∼ kɔ́mɛtɛlɔ *kɔ́mɛtelɔ, *kɔ́metɛlɔ	'eat them (for you)!'

- Pretonic vowels optionally harmonize in lockstep, but only with post-tonic harmony:

(4)	a.	*momentos*	momɛ́ntɔ ∼ mɔmɛ́ntɔ	'instants'
	b.	*reloj*	relɔ́ ∼ rɛlɔ́	'watch'
	c.	*relojes*	relɔ́hɛ ∼ rɛlɔ́hɛ	'watches'
	d.	*monederos*	moneðɛ́rɔ ∼ mɔnɛðɛ́rɔ *mɔneðɛ́rɔ, *monɛðɛ́rɔ	'purses'
	e.	*recógelos*	rekɔ́helɔ ∼ rekɔ́hɛlɔ ∼ rɛkɔ́hɛlɔ *rɛkɔ́helɔ	'pick them'

- High vowels lax word finally but are transparent to harmony:

(5)	a.	*crisis*	kɾísɪ	'crisis'
	b.	*muchos*	múʃɔ	'many'
	c.	*mios*	míɔ	'mine (pl.)'
	d.	*cojines*	kohínɛ ∼ kɔhínɛ	'pillows'
	e.	*cotillones*	kotiʒɔ́nɛ ∼ kɔtiʒɔ́nɛ	'cotillions'

- Transparency in (5d) and (5e) is derivationally opaque, so no account provided here.
- Summary: optionality is abundant, but has strict limitations:
  - Stressed vowels obligatorily harmonize.
  - Post-tonic vowels behave in lockstep; likewise pretonic vowels.
  - Pretonic harmony requires post-tonic harmony.
  - High vowels don't harmonize.
- Cf. optionality French schwa deletion (e.g. Dell 1980), English flapping (e.g. de Jong 2011): little coordination between loci.

3 Two Analyses in HG

- One analysis with harmonically bounded attested forms (negative constraints), the other with no harmonically bounded attested forms (a positive constraint).
- Only the latter supports an NHG model.
- Analyses based on existing OT analyses (Jiménez & Lloret 2007, Lloret 2018, Lloret & Jiménez 2009, Walker 2011), adapted for HG.
- Harmony on stressed syllable is driven by Positional Licensing (e.g. Walker 2011).
- Harmony elsewhere:
  - Post-tonic harmony: *Duplicate (no discontiguous harmony domains; Walker (2011))
  - Pretonic harmony: Maximal Licensing ([–ATR] must appear in every syllable; Walker (2011))
- NHG perturbs weights/harmony scores, so weights used here are just illustrative.
- Notation:
  - ☞ = winner
  - ✓ = attested
  - × = harmonically bounded

3.1 Negative Positional Licensing

- OT analyses: final laxing = docking of /s/'s aspiration feature on a vowel.
- Enforced by MAX(–ATR); must outweigh IDENT(ATR):

(6)

/krísis/	MAX(–ATR) 20	IDENT(ATR) 2	*H*
a. krísi	−1		−20
☞✓ b. krísɪ		−1	−2

- Standard categorical PL is pathological in HG; it must be gradient (Kaplan 2018):

(7) LICENSE([–ATR], $\acute{\sigma}$): assign −1 for each [–ATR] that does not coincide with $\acute{\sigma}$ and −1 for each syllable that intervenes between [–ATR] and the nearest $\acute{\sigma}$. (NG-PL)

(8)

/kómetelos/	MAX(–ATR) 20	LICENSE 4	IDENT(ATR) 2	*H*
a. kómetelo	−1			−20
b. kómetelɔ		−3	−1	−14
×✓ c. kɔ́metelɔ		−2	−2	−12
× d. kɔ́mɛtelɔ		−1	−3	−10
× e. kɔ́metɛlɔ		−1	−3	−10
☞✓ f. kɔ́mɛtɛlɔ			−4	−8

- LICENSE penalizes unharmonized vowels in candidate (c) to avoid pathologies (Kaplan 2018).
- Candidates that skip post-tonic vowels (c)–(e) are collectively harmonically bounded (Samek-Lodovici & Prince 1999) by candidates (b) and (f).
  - But [kɔ́metelɔ] is attested! That might be OK—let's let NHG deal with it.
- Pretonic harmony: Maximal Licensing

(9)

/monedéros/	MAX(–ATR) 20	LICENSE 4	MAXLIC 4	IDENT(ATR) 2	*H*
a. moneðéro	−1				−20
b. moneðérɔ		−1	−3	−1	−18
✓ c. moneðɛ́rɔ			−2	−2	−12
× d. mɔneðɛ́rɔ			−1	−3	−10
× e. monɛðɛ́rɔ			−1	−3	−10
☞✓ f. mɔnɛðɛ́rɔ				−4	−8

- w(IDENT(ATR)) > w(MAXLIC) → no pretonic harmony:

(10)

/monedéros/	MAX(–ATR) 20	LICENSE 4	MAXLIC 1	IDENT(ATR) 2	*H*
a. moneðéro	−1				−20
b. moneðérɔ		−1	−3	−1	−9
☞✓ c. moneðέrɔ			−2	−2	−6
× d. mɔneðέrɔ			−1	−3	−7
× e. monεðέrɔ			−1	−3	−7
✓ f. mɔnεðέrɔ				−4	−8

- Candidates (d) and (e) are collectively harmonically bounded by (c) and (f).
- Coordination between pretonic and post-tonic harmony:

(11) a.

/rekóhelos/	MAX(–ATR) 20	LICENSE 4	MAXLIC 4	IDENT(ATR) 2	*H*
a. rekóhelo	−1				−20
b. rekóhelɔ		−2	−3	−1	−22
×✓ c. rekɔ́helɔ		−1	−2	−2	−16
✓ d. rekɔ́hεlɔ			−1	−3	−10
☞✓ e. rεkɔ́hεlɔ				−4	−8
× f. rεkɔ́helɔ		−1	−1	−3	−14

b.

/rekóhelos/	MAX(–ATR) 20	LICENSE 4	MAXLIC 1	IDENT(ATR) 2	*H*
a. rekóhelo	−1				−20
b. rekóhelɔ		−2	−3	−1	−13
×✓ c. rekɔ́helɔ		−1	−2	−2	−11
☞✓ d. rekɔ́hεlɔ			−1	−3	−7
✓ e. rεkɔ́hεlɔ				−4	−8
× f. rεkɔ́helɔ		−1	−1	−3	−11

- Candidate (c) is collectively harmonically bounded by (b) and (d)! Again, let NHG handle it.
- Candidate (f) is harmonically bounded by (d).

- High vowels: *[+hi, –ATR] prevents harmony:

(12)

/krísis/	MAX(–ATR) 20	*[+hi, –ATR] 12	LICENSE 4	MAXLIC 1	IDENT(ATR) 2	*H*
a. krísi	−1					−20
☞✓ b. krísɪ		−1	−1	−1	−1	−19
c. krísɪ		−2			−2	−28

- What to do about the harmonically bounded attested forms?
  - Use NHG to access them.
  - Revise the analysis so they're not harmonically bounded.

3.2 Positive Positional Licensing

- Similarities to NG-PL analysis:
  - MAX(–ATR) triggers final-vowel laxing.
  - *[+hi, –ATR] protects high vowels.
  - LICENSE competes with IDENT to trigger harmony.

(13) LICENSE([–ATR], $\acute{\sigma}$): assign +1 for each [–ATR] that coincides with $\acute{\sigma}$ and +1 for each additional syllable that [–ATR] appears in. (PG-PL; Kaplan 2018)

- w(LICENSE) > w(IDENT) → full post-tonic harmony:

(14)

/kómetelos/	MAX(–ATR) 20	LICENSE 3	IDENT(ATR) 2	*H*
a. kómetelo	−1			−20
b. kómetelɔ			−1	−2
✓ c. kɔ́metelɔ		+2	−2	2
× d. kɔ́mɛtelɔ		+3	−3	3
× e. kɔ́metɛlɔ		+3	−3	3
☞✓ f. kɔ́mɛtɛlɔ		+4	−4	4

- [kɔ́metelɔ] is no longer harmonically bounded.
- Spreading to the licensor earns +2 from LICENSE but just −1 from IDENT.

- As long as w(IDENT) < $2w$(LICENSE), we get this harmony:

(15)

/kómetelos/	MAX(–ATR) 20	LICENSE 3	IDENT(ATR) 4	*H*
a. kómetelo	−1			−20
b. kómetelɔ			−1	−4
☞✓ c. kɔ́metelɔ		+2	−2	−2
× d. kɔ́mɛtelɔ		+3	−3	−3
× e. kɔ́metɛlɔ		+3	−3	−3
✓ f. kɔ́mɛtɛlɔ		+4	−4	−4

- PG-PL also motivates pretonic harmony—no need for MAXLIC.
- w(IDENT(ATR)-pretonic) > w(LICENSE) → no pretonic harmony:

(16)

/monedéros/	MAX(–ATR) 20	IDENT-pre 4	LICENSE 3	IDENT(ATR) 2	*H*
a. moneðéro	−1				−20
b. moneðérɔ				−1	−2
☞✓ c. moneðɛ́rɔ			+2	−2	2
× d. mɔneðɛ́rɔ		−1	+3	−3	−1
× e. monɛðɛ́rɔ		−1	+3	−3	−1
✓ f. mɔnɛðɛ́rɔ		−2	+4	−4	−4

- w(LICENSE) > w(IDENT) + w(IDENT-pretonic) → pretonic harmony:

(17)

/monedéros/	MAX(–ATR) 20	IDENT-pre 0.5	LICENSE 3	IDENT(ATR) 2	*H*
a. moneðéro	−1				−20
b. moneðérɔ				−1	−2
✓ c. moneðɛ́rɔ			+2	−2	2
× d. mɔneðɛ́rɔ		−1	+3	−3	2.5
× e. monɛðɛ́rɔ		−1	+3	−3	2.5
☞✓ f. mɔnɛðɛ́rɔ		−2	+4	−4	3

- Coordination between pretonic and post-tonic harmony:

(18) a. w(IDENT) > w(LICENSE) → no pretonic or post-tonic harmony

/rekóhelos/	MAX(–ATR) 20	IDENT-pre 0.5	LICENSE 3	IDENT(ATR) 4	*H*
a. rekóhelo	−1				−20
b. rekóhelɔ				−1	−4
☞✓ c. rekɔ́helɔ			+2	−2	−2
✓ d. rekɔ́hɛlɔ			+3	−3	−3
✓ e. rɛkɔ́hɛlɔ		−1	+4	−4	−4.5
× f. rɛkɔ́helɔ		−1	+3	−3	−3.5

b. w(IDENT-pre) > w(LICENSE) > w(IDENT) → only post-tonic harmony

/rekóhelos/	MAX(–ATR) 20	IDENT-pre 4	LICENSE 3	IDENT(ATR) 2	*H*
a. rekóhelo	−1				−20
b. rekóhelɔ				−1	−2
✓ c. rekɔ́helɔ			+2	−2	2
☞✓ d. rekɔ́hɛlɔ			+3	−3	3
✓ e. rɛkɔ́hɛlɔ		−1	+4	−4	0
× f. rɛkɔ́helɔ		−1	+3	−3	−1

c. w(LICENSE) > w(IDENT) + w(IDENT-pre) → pretonic and post-tonic harmony

/rekóhelos/	MAX(–ATR) 20	IDENT-pre 0.5	LICENSE 3	IDENT(ATR) 2	*H*
a. rekóhelo	−1				−20
b. rekóhelɔ				−1	−2
✓ c. rekɔ́helɔ			+2	−2	2
✓ d. rekɔ́hɛlɔ			+3	−3	3
☞✓ e. rɛkɔ́hɛlɔ		−1	+4	−4	3.5
× f. rɛkɔ́helɔ		−1	+3	−3	2.5

(19) High vowels:

/krísis/	MAX(–ATR) 20	*[+hi, –ATR] 12	IDENT-pre 0.5	LICENSE 3	IDENT(ATR) 2	H
a. krísi	−1					−20
☞✓ b. krísɪ		−1			−1	−14
c. krɪ́sɪ		−2		+2	−2	−22

3.3 Summary

(20)

Input	**Candidate**	**Attested?**	**Neg. PL**	**Pos. PL**
a. /monedéros/	moneðéro			
‘purses’	moneðérɔ			
	moneðɛ́rɔ	✓		
	mɔneðɛ́rɔ		Bounded	Bounded
	monɛðɛ́rɔ		Bounded	Bounded
	mɔnɛðɛ́rɔ	✓		
b. /kómetelos/	kómetelo			
‘eat them	kómetelɔ			
(for you)!’	kɔ́metelɔ	✓	Bounded	
	kɔ́mɛtelɔ		Bounded	Bounded
	kɔ́metɛlɔ		Bounded	Bounded
	kɔ́mɛtɛlɔ	✓		
c. /rekógelos/	rekóhelo			
‘pick them’	rekóhelɔ			
	rekɔ́helɔ	✓	Bounded	
	rekɔ́hɛlɔ	✓		
	rɛkɔ́helɔ		Bounded	Bounded
	rɛkɔ́hɛlɔ	✓		
d. /krísis/	krísi			
‘crisis’	krísɪ	✓		
	krɪ́sɪ			

- Negative PL: two attested candidates are harmonically bounded: [kɔ́metelɔ], [rekɔ́helɔ].
- Positive PL: no attested candidate is harmonically bounded.
- NHG with negative PL must produce [kɔ́metelɔ], [rekɔ́helɔ] without producing other harmonically bounded forms.

4 Noisy HG & Simulations

- Several families of implementations (Hayes 2017):

(21) a. *Constraint-level noise (2 versions)*

	C_1 $2{+}i$	C_2 $1{+}j$	H *premultiplicative*	H *postmultiplicative*
(☞) a. CandA	-1	-1	$-1(2+i)-1(1+j)$	$(-1*2)+i+(-1*1)+j$
(☞) b. CandB		-2	$0(2+i)-2(1+j)$	$(0*2)+i+(-2*1)+j$

b. *Cell-level noise (2 versions)*

	C_1 2	C_2 1	H *premultiplicative*	H *postmultiplicative*
(☞) a. CandA	-1 i	-1 j	$-1(2+i)-1(1+j)$	$(-1*2)+i+(-1*1)+j$
(☞) b. CandB	k	-2 l	$0(2+k)-2(1+l)$	$(0*2)+k+(-2*1)+l$

c. *Candidate-level noise*

	C_1 2	C_2 1	H
(☞) a. CandA	-1	-1	$-3+i$
(☞) b. CandB		-2	$-2+j$

d. *Maximum Entropy (Goldwater & Johnson 2003)*

	C_1 2	C_2 1	H	*Proabability*
(☞) a. CandA	-1	-1	-3	0.269
(☞) b. CandB		-2	-2	0.731

- Our taxonomy:

1. Noise at the constraint level
    (a) Classical NHG: Noise added before multiplication of penalties by weights: $penalty * (weight + noise)$
    (b) Noise added after multiplication of penalties by weights: $(penalty * weight) + noise$
2. Noise at the cell level
    (a) Noise added before multiplication of penalties by weights: $penalty * (weight + noise)$
    (b) Noise added after multiplication of penalties by weights: $(penalty * weight) + noise$
3. Noise at the candidate level
4. Maximum Entropy

- Only Classical NHG cannot produce harmonically bounded outputs (Hayes 2017).[1]
- Monte Carlo simulations following Hayes (2017) using OTSoft (Hayes et al. 2013): 6 variants of NHG; NG-PL and PG-PL.
- 100,000 trials per simulation. Negative constraint weights were disallowed.

4.1 Constraint-Level Noise

- Most successful arrangement: Hayes's Classical NHG (variety 1a) with PG-PL:

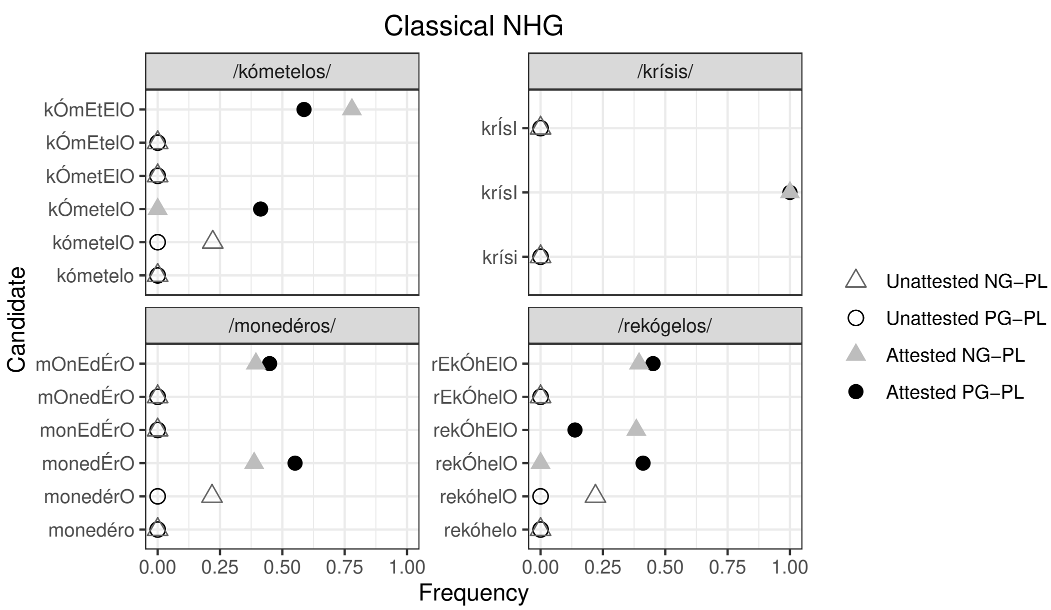


Figure 1: Results of simulations under variety 1a

- All and only attested forms produced.
- Subsequent iterations: unattested forms produced rarely.
  - Worst result: *[krísi] produced 38 times out of 100,000 trials.
  - 2 other illicit forms produced: *[kɔ́mɛtelɔ], *[monɛðέrɔ]
- Classical NHG with NG-PL is less successful.
  - Attested [kɔ́metelɔ], [rekɔ́helɔ] cannot be produced.
  - Unattested *[moneðérɔ], *[kómetelɔ], *[rekóhelɔ] appear at a ∼ 22% rate.

[1]With only positive constraint weights, a harmonically bounded candidate is selected under Classical NHG only when it ties with a rival (Hayes 2017). Ties occurred very rarely in my simulations (for the PG-PL simulation in Figure 1: 125 ties in 66,565,284 chances), so I take it to be a reasonable approximation to say that Classical NHG does not produce harmonically bounded candidates. Indeed, in none of my simulations with Classical NHG did a harmonically bounded candidate win.

- Classical NHG succeeds only when no attested form is harmonically bounded. Under those conditions, it performs very well.

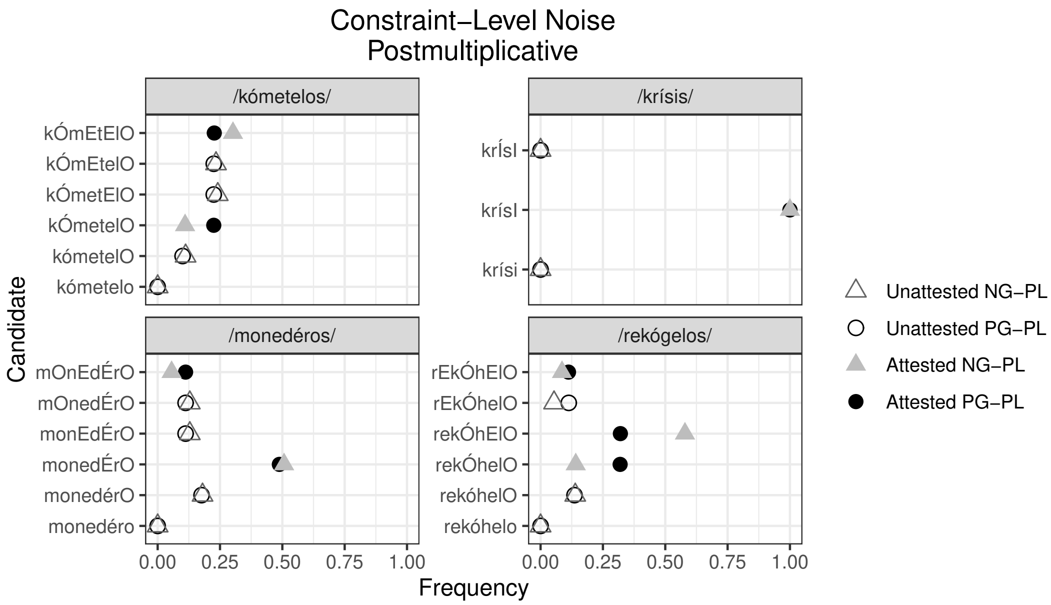


Figure 2: Results of simulations under variety 1b

- PG-PL: $w(\textsc{License}) = 24517.285$

4.2 Cell-Level Noise

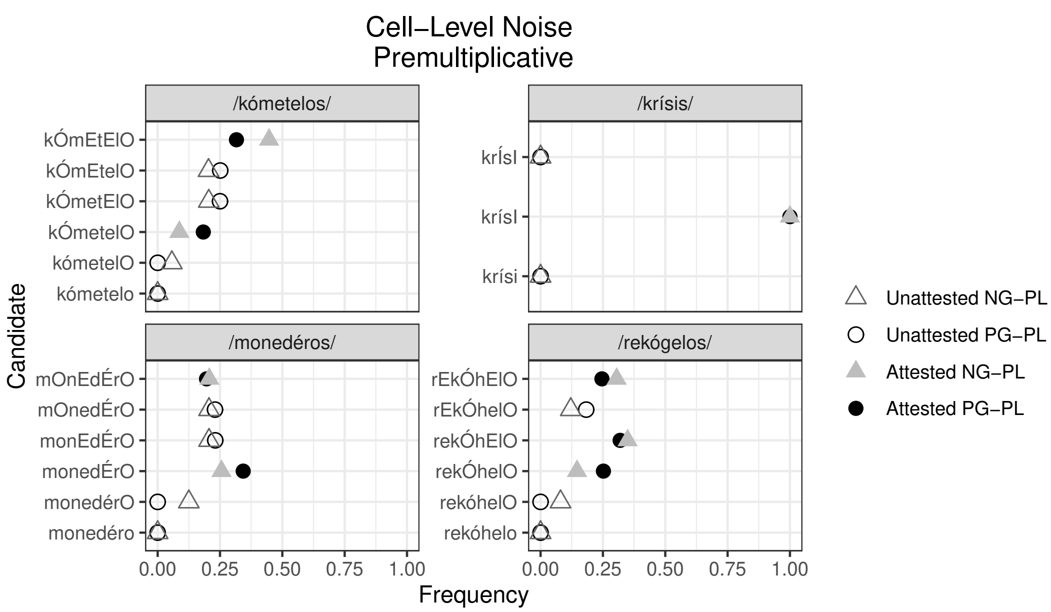


Figure 3: Results of simulations under variety 2a

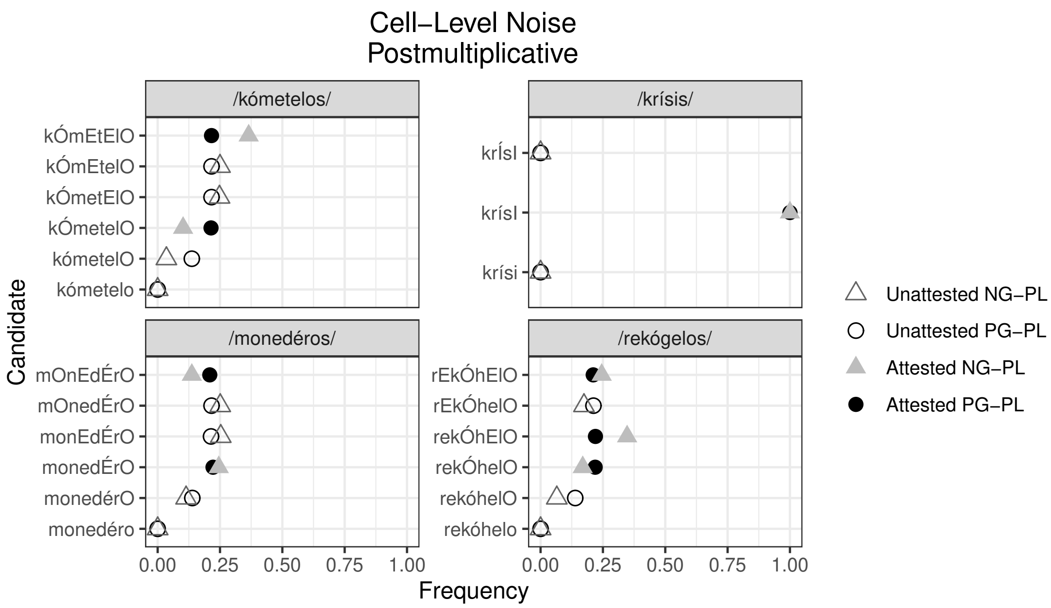


Figure 4: Results of simulations under variety 2b

- PG-PL: $w(\textsc{License}) = 22586.572$

4.3 Candidate-Level Noise

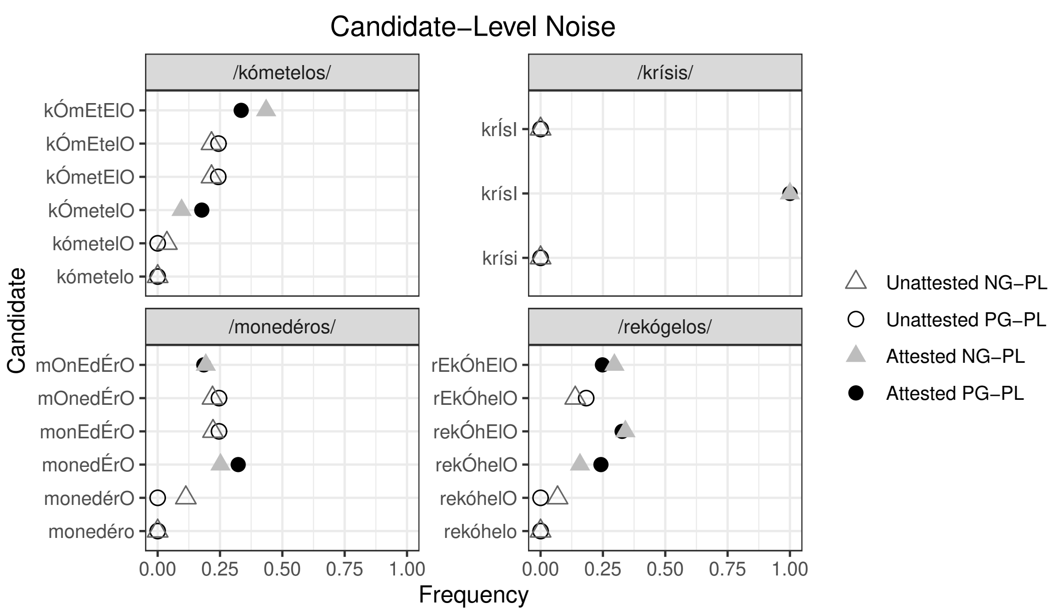


Figure 5: Results of simulations under variety 3

4.4 MaxEnt

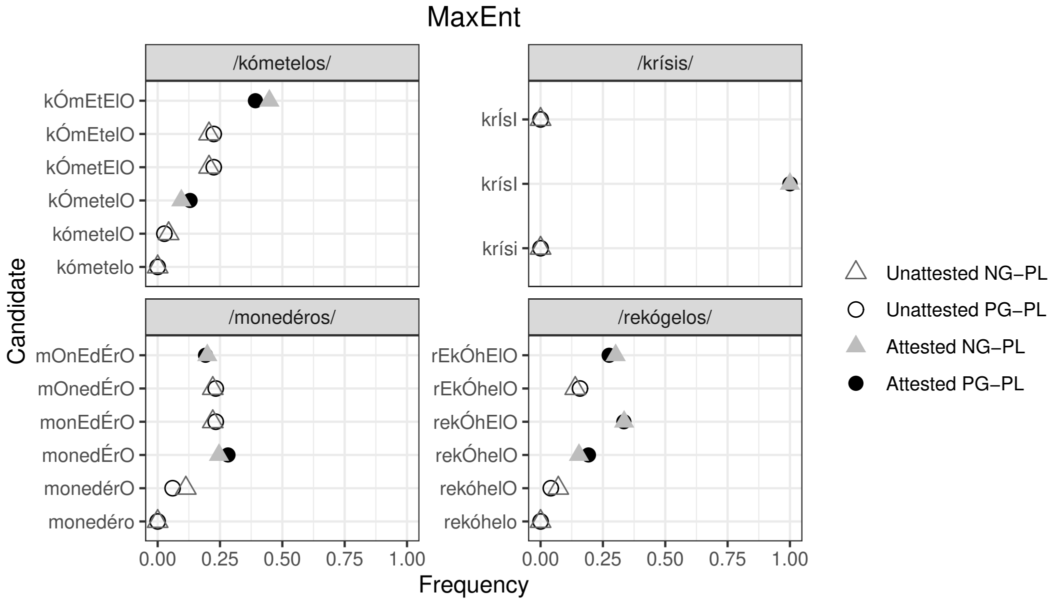


Figure 6: Results of simulations under MaxEnt

- NG-PL & PG-PL: Max(–ATR) always at ceiling

5 Why is Classical NHG Better?

- Weights from Classical NHG with PG-PL:

(22)

Max(–ATR)	46.000
*[+hi, –ATR]	27.000
License	11.655
Ident(ATR)	11.345
Ident(ATR)-pretonic	0.251

- Dominance of Max(–ATR): final vowels always lax.
- *[+hi, –ATR] in second place: no non-final high lax vowels.
- All versions of NHG can do these two things.
- Classical NHG has the right tools for the remaining challenges:
  - Harmonically bounded candidates are excluded.
  - Only remaining unattested forms have no harmony (*[moneðérɔ]): ruled out if w(Ident) $< 2w$(License).

- Harmonically bounded candidates are inevitable for non-Classical NHG:

(23)

/kómetelos/	LICENSE w_L	IDENT w_I	H
✓ a. kɔ́metelɔ	+2	−2	$2w_L - 2w_I$
× b. kɔ́mɛtelɔ	+3	−3	$3w_L - 3w_I$
× c. kɔ́metɛlɔ	+3	−3	$3w_L - 3w_I$
✓ d. kɔ́mɛtɛlɔ	+4	−4	$4w_L - 4w_I$

(24) Outcomes:

a. $w_L > w_I \rightarrow$ (d) wins; (b/c) have better scores than (a)
b. $w_L < w_I \rightarrow$ (a) wins; (b/c) have better scores than (d)
c. $w_L = w_I \rightarrow$ 4-way tie

- Under (24a) or (24b): candidates (b) and (c) have scores between (a) and (d).
  - Good for Classical NHG, bad for other versions.
  - Classical NHG: only (a) and (d) win.
  - MaxEnt: probabilities are proportional to harmony scores. (b/c) must be at least as probable as (a) or (d).
  - Candidate-level noise: (b/c) have better "base" scores than (a) or (d), so they have a better chance of winning after noise is added.
  - Remaining varieties: same story: (b/c) have a head start on (a) or (d).
- Under (24c):
  - Classical NHG: unlikely after stochastic manipulation of weights.
  - The best arrangement for non-Classical NHG: (a) and (d) have equal starting scores and equal probabilities. But so do (b/c).

⇒ It is impossible to elevate (a/d) without also elevating (b/c)!

- Classical NHG is fundamentally different in an advantageous way.
- Full NG-PL analysis: (a) is also harmonically bounded. If NHG produces this harmonically bounded candidate, it produces the others, too.
- Better to let the constraints identify viable candidates that NHG can choose from. We want the harmonically bounded candidates to be out of reach.

6 Optional Reduplication in Pima

- Pima (Uto-Aztecan; Arizona): plural marked with C or CV reduplication (Munro & Riggle 2004, Riggle 2006):

(25)

		Singular	*Plural*	*Gloss*
(25)	a.	mavit̪	mamvit̪	'lion'
		nakʃɨɹ	nankʃɨɹ	'scorpion'
		kakait͡ʃu	kakkait͡ʃu	'quail'
		kosvuɹ	koksvuɹ	'cocoon'
		maʃad	mamʃad	'moon'
	b.	hod̪ai	hohod̪ai	'rock'
		biʃp	bibiʃp	'horse collar'
		ʔiput̪	ʔiʔiput̪	'dress'
		ɲɨpod	ɲɨɲɨpod	'night hawk'
		mond͡ʒuɹ	momond͡ʒuɹ	'cape'

- In compounds, any number of stems may reduplicate (as long as at least one does):

	Singular	*Plural*	*Gloss*
(26)	mìish-kíi	mìmsh-kíik, mìmsh-kíi, mìish-kíik	'church' (mass-house)
	bàn-nódːadag	bàban-nóndːadag, bàban-nódːadag, bàn-nóndːadag	'peyote' (coyote-plant.type)
	ʔùs-kálit	ʔùʔus-káklit, ʔùʔus-kálit, ʔùs-káklit	'wagon' (tree-car)

- For n stems, $2^n - 1$ possible plurals.
- Unlike Eastern Andalusian, no logically possible combinations are illicit (except lack of reduplication).

- Larger compounds: all combinations of reduplication possible:

(27)

	Singular	*Plural*
a.	[ʔus-kàlit]-[vaínom] 'wagon-knife' [tree-car]-[knife]	[ʔuʔus-kàkalit]-[vápainom] (7 variants)
b.	[vil-gòodii]-[pas-tíil] 'apricot pie' [apricot]-[pie]	[vipil-gògodii]-[paps-títil] (15 variants)
c.	[li-mìida]-[hoas-hàʔa]-[dágkuanakudː] 'glass dish cloth' [glass]-[baskety-jar]-[wiper]	[lil-mìmida]-[hoahas-hàhaʔa]-[dádagkuanakudː] (31 variants)

- Riggle & Wilson (2005):
  - Reduplication is motivated by Max-[C-BR and penalized by *Structure.
  - RealizeMorpheme (e.g. Kurisu 2001) ensures at least one reduplicant.
- But intermediate levels of reduplication are harmonically bounded:

(28)

/[vil-gòodii]-[pas-tíil]/	RealizeMorph	Max-[C-BR	*Structure
a. [vil-gòodii]-[pas-tíil]	−1	−4	
✓ b. [vipil-gòdii]-[pas-tíl] etc.		−3	−1
×✓ c. [vipil-gògodii]-[pas-tíl] etc.		−2	−2
×✓ d. [vil-gògodii]-[paps-títil] etc.		−1	−3
✓ e. [vipil-gògodii]-[paps-títil]			−4

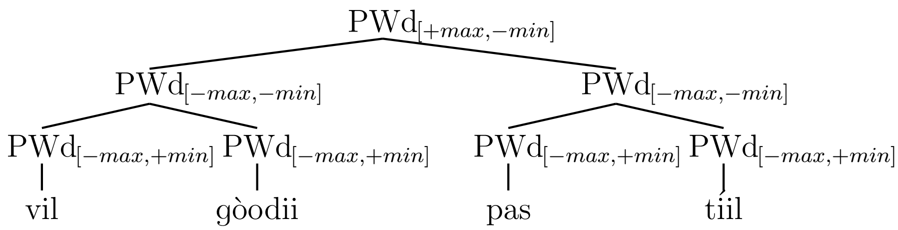
- Positive constraints are no use: no possibility for 2-for-1 tradeoffs.
  - Positive *Structure: +1 for each stem with no reduplicant:

(29)

/[vil-gòodii]-[pas-tíil]/	RealizeMorph	Max-[C-BR	*Structure
a. [vil-gòodii]-[pas-tíil]	−1	−4	+4
✓ b. [vipil-gòdii]-[pas-tíl] etc.		−3	+3
×✓ c. [vipil-gògodii]-[pas-tíl] etc.		−2	+2
×✓ d. [vil-gògodii]-[paps-títil] etc.		−1	+1
✓ e. [vipil-gògodii]-[paps-títil]			

- This seems like an excellent argument for non-Classical NHG!
- Solution: position-sensitive constraints.
- A recursive view (Ito & Mester 2009 et. seq., especially Ito & Mester 2013) of Pima's compounds, based on Munro & Riggle's (2004) description:

(30)



- Positional Faithfulness constraints (Beckman 1999) can trigger or block reduplication in prominent positions:

(31) a. The minimal PWd that is the head of the maximal PWd: *tíil*
b. Minimal PWds that are heads of intermediate PWds: *gòodii*, *tíil*
c. PWds that are initial in the maximal PWd: *vil*

- Kaplan (2016):
  - Max-BR for each position in (31): triggers reduplication
  - Contiguity for each position in (31): blocks reduplication
  - RealizeMorpheme as before
  - Variable rankings (Anttila 1997) yield all possibilities.
- Classical NHG produces all outputs for 'apricot pie' (underline = reduplicated stem):

(32)

Candidate	Frequency	Candidate	Frequency
[vil-góodii]-[pas]-[tíil]	0.000	✓[vil-$\underline{\text{g̀oodii}}$]-[$\underline{\text{pas}}$]-[tíil]	0.015
✓[$\underline{\text{vil}}$-góodii]-[pas]-[tíil]	0.151	✓[vil-$\underline{\text{g̀oodii}}$]-[pas]-[$\underline{\text{tíil}}$]	0.071
✓[vil-$\underline{\text{g̀oodii}}$]-[pas]-[tíil]	0.083	✓[vil-góodii]-[$\underline{\text{pas}}$]-[$\underline{\text{tíil}}$]	0.010
✓[vil-góodii]-[$\underline{\text{pas}}$]-[tíil]	0.124	✓[$\underline{\text{vil}}$-$\underline{\text{g̀oodii}}$]-[$\underline{\text{pas}}$]-[tíil]	0.040
✓[vil-góodii]-[pas]-[$\underline{\text{tíil}}$]	0.107	✓[$\underline{\text{vil}}$-$\underline{\text{g̀oodii}}$]-[pas]-[$\underline{\text{tíil}}$]	0.036
✓[$\underline{\text{vil}}$-$\underline{\text{g̀oodii}}$]-[pas]-[tíil]	0.013	✓[$\underline{\text{vil}}$-góodii]-[$\underline{\text{pas}}$]-[$\underline{\text{tíil}}$]	0.019
✓[$\underline{\text{vil}}$-góodii]-[$\underline{\text{pas}}$]-[tíil]	0.048	✓[vil-$\underline{\text{g̀oodii}}$]-[$\underline{\text{pas}}$]-[$\underline{\text{tíil}}$]	0.060
✓[$\underline{\text{vil}}$-góodii]-[pas]-[$\underline{\text{tíil}}$]	0.018	✓[$\underline{\text{vil}}$-$\underline{\text{g̀oodii}}$]-[$\underline{\text{pas}}$]-[$\underline{\text{tíil}}$]	0.206

- Classical NHG doesn't preclude analysis of optionality like Pima's.
- Like Eastern Andalusian, we just have to use the right constraints!

7 Conclusion

- Harmonic bounding imposes beneficial structure on the candidate set, passing a more manageable set of candidates to NHG.
- Circumventing harmonic bounding seems advantageous for optionality, but it's actually counterproductive.
- The best model comes from the least powerful framework, Classical NHG...
- ... but Classical NHG needs positive constraints—positive constrains are useful!
- Intricate optionality can emerge without a bulky apparatus dedicated to it: Classical NHG merely adjusts constraint weights.
- Conclusions about the necessary arrangements for optionality have implications for non-optional phenomena.

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