Serial versus Parallel Noisy HG Accounts of Eastern Andalusian Harmony

Aaron Kaplan
University of Utah
a.kaplan@utah.edu

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Introduction

- Noisy Harmonic Grammar: probabilistic implementations of Harmonic Grammar (Goldwater & Johnson 2003; Boersma & Pater 2016; Jesney 2007; Flemming 2017; Zuraw & Hayes 2017).
- Different implementations of NHG have different empirical properties (Hayes 2017).
  - Only one version of NHG respects harmonic bounding, e.g.
- That version is the only one that provides a satisfactory parallel account of optionality in Eastern Andalusian's ATR harmony (Kaplan 2019).

Introduction

- Does this result change for a serial analysis of Eastern Andalusian?
    - The harmony-driving constraint requires serialism, so understanding NHG's properties in a serial framework is important.

Introduction

- Computational implementations of a serial NHG account of Eastern Andalusian show that:
  1. The same version of NHG that succeeds in parallel is the only one that succeeds serially.
  2. Other versions fail in serialism for the same reason they fail in parallelism.

Introduction

- Two implications:
  1. Serial NHG inherits many of parallel NHG's properties.
  2. Maintaining harmonic bounding and its consequences is important.

Introduction

- The necessary pieces:
  1. The data
  2. Harmony in serialism
  3. Constraints
  4. The mechanics of NHG

Variable Harmony in Eastern Andalusian

- Data from Jiménez & Lloret (2007); Lloret & Jiménez (2009); Lloret (2018).
- /s/-aspiration (= deletion) causes laxing of word final vowel, which triggers [–ATR] harmony on the stressed syllable:

tesis	ˈtɛsɪ	'thesis'	*nenes*	ˈnɛnɛ	'babies'
tienes	ˈtjɛnɛ	'you have'	*pesos*	ˈpɛsɔ	'weights'
monos	ˈmɔnɔ	'monkeys'	*lejos*	ˈlɛhɔ	'far'
bocas	ˈɔkæ̞	'mouths'	*asas*	ˈa̞sæ̞	'handles'

- Harmony on other vowels is optional. . .

Variable Harmony in Eastern Andalusian

- Nonfinal post-tonic vowels optionally harmonize in lockstep:

treboles	ˈtrɛβolɛ ∼ ˈtrɛβɔlɛ	'clovers'
cómetelos	ˈkɔmetelɔ ∼ ˈkɔmɛtɛlɔ	'eat them (for you)!'
	*ˈkɔmɛtelɔ, *ˈkɔmetɛlɔ	

- Likewise for pretonic vowels; post-tonic harmony is a prerequisite for pretonic harmony:

momentos	moˈmɛntɔ ∼ mɔˈmɛntɔ	'instants'
relojes	reˈlɔhɛ ∼ rɛˈlɔhɛ	'watches'
monederos	moneˈðɛɾɔ ∼ mɔnɛˈðɛɾɔ	'purses'
	*mɔneˈðɛɾɔ, *monɛˈðɛɾɔ	
recógelos	reˈkɔhelɔ ∼ reˈkɔhɛlɔ ∼ rɛˈkɔhɛlɔ	'pick them'
	*rɛˈkɔhelɔ	

Variable Harmony in Eastern Andalusian

- But high vowels do not undergo harmony:

crisis	ˈkɾisɪ	'crisis'
muchos	ˈmuʃɔ	'many'
ídolos	ˈiðolɔ ∼ ˈiðɔlɔ	'idols'
cojines	koˈhinɛ ∼ kɔˈhinɛ	'pillows'
cotillones	kotiˈʒɔnɛ ∼ kɔtiˈʒɔnɛ	'cotillions'

Variable Harmony in Eastern Andalusian

- Words used in simulations:
  1. /ˈkometelos/: coordinated post-tonic harmony
  2. /moneˈderos/: coordinated pretonic harmony
  3. /kotiˈʒones/: transparent high vowel
  4. /reˈkohelos/: interaction between pretonic and post-tonic harmony
  5. /ˈkrisis/: stressed and final high vowels

Serial Harmony

- For simplicity, derivations begin after /s/-aspiration; the input is /ˈkometelɔ/, not /ˈkometelos/, e.g.
- Only one vowel can harmonize on any step.
- There are arguments for gradual feature change (McCarthy 2008), but I assume fell-swoop harmony: a vowel becomes fully harmonic on one step:
- ˈkometelɔ → ˈkɔmetelɔ (→ ˈkɔmɛtelɔ → ˈkɔmɛtɛlɔ)
  - Unstressed vowels can harmonize in any order.

Analysis in Harmonic Grammar

- HG analysis based on OT analyses by Jiménez & Lloret (2007); Lloret & Jiménez (2009); Lloret (2018); Walker (2011).

Core Constraints

- LICENSE([–ATR], $\acute{\sigma}$): for [–ATR] that appears in the stressed syllable, assign $+1$ for each syllable that this feature appears in (Kaplan 2018a; Walker 2011).
  - This drives harmony, first on the stressed syllable, then possibly elsewhere.
  - Positive constraints require serialism (Kimper 2011).
- *[–ATR]: assign -1 for each vowel bearing [–ATR].

The Basic Idea

w(LICENSE) $>$ w(*[–ATR]) $\rightarrow$ more harmony

Core Constraints

- $\textsc{CrispEdge}([-\text{ATR}], \acute{\sigma}, \text{L})$: assign -1 for each syllable to the left of the stressed syllable with which it shares a [–ATR] feature (e.g. Ito & Mester 1999; Kaplan 2018b).

Pretonic Syllables

$w(\textsc{License}) > w(*[\text{–ATR}]) + w(\textsc{CrispEdge}) \rightarrow$ pretonic harmony

Other Relevant Constraints

- *[+hi, –ATR]: assign −1 for [ɪ, ʊ].
  - Prevents high vowels from harmonizing: *[kɔtɪˈʒɔnɛ]
- Max(–ATR) (informal definition): assign −1 for a candidate with /s/-aspiration but no [–ATR] feature.
  - Ensures final laxing: *[ˈkometelo], *[ˈkɾisi]
- Anchor-R: assign −1 for a [–ATR] feature not associated with the rightmost vowel.
  - Ensures that final laxing always targets the final vowel: *[ˈkɾɪsi]

Weights

/rekóhelos/	LICENSE 11	CRISPEDGE 0.25	*[–ATR] 11
a. reˈkohelɔ			−1
(☞) b. reˈkɔhelɔ	+2		−2
(☞) c. reˈkɔhɛlɔ	+3		−3
(☞) d. rɛˈkɔhɛlɔ	+4	−1	−4
e. rɛˈkɔhelɔ	+3	−1	−3

- Harmony on stressed syllable: $w(\text{*[–ATR]}) < 2w(\textsc{License})$
- Post-tonic harmony:
  - $w(\textsc{License}) > w(\text{*[–ATR]})$ **or**
  - $w(\textsc{License}) < w(\text{*[–ATR]})$
- Pretonic Harmony:
  - $w(\textsc{License}) > w(\text{*[–ATR]}) + w(\textsc{CrispEdge})$ **or**
  - $w(\textsc{License}) < w(\text{*[–ATR]}) + w(\textsc{CrispEdge})$

Weights

Constraint	Weight
*[–ATR]	11
LICENSE	11
CRISPEDGE	0.25
MAX(–ATR)	50
ANCHOR-R	100
*[+hi, –ATR]	40

NHG: the Mechanics

Add noise to the computation of harmony scores at various levels (Hayes 2017):

/rekóhelos/	LICENSE 11	CRISPEDGE 0.25	*[−ATR] 11	*H*
a. reˈkohelɔ			−1	−11
(☞) b. reˈkɔhelɔ	+2		−2	0
(☞) c. reˈkɔhɛlɔ	+3		−3	0
(☞) d. rɛˈkɔhɛlɔ	+4	−1	−4	−0.25
e. rɛˈkɔhelɔ	+3	−1	−3	−0.25

Add noise to the computation of harmony scores at various levels (Hayes 2017): constraint ("classical NHG"),

/rekóhelos/	LICENSE 11 +.5	CRISPEDGE 0.25 −.2	*[−ATR] 11 +.3	*H*	
a. reˈkohelɔ			−1	~~−11~~	→ −11.3
(☞) b. reˈkɔhelɔ	+2		−2	~~0~~	→ 0.4
(☞) c. reˈkɔhɛlɔ	+3		−3	~~0~~	→ 0.6
(☞) d. rɛˈkɔhɛlɔ	+4	−1	−4	~~−0.25~~	→ 0.75
e. rɛˈkɔhelɔ	+3	−1	−3	~~−0.25~~	→ 0.55

NHG: the Mechanics

Add noise to the computation of harmony scores at various levels (Hayes 2017): constraint ("classical NHG"), cell,

/rekóhelos/	LICENSE 11	CRISPEDGE 0.25	*[−ATR] 11	*H*	
a. reˈkohelɔ	$_{+.9}$	$_{-.8}$	-1 $_{-.5}$	~~−11~~	→ −10.5
(☞) b. reˈkɔhelɔ	$+2$ $_{+.5}$	$_{-.7}$	-2 $_{-.5}$	~~0~~	→ 2
(☞) c. reˈkɔhɛlɔ	$+3$ $_{+0}$	$_{+.6}$	-3 $_{-.9}$	~~0~~	→ 2.7
(☞) d. rɛˈkɔhɛlɔ	$+4$ $_{-.9}$	-1 $_{+.7}$	-4 $_{+.2}$	~~−0.25~~	→ −5.35
e. rɛˈkɔhelɔ	$+3$ $_{+.2}$	-1 $_{-.2}$	-3 $_{+.6}$	~~−0.25~~	→ −1.25

NHG: the Mechanics

Add noise to the computation of harmony scores at various levels (Hayes 2017): constraint (“classical NHG”), cell, or candidate.

/rekóhelos/	LICENSE 11	CRISPEDGE 0.25	*[−ATR] 11	*H*	
a. reˈkohelɔ			−1	~~−11~~ +.4	→ −10.6
(☞) b. reˈkɔhelɔ	+2		−2	~~0~~ +.2	→ 0.2
(☞) c. reˈkɔhɛlɔ	+3		−3	~~0~~ −.8	→ −0.8
(☞) d. rɛˈkɔhɛlɔ	+4	−1	−4	~~−0.25~~ −.3	→ −.55
e. rɛˈkɔhelɔ	+3	−1	−3	~~−0.25~~ .4	→ 0.65

Also MaxEnt (Goldwater & Johnson 2003)

Only classical NHG accounts for Eastern Andalusian in parallel NHG (Kaplan 2018a; Kaplan 2019); also in serial NHG. . .

Serial Versions of Constraint-Level Noise

1. Constant noise: weights are perturbed once at the outset, fixing their values for the whole derivation.

   Step 1: $w(C) + i$
   Step 2: $w(C) + i$

2. Variable Noise: weights are perturbed anew at each step in the derivation.

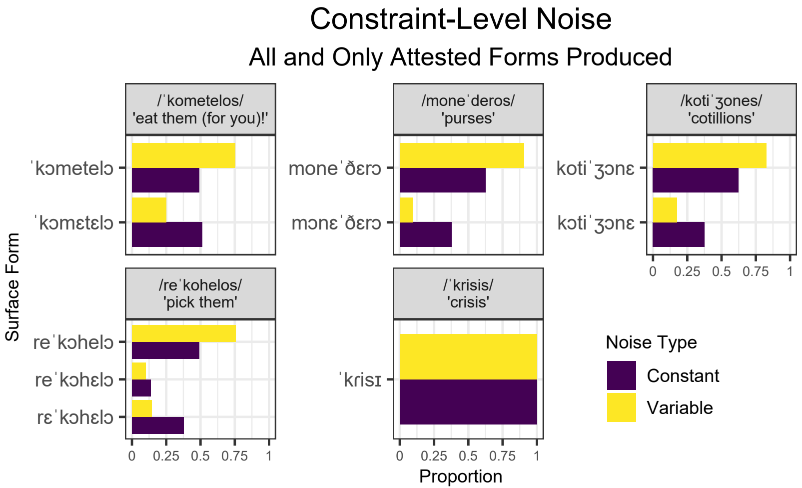
   Step 1: $w(C) + i$
   Step 2: $w(C) + j$

Simulations

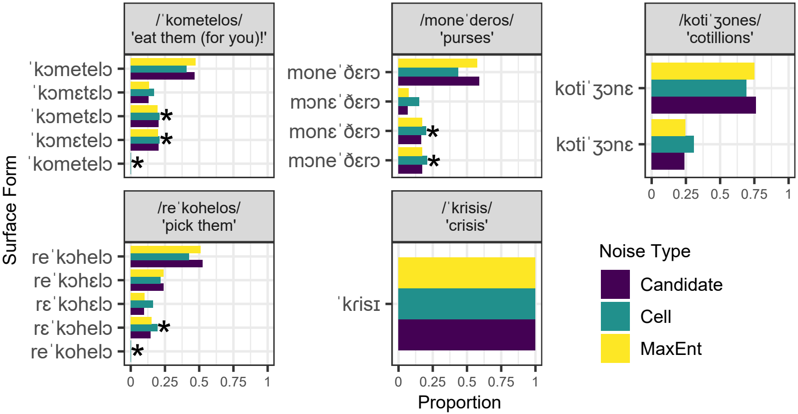
- Existing software (OTsoft (Hayes, Tesar & Zuraw 2013), OT-Help (Staubs et al. 2010), e.g.) doesn't support serial NHG.
- My own implementations, built in R (R Core Team 2020). Some details:
  - Noise was drawn from a normal distribution with mean of 0 and standard deviation of 1.
  - Negative weights were reverted to 0 (following Hayes (2017)).
  - In the event of tied winners, one is chosen at random.
  - Results from each implementation were aggregated over 10,000 iterations.
  - Weights supplied at the outset.

Simulations

- Both constraint-level noise simulations produce the licit outputs.
    - Different frequency predictions, but no way to assess them.
- Cell- and candidate-level noise and MaxEnt all overgenerate, unavoidably producing illicit candidates.


Constraint-Level Noise
All and Only Attested Forms Produced
/ˈkometelos/
'eat them (for you)!'
ˈkometelɔ
ˈkɔmɛtɛlɔ
/moneˈderos/
'purses'
moneˈðɛrɔ
mɔnɛˈðɛrɔ
/kotiˈʒones/
'cotillions'
kotiˈʒɔnɛ
kɔtiˈʒɔnɛ
/reˈkohelos/
'pick them'
reˈkɔhelɔ
reˈkɔhɛlɔ
rɛˈkɔhɛlɔ
/ˈkrisis/
'crisis'
ˈkrisɪ
Surface Form
0
0.25
0.5
0.75
1
Proportion
Noise Type
Constant
Variable

Candidate- and Cell-Level Noise and MaxEnt



* = unattested; those with near-zero frequencies (2 tokens) all come from cell-level noise

Simulations

- Why do these fail?

/k'ɔmetɛlɔ/	LICENSE	*[–ATR]
a. k'ɔmetɛlɔ	+3	−3
(☞) b. k'ɔmɛtɛlɔ	+4	−4
(☞) c. k'ɔmetelɔ	+2	−2

- Candidate (a) is collectively harmonically bounded (Samek-Lodovici & Prince 1999):
  - $w(\text{License}) > w(\text{*[–ATR]}) \rightarrow H(b) > H(a) > H(c)$
  - $w(\text{*[–ATR]}) > w(\text{License}) \rightarrow H(c) > H(a) > H(b)$
  - $w(\text{*[–ATR]}) = w(\text{License}) \rightarrow H(a) = H(b) = H(c)$

Simulations

- Candidate (a) is at least as well off one licit form, and therefore at least as likely to win.
    - MaxEnt: output probability is proportional to harmony.
    - Candidate-level noise: harmony is perturbed, so candidates with better harmony get a leg up.
    - Cell-level noise: weights are perturbed for each candidate. Weights favoring one candidate are likely to remain that way after noise.
- These unattested forms must be at least as common as an attested form.
- Similar situations arise with other words.

/kˈɔmetɛlɔ/	LICENSE	*[−ATR]
a. kˈɔmetɛlɔ	+3	−3
(☞) b. kˈɔmɛtɛlɔ	+4	−4
(☞) c. kˈɔmetelɔ	+2	−2

- Ideal situation for constraint-level noise.
- No combination of weights favors candidate (a).
- Candidate (a)'s only hope: tied weights—a vanishingly improbable outcome.
- The result: coordinated harmony on unstressed vowels.

Parallel NHG

/kˈɔmetɛlɔ/	LICENSE	*[−ATR]
a. kˈɔmetɛlɔ	+3	−3
(☞) b. kˈɔmɛtɛlɔ	+4	−4
(☞) c. kˈɔmetelɔ	+2	−2

- The parallel counterpart of this tableau just has more candidates. The collective harmonic bounding is the same.
- Constraint-level noise respects harmonic bounding, so it chooses only (b) or (c).
- Cell-level noise, candidate-level noise, and MaxEnt fail for exactly the same reasons.

Implications

- Harmonic bounding is important.
    - It imposes useful structure on the candidate set that NHG ignores at its peril.
    - If a licit output appears to be harmonically bounded, change the constraints, not harmonic bounding.

Implications

- Serial NHG is very similar to parallel NHG.
  - It inherits parallel NHG's properties regarding harmonic bounding.
  - The suitability of any version of NHG might be independent of parallel/serial choice.

Conclusion

- NHG with constraint-level noise provides a viable account of optionality in both parallel and serial frameworks.
    - Serialism: constraint-level noise allows coordination of harmony across multiple steps.
- Parallel NHG can be a rough guide to serial NHG's behavior.
- The greater power of other versions of NHG can be a liability.

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