Noisy HG Models of Eastern Andalusian Harmony

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1 Introduction

- Noisy Harmonic Grammar (NHG) provides a range of ways to produce variation depending on the details of the formal implementation (Hayes 2017).
- ATR harmony in Eastern Andalusian presents a good test of these possibilities:
  - Variation instantiates almost all of Walker's (2011) licensing-based typology.
  - This variation is constrained by categorical requirements.
  - Depending on the constraint set, some attested forms are harmonically bounded.
- My argument: the best NHG model of Eastern Andalusian is one that cannot produce harmonically bounded forms. Therefore we must use constraints under which attested forms are not harmonically bounded.

2 Eastern Andalusian Harmony

- /s/-aspiration: word-final /s/ deletes, triggering laxing of adjacent vowel.
- These lax vowels trigger variable harmony on preceding vowels.
- The stressed vowel always harmonizes (data from Jiménez & Lloret 2007, Lloret & Jiménez 2009):

(1)

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*	bɔ́kạ̈	'mouths'

- Other post-tonic vowels optionally harmonize as a group:

(2)

a.	*treboles*	tréβolɛ ∼ tréβɔlɛ	‘clovers’
b.	*cómetelos*	kómetelɔ ∼ kómɛtɛlɔ	‘eat them (for you)!’
		*kómɛtelɔ, *kómetɛlɔ	

- Pretonic vowels optionally harmonize as a group, but only with post-tonic harmony:

(3)

a.	*momentos*	moméntɔ ∼ mɔméntɔ	‘instants’
b.	*reloj*	relɔ́ ∼ rɛlɔ́	‘watch’
c.	*relojes*	relɔ́hɛ ∼ rɛlɔ́hɛ	‘watches’
d.	*monederos*	moneðéɾɔ ∼ mɔnɛðéɾɔ	‘purses’
		*mɔneðéɾɔ, *monɛðéɾɔ	
e.	*cojines*	kohínɛ ∼ kɔhínɛ	‘pillows’
f.	*cotillones*	kotiʒɔ́nɛ ∼ kɔtiʒɔ́nɛ	‘cotillions’
g.	*recógelos*	rekɔ́helɔ ∼ rekɔ́hɛlɔ ∼ rɛkɔ́hɛlɔ	‘pick them’
		*rɛkɔ́helɔ	

- High vowels lax word finally but do not undergo harmony:

(4)

a.	*crisis*	krísɪ	‘crisis’
b.	*muchos*	múʃɔ	‘many’
c.	*mios*	míɔ	‘mine (pl.)’

- Positional licensing (PL): [–ATR] must appear in the stressed syllable or in every syllable (Jiménez & Lloret 2007, Lloret 2018, Lloret & Jiménez 2009, Walker 2011; analyses below are based on this work).

- Goal: assess which combinations of constraints and implementations of NHG best model Eastern Andalusian harmony.
  - Constraints: negative and positive versions of PL (Kaplan 2018).
  - NHG: 7 implementations from Hayes (2017).

- Hayes’s (2017) “classic NHG” does best for Eastern Andalusian: NHG cannot adequately distinguish “good” harmonically bounded candidates from “bad” ones. It needs help from the constraint set.

- That help is provided by positive PL.

3 Positional Licensing Analyses

3.1 Candidates of Interest

(5)

Input	Candidate	Attested?	Neg. PL	Pos. PL
a. /monedéros/	moneðéro			
'purses'	moneðéɾɔ			
	moneðɛ́ɾɔ	✓		
	mɔneðɛ́ɾɔ		Bounded	Bounded
	monɛðɛ́ɾɔ		Bounded	Bounded
	mɔnɛðɛ́ɾɔ	✓		
b. /kómetelos/	kómetelo			
'eat them	kómeteloɔ			
(for you)!'	kɔ́meteloɔ	✓	Bounded	
	kɔ́mɛteloɔ		Bounded	Bounded
	kɔ́meteɛloɔ		Bounded	Bounded
	kɔ́mɛteɛloɔ	✓		
c. /rekógelos/	rekóhelo			
'pick them'	rekóheloɔ			
	rekɔ́heloɔ	✓	Bounded	
	rekɔ́hɛloɔ	✓		
	rɛkɔ́heloɔ		Bounded	Bounded
	rɛkɔ́hɛloɔ	✓		
d. /kɾísis/	kɾísi			
'crisis'	kɾísɪ	✓		
	kɾísɪ			

- Positive PL: no attested candidate is harmonically bounded.
- Negative PL: two attested candidates are harmonically bounded: *kɔ́meteloɔ, rekɔ́heloɔ*.
- Both: some unattested candidates are harmonically bounded; other are not.
- NHG with negative PL must produce *kɔ́meteloɔ, rekɔ́heloɔ* without producing other harmonically bounded forms.

3.2 Negative PL

- To avoid pathologies in HG, PL must be gradient: Negative Gradient PL (NG-PL; Kaplan 2018):

(6) 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 $\acute{\sigma}$.

- This accounts for harmony up to the licensor.

- Pretonic harmony: Maximal Licensing (Walker 2011) requires [–ATR] to appear in every syllable.
- IDENT(ATR) disfavors harmony.
- These constraints produce post-tonic and pretonic harmony, but forms with no post-tonic harmony are harmonically bounded.
- LICENSE penalizes unharmonized post-tonic vowels in *kɔ́metelɔ*, *rekɔ́helɔ* to avoid pathologies (Kaplan 2018).
- ☞ = attested; × = harmonically bounded

(7) a.

/monedéros/	LICENSE	MAXLIC	IDENT	*Comments*
a. moneðéɾɔ	−1	−3	−1	
☞ b. moneðéɾɔ		−2	−2	
☞ c. mɔnɛðéɾɔ			−4	
× d. mɔneðéɾɔ		−1	−3	collectively bounded[1] by (b) & (c)
× e. monɛðéɾɔ		−1	−3	collectively bounded by (b) & (c)

b.

/kómetelos/	LICENSE	MAXLIC	IDENT	*Comments*
a. kómeteɭɔ	−3	−3	−1	
×☞ b. kɔ́meteɭɔ	−2	−2	−2	collectively bounded by (a) & (c)
☞ c. kɔ́mɛtɛɭɔ			−4	
× d. kɔ́mɛteɭɔ	−1	−1	−3	collectively bounded by (a) & (c)
× e. kɔ́metɛɭɔ	−1	−1	−3	collectively bounded by (a) & (c)

c.

/rekóhelos/	LICENSE	MAXLIC	IDENT	*Comments*
a. rekóheɭɔ	−2	−3	−1	
×☞ b. rekɔ́heɭɔ	−1	−2	−2	collectively bounded by (a) & (c)
☞ c. rekɔ́hɛɭɔ		−1	−3	
☞ d. rɛkɔ́hɛɭɔ			−4	
× e. rɛkɔ́heɭɔ	−1	−1	−3	bounded by (c)

[1]Collective harmonic bounding: Samek-Lodovici & Prince (1999)

- High vowels: *[+hi, –ATR] prevents harmony, MAX(–ATR) forces laxing word-finally.

(8)

/kɾ́isis/	*[+hi, –ATR]	MAX(–ATR)	LICENSE	MAXLIC	IDENT
a. kɾ́isi		−1			
☞ b. kɾ́isɪ	−1		−1	−1	−1
c. kɾísɪ	−2				−2

- What to do about the harmonically bounded attested forms?
  - Nothing: let NHG deal with them.
  - Revise PL: Positive Gradient PL (PG-PL; Kaplan 2018)

3.3 Positive PL

(9) LICENSE([–ATR], $\acute{\sigma}$): assign +1 for each [–ATR] that coincides with $\acute{\sigma}$ and +1 for each additional syllable that [–ATR] appears in.

- This subsumes MAXLIC; we need IDENT(ATR)-pretonic to block pretonic harmony.
- All attested forms are now possible winners.

(10) a.

/monedéros/	LICENSE	IDENT-pretonic	IDENT
a. moneðéɾɔ			−1
☞ b. moneðéɾɔ	+2		−1
☞ c. mɔnɛðéɾɔ	+4	−2	−4
× d. mɔneðéɾɔ	+3	−1	−3
× e. monɛðéɾɔ	+3	−1	−3

b.

/kómetelos/	LICENSE	IDENT-pretonic	IDENT
a. kómetelɔ			−1
☞ b. kɔ́metelɔ	+2		−2
☞ c. kɔ́mɛtɛlɔ	+4		−4
× d. kɔ́mɛtelɔ	+3		−3
× e. kɔ́metɛlɔ	+3		−3

c.

/rekóhelos/	License	Ident-pretonic	Ident
a. rekóhelɔ			−1
☞ b. rekɔ́helɔ	+2		−2
☞ c. rekɔ́hɛlɔ	+3		−3
☞ d. rɛkɔ́hɛlɔ	+4	−1	−4
× e. rɛkɔ́helɔ	+3	−1	−3

d.

/krísis/	*[+hi, –ATR]	Max(–ATR)	License	Ident-pretonic	Ident
a. krísi		−1			
☞ b. krísɪ	−1				−1
☞ c. krísɪ	−2		+2		−2

(11) Core weighting requirements:

a. Harmony on $\acute{\sigma}$ only: $2w(\text{License}) > w(\text{Ident}) > w(\text{License})$
b. Full post-tonic harmony: $w(\text{Ident}) + w(\text{Ident-pre}) > w(\text{License}) > w(\text{Ident})$
c. Maximal harmony: $w(\text{License}) > w(\text{Ident}) + w(\text{Ident-pretonic})$
d. High vowels: $w(\text{Max}(\text{–ATR})) > w(*[\text{+hi, –ATR}]) + w(\text{Ident}) > 2w(\text{License})$

- Summary: 2 ways to produce the variation in Eastern Andalusian:

1. NG-PL: NHG responsible for variation and relieving harmonic bounding.
2. PG-PL: NHG responsible for variation only.

(12) Constraint inventories:

NG-PL	*PG-PL*
License	License
Ident(ATR)	Ident(ATR)
*[+hi, –ATR]	*[+hi, –ATR]
Max(–ATR)	Max(–ATR)
MaxLicense	Ident(ATR)-pretonic
Ident(ATR)-pretonic	

4 Simulations

- Monte Carlo simulations following Hayes (2017): 7 variants of NHG; NG-PL and PG-PL.

1. Noise at the constraint level
   (a) Noise added before multiplication of penalties by weights: $penalty * (weight + noise)$

(b) Noise added after multiplication of penalties by weights, no noise allowed if penalty = 0: $(penalty * weight) + noise$

(c) Noise added after multiplication of penalties by weights, noise allowed if penalty = 0: $(penalty * weight) + noise$

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, no noise allowed if penalty = 0: $(penalty * weight) + noise$

(c) Noise added after multiplication of penalties by weights, noise allowed if penalty = 0: $(penalty * weight) + noise$

3. Noise at the candidate level

- 100,000 trials per simulation. Negative constraint weights were disallowed.
- Target: low probabilities for illicit forms and high probabilities for attested ones
- Most successful arrangement: Hayes's classic NHG (option 1a) with PG-PL:

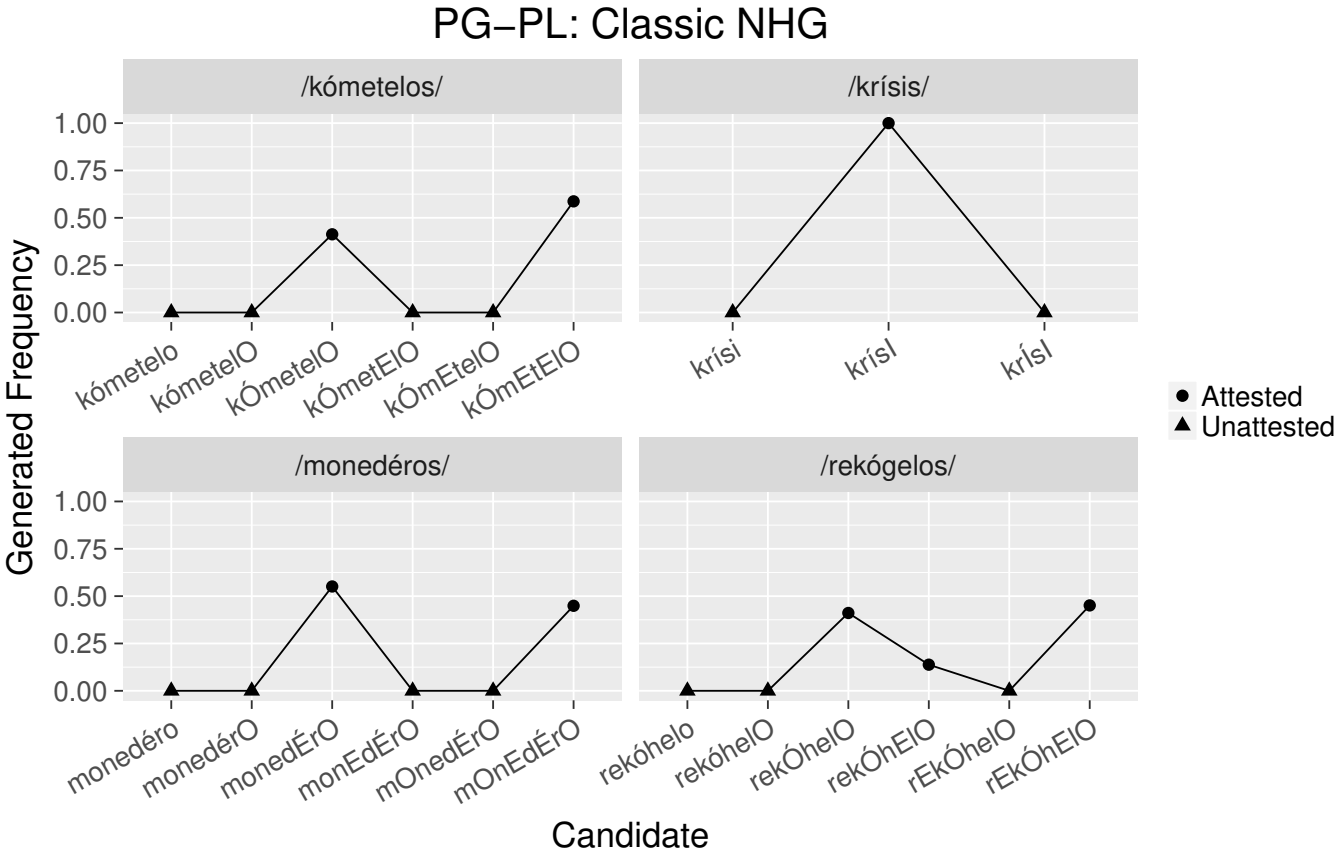

Figure 1: Results of a simulation using PG-PL & variety 1a

- In particular simulation shown here, all and only attested forms produced. Not a minor accomplishment: some illicit forms are not harmonically bounded.
- Subsequent simulations: unattested forms produced rarely. Worst result: *krísi* produced 38 times out of 100,000 trials. 2 other illicit forms produced: *kɔ́mɛtelɔ*, *monɛðérɔ*
- Because classic NHG produces harmonically bounded candidates only under special circumstances,[2] the comparable simulation with NG-PL fares poorly:

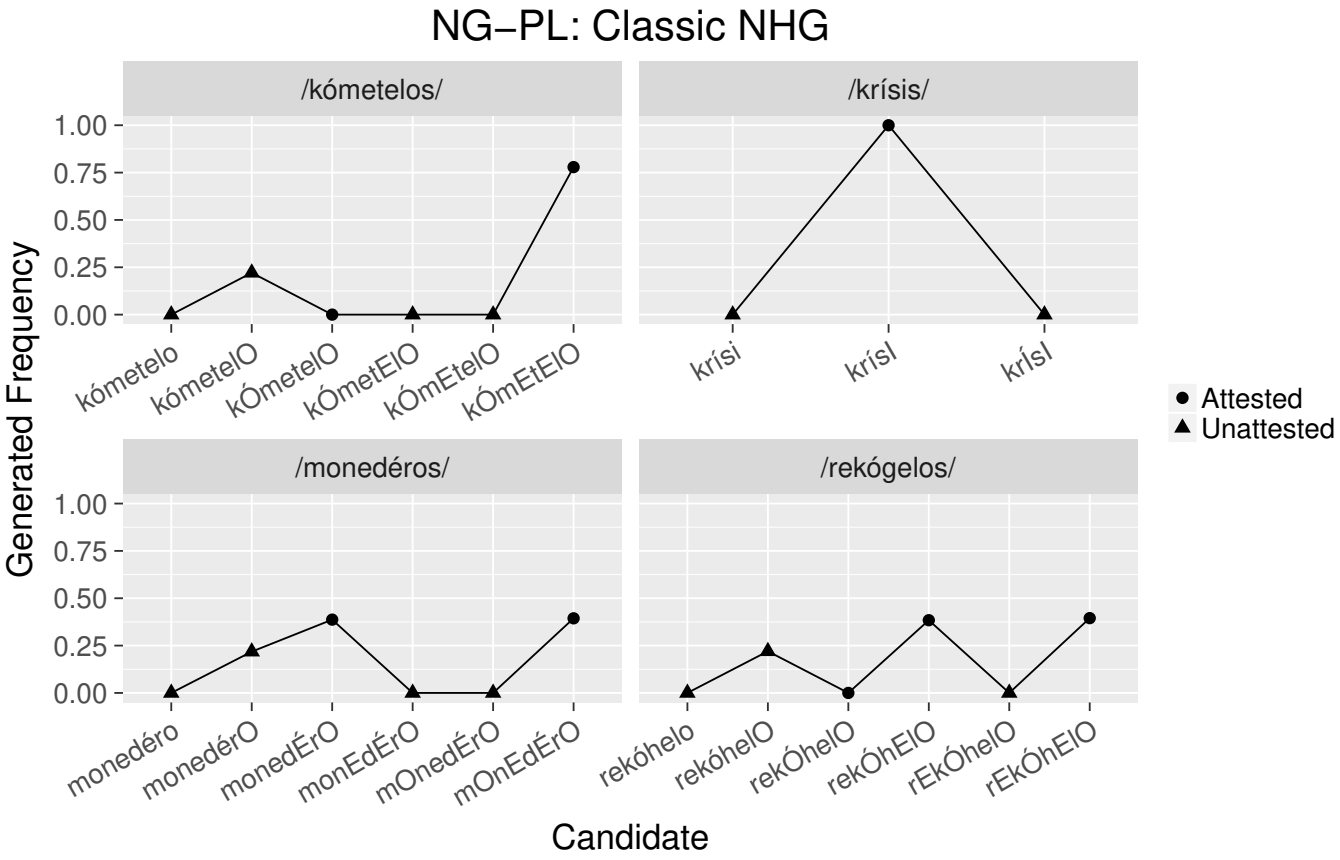

Figure 2: Results of a simulation using NG-PL & variety 1a

- Attested [kɔ́metelɔ], [rekɔ́helɔ] cannot be produced.
- Unattested [moneðérɔ], [kómetelɔ], [rekóhelɔ] appear at a $\sim 22\%$ rate.
- Not surprisingly, classic NHG succeeds only when no attested form is harmonically bounded. Under those conditions, it performs very well on Eastern Andalusian.

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

4.1 Constraint-Level Noise

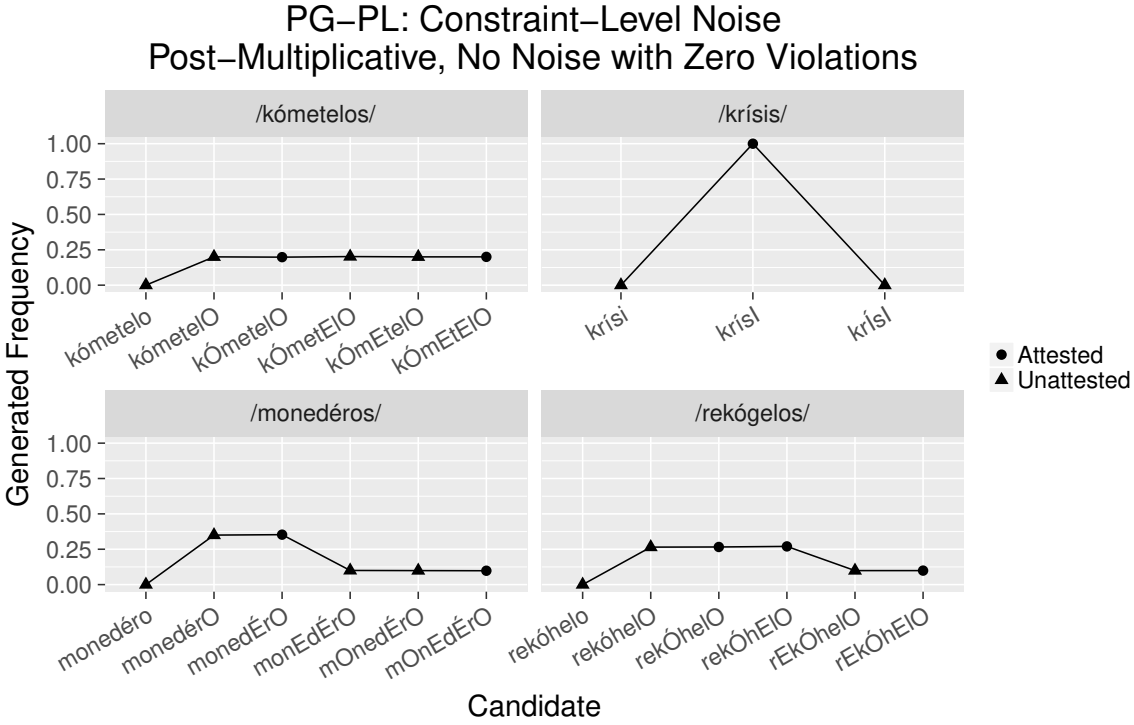

Figure 3: Results of a simulation using PG-PL & option 1b

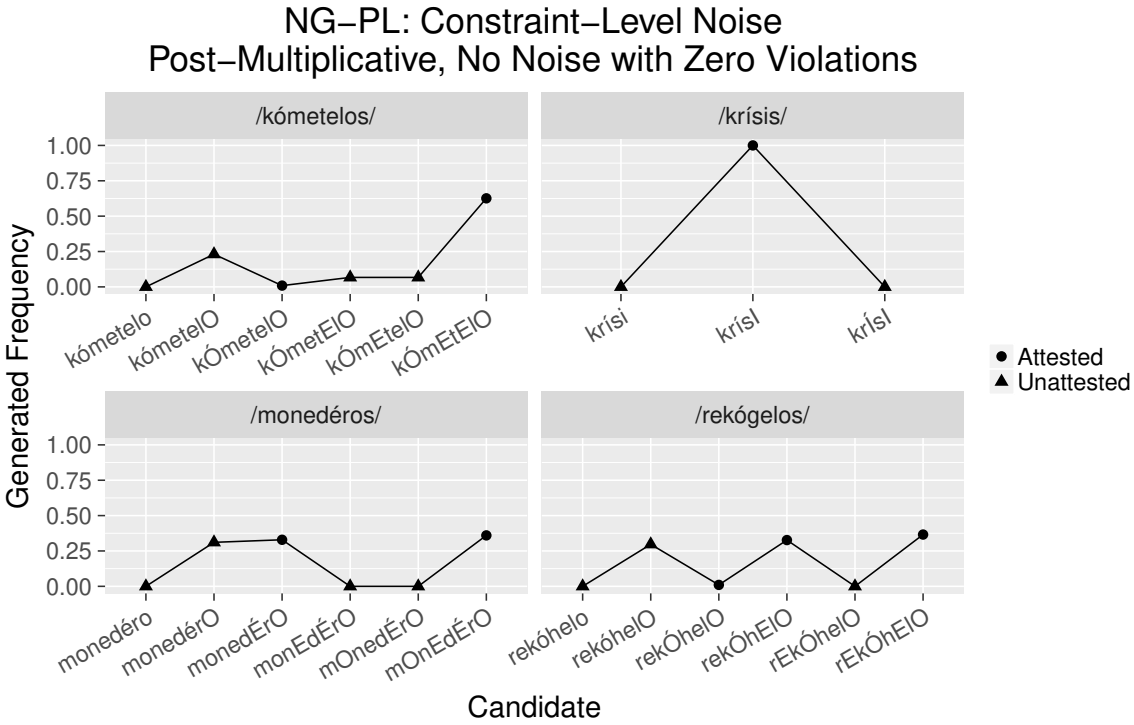

Figure 4: Results of a simulation using NG-PL & option 1b

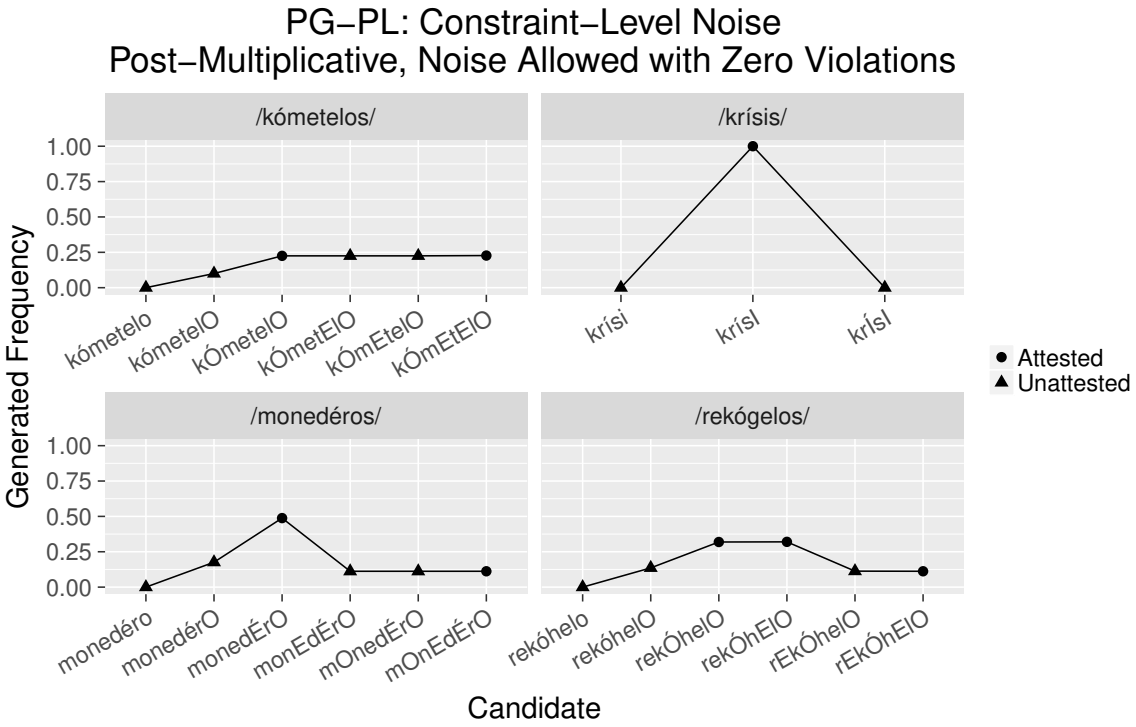

Figure 5: Results of a simulation using PG-PL & option 1c

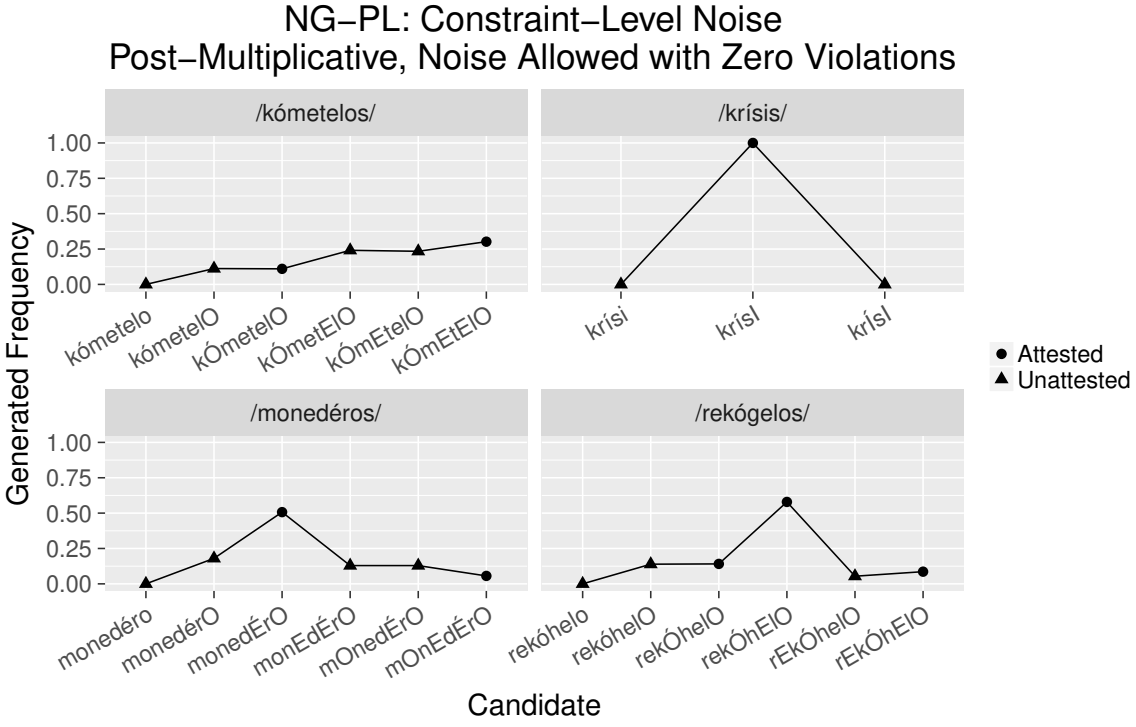

Figure 6: Results of a simulation using NG-PL & option 1c

4.2 Cell-Level Noise

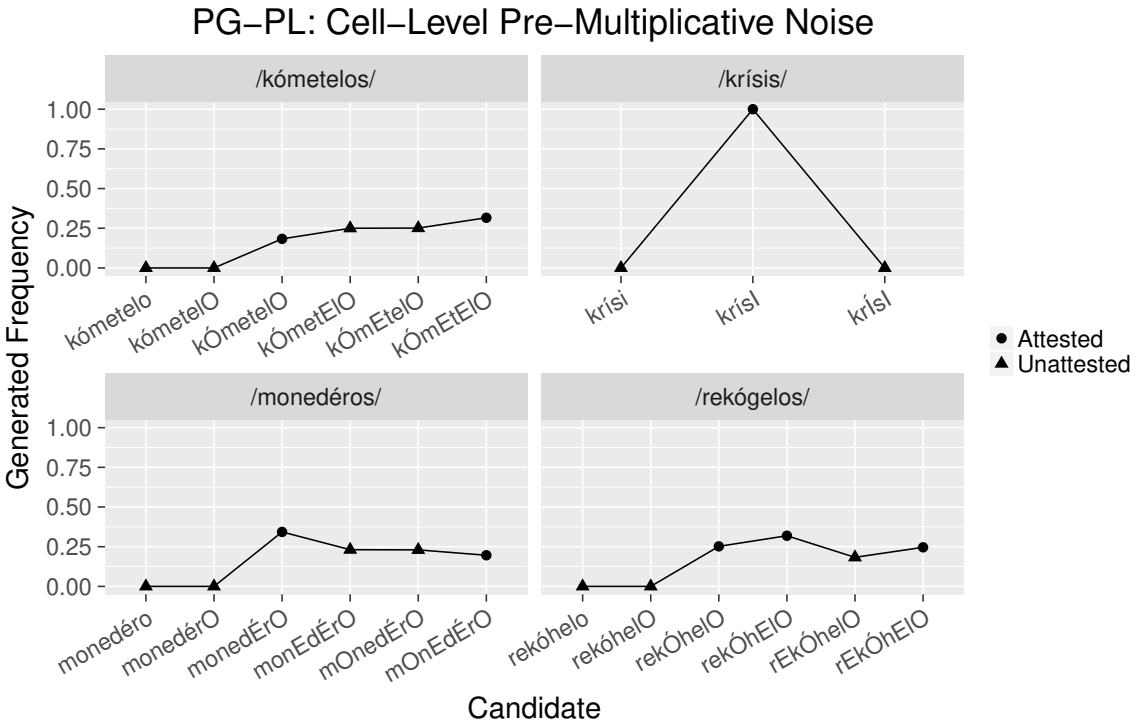

Figure 7: Results of a simulation using PG-PL & variety 2a

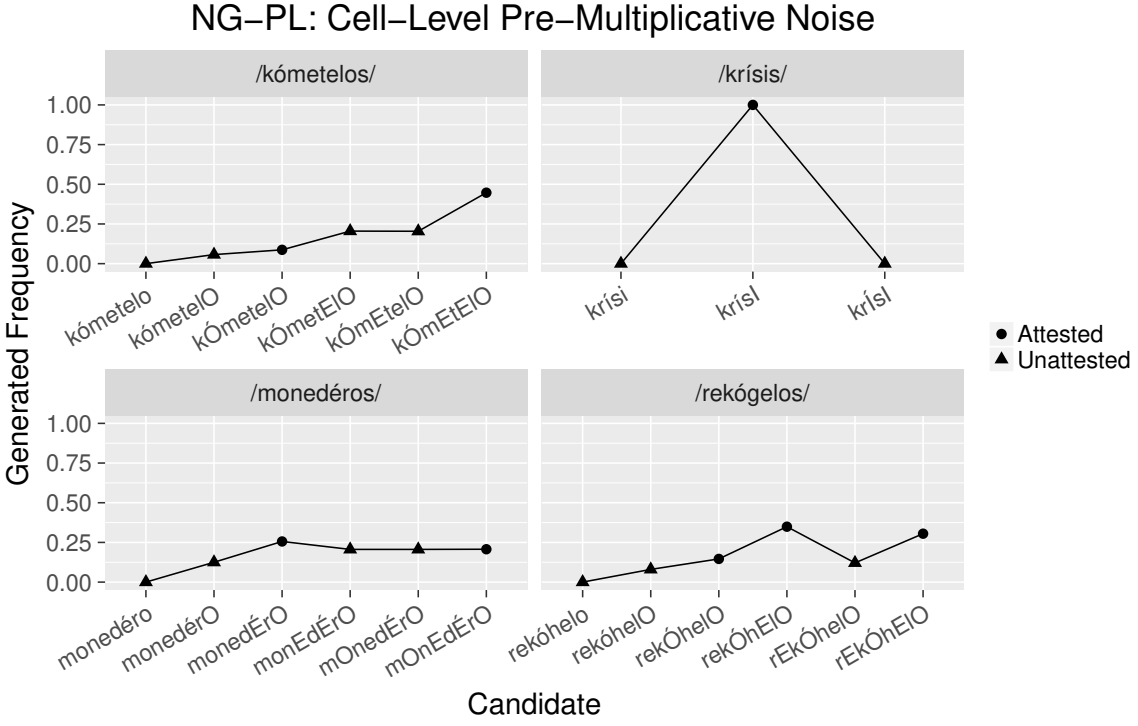

Figure 8: Results of a simulation using NG-PL & variety 2a

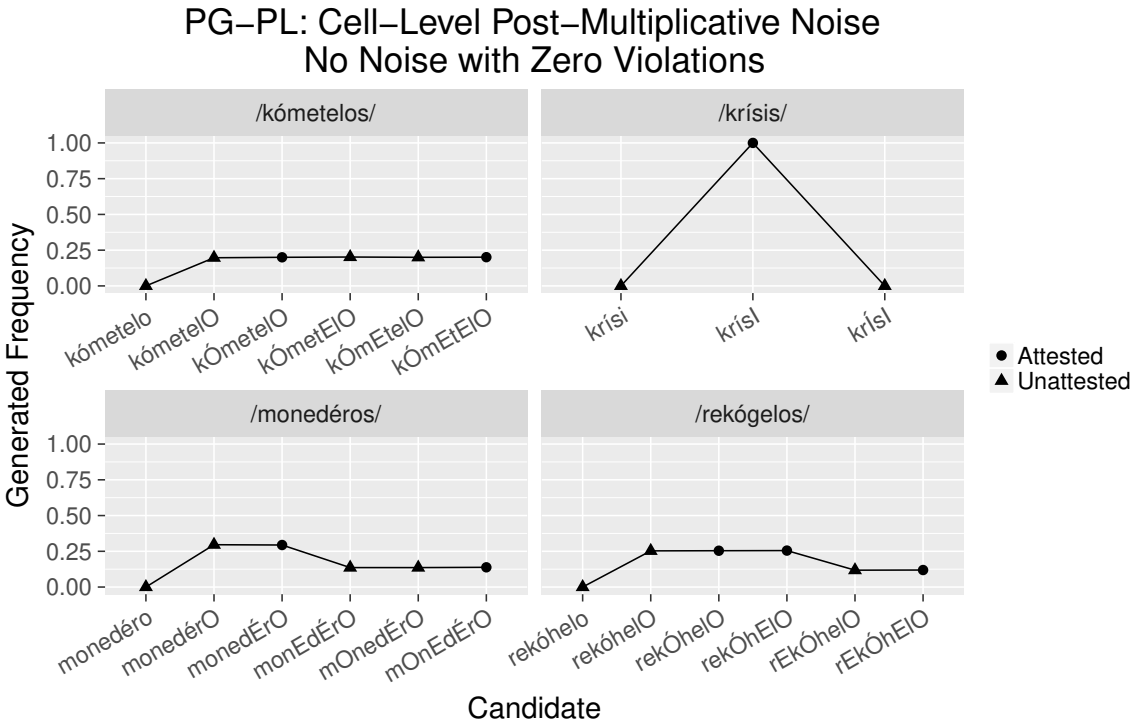

Figure 9: Results of a simulation using PG-PL & option 2b

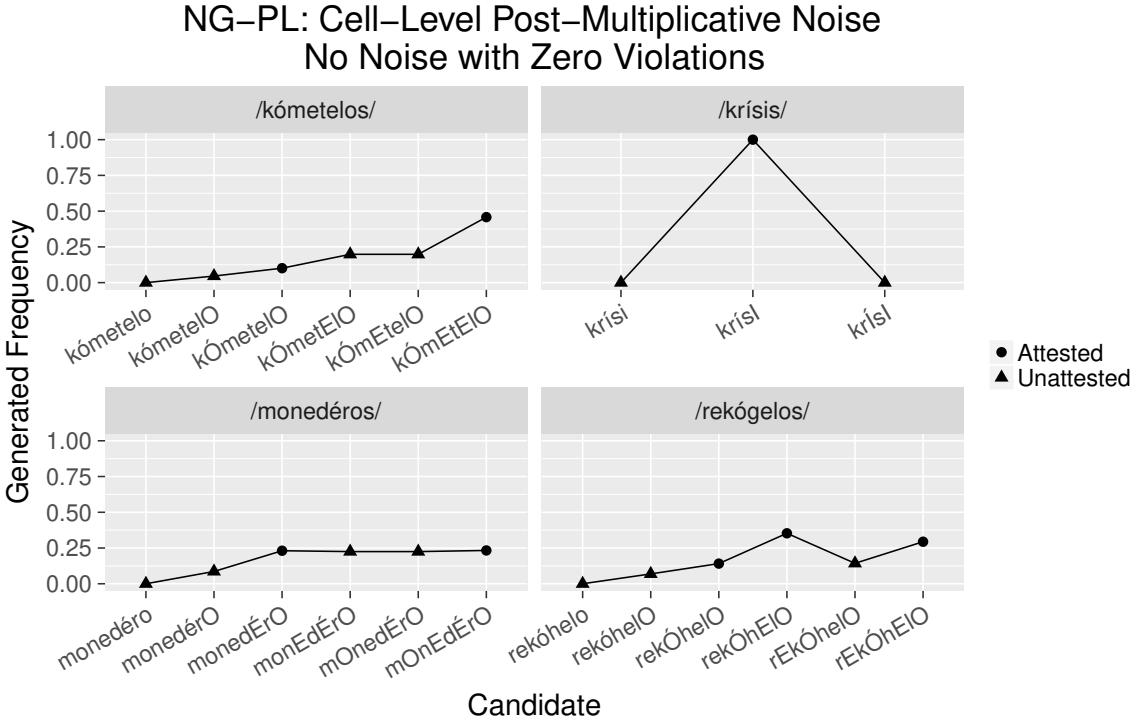

Figure 10: Results of a simulation using NG-PL & option 2b

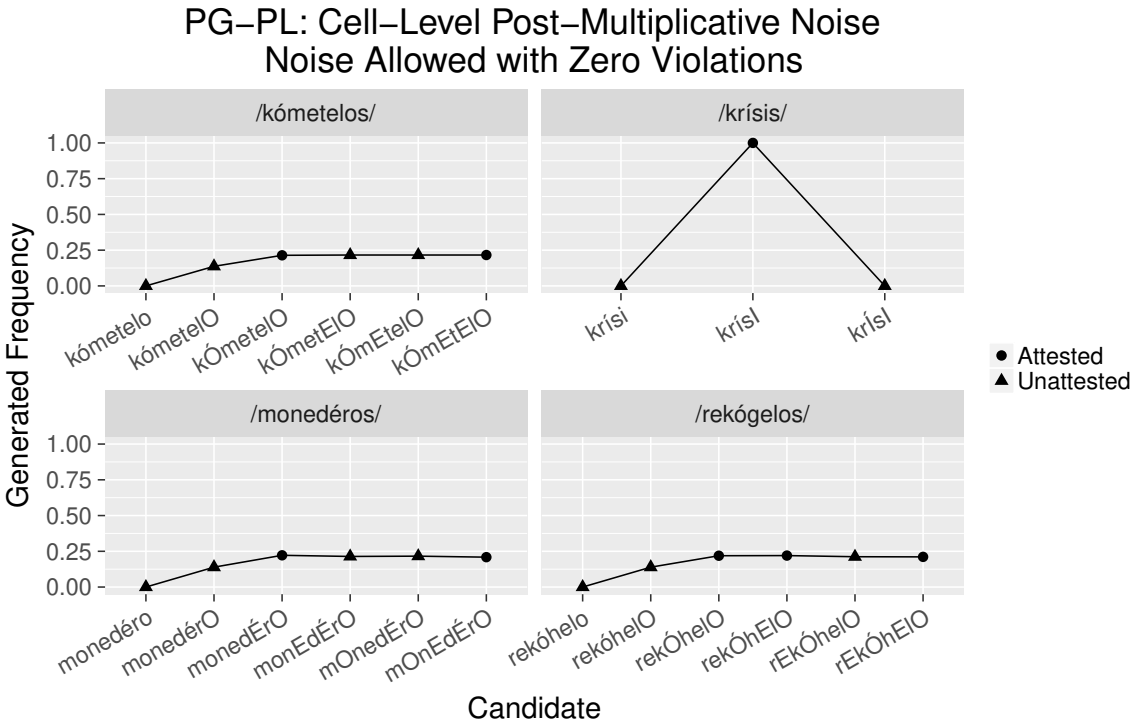

Figure 11: Results of a simulation using PG-PL & option 2c

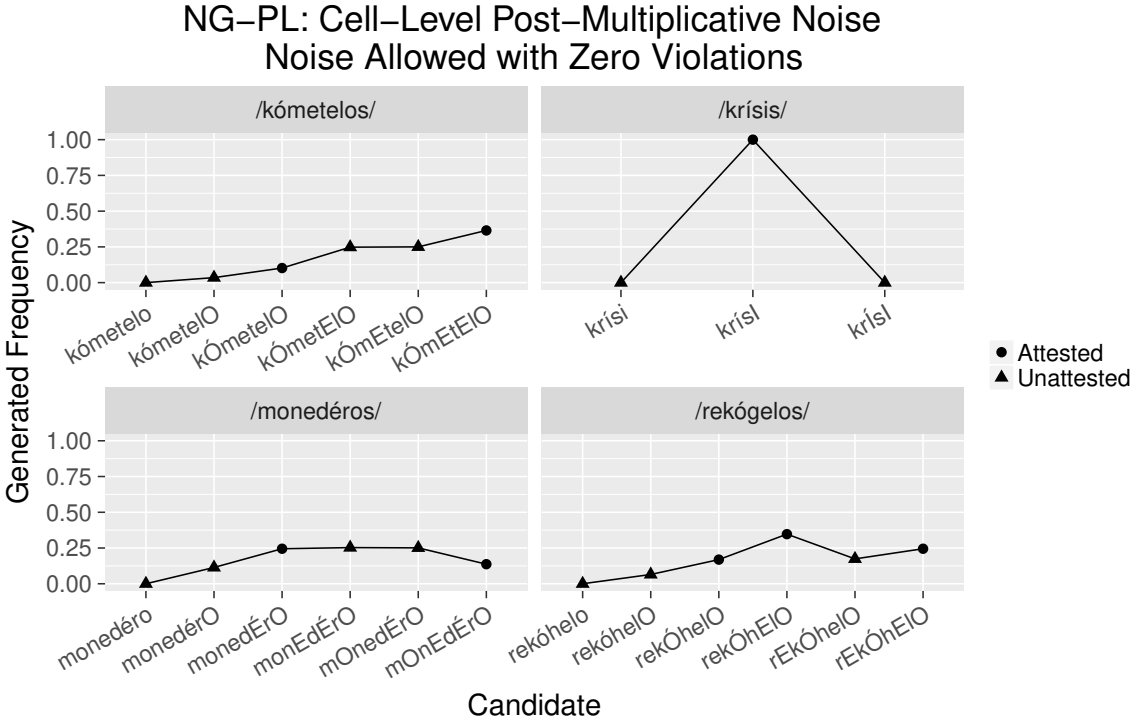

Figure 12: Results of a simulation using NG-PL & option 2c

4.3 Candidate-Level Noise

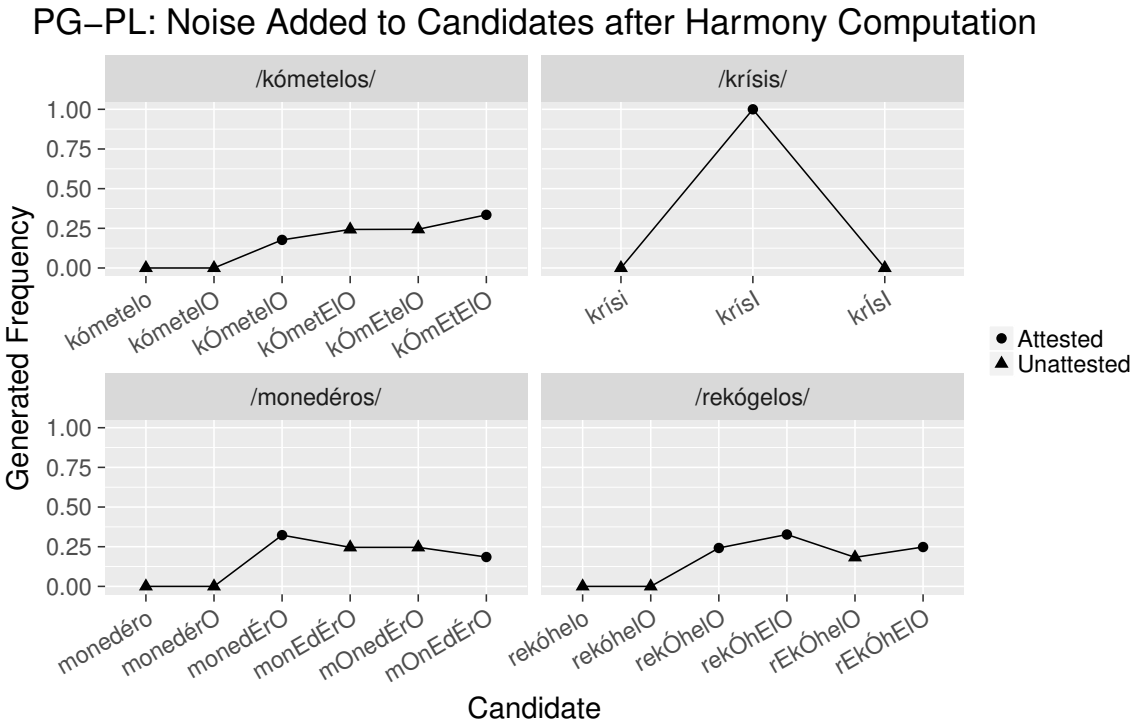

Figure 13: Results of a simulation using PG-PL & variety 3

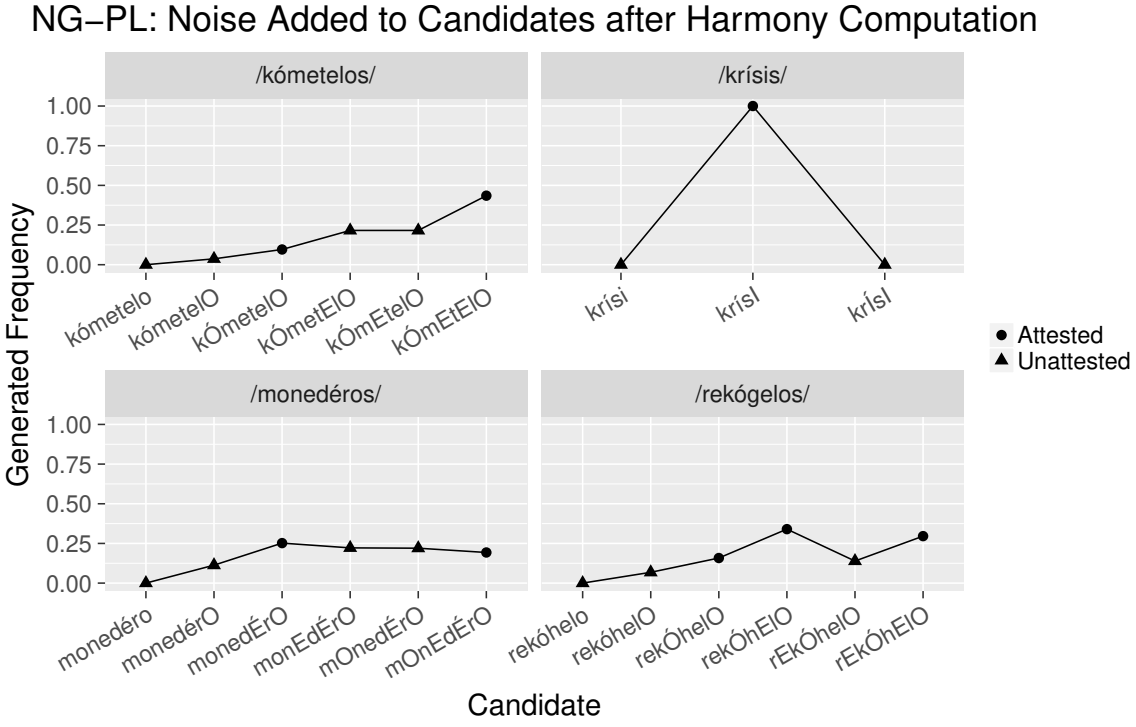

Figure 14: Results of a simulation using NG-PL & variety 3

5 Discussion

- /kríːsis/: no variation here, so weights approximating "MAX(–ATR) ≫ *[+hi, –ATR] ≫ everything else" can be established.
- For this reason, forms with no lax vowels (e.g. *moneðéro*) never win.
- Classic NHG with PG-PL works best: this implementation makes it easy to set weights that strictly or effectively rule out illicit candidates.
  - No attested form is harmonically bounded.
  - Candidates with partial pretonic/post-tonic harmony, and pretonic harmony without post-tonic harmony, are harmonically bounded and therefore impossible to select.
  - This leaves forms with no lax vowels (e.g. *moneðéro*), which are ruled out by high-weighted MAX(–ATR), and forms with no harmony (*moneðérɔ*), which is ruled out by ensuring (11a) cannot be subverted.
  - This is borne out in the weights found under this simulation:

(13)

46.000	MAX(–ATR)
27.000	*[+hi, –ATR]
11.655	LICENSE
11.345	IDENT(ATR)
0.251	IDENT(ATR)-pretonic

- Other implementations of NHG make it easier to subvert these arrangements: harmonically bounded candidates can win, or crucial weighting relationships can be reversed (e.g. by adding noise unequally to candidates).
- The nature of Eastern Andalusian's optionality is tailor-made for classic NHG:
  - Post-tonic vowels harmonize in "lockstep" (Hayes 2017), as do pretonic vowels; local optionality is disallowed.
  - Classic NHG produces only lockstep candidates (if the alternatives are harmonically bounded).
  - But what counts as a bounded non-lockstep candidate depends on constraints:

(14)

/kómetelos/		LICENSE	IDENT
lockstep	a. kómetelɔ	−3	−1
× ☞	b. kɔ́metelɔ	−2	−2
×	c. kɔ́mɛtelɔ	−1	−3
×	d. kɔ́metɛlɔ	−1	−3
lockstep ☞	e. kɔ́mɛtɛlɔ		−4

(15)

/kómetelos/		License$_2$	Ident$_3$	H
lockstep	a. kómetelɔ		−1	−3
☞	b. kómetelɔ	+2	−2	−2
×	c. kómɛtelɔ	+3	−3	−3
×	d. kómetɛlɔ	+3	−3	−3
lockstep ☞	e. kómɛtɛlɔ	+4	−4	−4

- NHG cannot relieve the lockstep problem on its own: opening the door to one bounded candidate opens the door to others.
- Better to let the constraints identify viable candidates that NHG can choose from.

6 Conclusion

- These results provide support for classic NHG and positive constraints.
- Implications for local optionality: it may be wiser to let constraints make all licit candidates available (Kaplan 2016) than to undermine harmonic bounding.
  - At the very least, that route is more compatible with other non-local optionality.
- Small changes make a big difference.

References

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