University of Massachusetts Amherst

A Parallel, Constraint-based Account of Moroccan Arabic Iambic Broken Plurals

Ali Nirheche

Interdisciplinary Perspectives on Phonology and its Interfaces
Ibn Tofail University, Kenitra

Moroccan Arabic plurals

- Two kinds of plurals in Moroccan: “sound” = suffixal (a-c) and “broken” = templatic (d)

(1)

	Singular	Plural	Gloss
a.	bidˤa	bidˤa-t	‘egg’
	kəlma	kəlma-t	‘word’
b.	mədˤrub	mədˤrub-in	‘beaten’
	tˤəmmaʃ	tˤəmmaʃ-in	‘envious’
c.	bənnaj	bənnaj-a	‘mason’
	kəddab	kəddab-a	‘liar’
d.	bənt	bnat	‘girl’
	ktab	ktub(a)	‘books’
	rəkba	rkabi	‘knee’
	fəndəq	fnadəq	‘hotel’

Previous Approaches

- **MSA:**
  - McCarthy & Prince (1990) argue for the productivity of iambic plurals
    - Used prosodic circumscription to analyse MSA iambic plurals.
  - McCarthy (1997) proposes an account using Output-Output correspondence in OT.
- **MA:**
  - Previous accounts (Al Ghadi 1990; Nirheche 2021) assume various patterns are productive but often lack empirical evidence.
    - Al Ghadi (1990) used an autosegmental approach.
    - Nirheche (2021) used Stratal OT.

Current Proposal

- **Productivity:** Only a specific subset of patterns (Minor Iambs) is productive
  - Providing evidence from a corpus study.
- **Framework**: A Parallel, Constraint-Based Approach using Maximum Entropy (MaxEnt) grammar.
  - Eliminates the need for cyclicity and typologically dispreferred constraints, such as INITIAL-CC (Boudlal 2001).

Corpus Study

- **Data source:**
  - Based on the *Darija Open Dataset* (DODa, Outchakoucht and Es-Samaali 2021)
  - *Plurals corpus:* Extracted all nouns from DODa and manually generated their plurals:
    - 257 broken plurals.
- **Iambicity of MA broken plurals**:
  - Like MSA, MA broken plurals strongly prefer an **Iambic Feet** (LL or LH).
  - Most MA plurals begin with a **Minor Iamb**
    - The weak syllable consists only of a consonant (C.CV...)

Results

- **99.5%** of plurals begin with an iamb
- **95.5%** begin with a Minor lamb.
- **C.Ca.CeC**, **C.CuC(a)**, **C.CaC**, and **C.Ca.Ci** account for **88%** of plurals.

(4)

Pattern	Example		Count	Percentage
C.Ca.CəC	f.na.dəq	“hotels”	78	31%
C.CuC(a)	k.tub(a)	“books”	68	27%
C.CaC	k.taf	“shoulders”	43	17%
C.Ca.Ci	r.ka.bi	“knees”	26	10%
Ci.Can	ʒi.ran	“neighbors”	11	4%
CəC.Can	xər.fan	“sheep”	8	3%
C.Ca.Cat	x.wa.lat	“aunts”	5	2%
C.Cu.Cat	z.ju.tat	“oils”	5	2%
Others			11	5%
Total			**257**	**100%**

Results: Plurals of Nativized Borrowings

- How nativized borrowings are pluralized is a strong test for productivity.
- Borrowings (French/Spanish) that take broken plurals almost exclusively **(87%)** adopt Minor lamb patterns: **C.CaC**, **C.CuC(a)**, **C.Ca.CəC**, or **C.Ca.Ci**.

(5)

Source	Target	Plural	Pattern	Gloss
goʊl	gol	gwal	CCaC	'goalkeeper'
pʁiz	priz	prajəz	CCaCəC	'power plug'
tabl	tˢəbla	tˢbali	CCaCi	'table'

Summary so far

- The Major Productive Patterns:
  - C.CaC
  - C.CuC(a)
  - C.Ca.Ci
  - C.Ca.CəC
- They all begin with a **Minor lamb**.
- **Next Step:**
  - How do we formally account for the derivation of these patterns (including the variation in *CCuC(a)*)?

Analysis: a parallel constraint-based approach

- Why a parallel constraint-based approach?
  - It avoids the complexity of Serial/Stratal OT.
- Why Maximum Entropy (MaxEnt)?
  - It can model the optionality observed in the CCuC(a) pattern (e.g., ktub ~ ktuba).
  - How MaxEnt works:
    - **Weights vs. Rankings:** Constraints have numerical weights, not strict rankings
    - **Harmony (*H*):** The sum of weighted violations.
    - **Probability (*p*):** Candidates with higher harmony are more probable.
    - The goal is to find a set of weights that predicts the observed probability of the productive patterns.
    - Subtle differences in constraint weights enable variable outcomes.

Analysis: Maximum Entropy (MaxEnt)

(7)

/CVC/	NoCoda $w = 6$	Max $w = 1$	$\mathscr{H}$	p
a. ☞ CV		-1	-1	≈1
b. CVC	-1		-6	≈0

(8)

/CVC/	NoCoda $w = 2$	Max $w = 2$	$\mathscr{H}$	p
a. ☞ CV		-1	-2	≈0.5
b. ☞ CVC	-1		-2	≈0.5

Analysis: Iambicity

- All productive patterns begin with an iamb (LL or LH).
  - INITIALIAMB: Assign a violation if the output does not begin with an LL or LH foot.
  - INITIALTROCHEE: Assign a violation if the output does not begin with a trochee.

(9)

/CCC/ + /V/	INITIALIAMB $w = 10.6$	INITIALTROCHEE $w = 0$	$\mathscr{H}$	p
a. ☞ (C.CVC)		-1	0	$\approx$1
b. (CVC.C)	-1		-10.6	$\approx$0

Analysis: CCaC plurals, CCC/CVC roots

(10)

Root	Singular	Plural	Gloss
klb	kəlb	klab	‘dog’
bnt	bənt	bnat	‘girl’

(11)

/klb/ + /a/	MAX $w = 17.4$	INITIALIAMB $w = 10.6$	DEP $w = 8$	INITIALTROCHEE $w = 0$	$\mathscr{H}$	p
a. ☞ (k.lab)				-1	0	≈1
b. (kal.b)		-1		-1	-10.6	≈0
c. (k.la).ba			-1		-8	≈0
d. (k.la)	-1			-1	-17.4	≈0

Analysis: INITIAL-CC vs MINORIAMB

(12)

Root	Singular	Plural	Gloss
bir	bir	bjar	'well'
fil	fil	fjal	'elephant'

- [bira] is a perfect iambic plural for /bir+a/.
- Boudlal (2001) proposed the constraint INITIAL-CC to account for diminutives which begin with an initial CC sequence.
  - **INITIAL-CC** (Boudlal, 2001, p. 258): Words must begin with two consonants
- Typologically, having an initial CC sequence is generally dispreferred. Therefore, I propose the following constraint:
  - **MINORIAMB**: Assign a violation mark to any output that has a vowel in the weak syllable of an iambic foot
  - MINORIAMB is consistent with iambic patterns seen crosslinguistically (Ulrich, 1986; Hayes, 1995)

Analysis: CCaC plurals, CCC/CVC roots

- MINORIAMB competes with IDENT(cons).
  - **IDENT(cons)**: Assign a violation mark to any output whose value of the feature [±consonantal] is different from its corresponding input form

(13)

/bir/ + /a/	MINORIAMB $w = 10.9$	IDENT(cons) $w = 0$	$\mathscr{H}$	p
a. ☞ (b.jar)		-1	0	≈1
b. (bi.ra)	-1		-10.9	≈0

Analysis: CCuC(a) plurals, CCC/CVC roots

(14)

	Root	Singular	Plural	Gloss
a.	ktb	ktab	ktub~ktuba	‘book’
	qlb	qəlb	qlub~qluba	‘heart’
b.	bit	bit	bjut~bjuta	‘house’
	ħitˤ	ħitˤ	ħjutˤ~ħjutˤa	‘wall’

- NONFINALITY: Assign a violation mark to any output whose final syllable is footed.

(15)

/klb/ + /u/	DEP $w = 8$	NONFINALITY $w = 8$	$\mathscr{H}$	p
a. ☞ (k.tub)		-1	-8	≈0.5
b. (k.tu).ba	-1		-8	≈0.5

Analysis: preventing CCaCa

- The broken plural CCaC does not allow the insertion of a final [a].
- **OCP(V)**: an output cannot contain two adjacent identical vowels on the vocalic tier.

(16)

/klb/ + /a/	OCP(V) $w = 11.5$	DEP $w = 8$	NONFINALITY $w = 8$	$\mathscr{H}$	p
a. ☞ (k.lab)			-1	-8	≈1
b. (k.la).ba	-1	-1		-19.5	≈0

(17)

/ktb/ + /u/	OCP(V) $w = 11.5$	DEP $w = 8$	NONFINALITY $w = 8$	$\mathscr{H}$	p
a. ☞ (k.tub)			-1	-8	≈0.5
b. ☞ (k.tu).ba		-1		-8	≈0.5

Analysis: CCaCi plurals, CCC/CVC roots

(18)

	Root	Singular	Plural	Gloss
a.	rkb	rəkba	rkabi	‘knee’
	ʒrd	ʒərda	ʒradi	‘garden’
b.	lil	lila	ljali	‘night’
	ʕaf	ʕafja	ʕwafi	‘fire’

(19)

/rkb/ + /a_i/	MAX $w = 17.4$	MINORIAMB $w = 10.9$	INITIALIAMB $w = 10.6$	INITIALTROCHEE $w = 0$	$\mathscr{H}$	p
a. ☞ (r.ka).bi				-1	0	≈1
b. (r.kab)	-1			-1	-17.4	≈0
c. (rak.bi)			-1		-10.6	≈0
d. (ra.kib)		-1		-1	-10.9	≈0

Analysis: CCaCəC plurals, CCCC/CVCC/CCVC roots

(20)

	Root	Singular	Plural	Gloss
a.	fndq	fəndəq	fnadəq	‘hotel’
	mskn	məskin	msakən	‘poor’
b.	xatm	xatəm	xwatəm	‘ring’
	gitˁn	gitˁun	gjatˁən	‘tent’
c.	blasˁ	blasˁa	blajəsˁ	‘place’
	dqiq	dqiqa	dqajəq	‘minute’

- One additional constraint is needed to ensure that the schwa appears between the third and forth consonants. i.e. to avoid ending in a final CC sequence.
- ***CC#:** Assign a violation mark to any output that ends in a sequence of two consonants.

Analysis: CCaCəC plurals, CCCC roots

(21)

/fndq/ + /a/	*CC# $w = 18.9$	MAX $w = 17.4$	INITIALIAMB $w = 10.6$	NONFINALITY $w = 8$	DEP $w = 8$	$\mathscr{H}$	p
a. ☞ (f.na).dəq					-1	-8	≈1
b. (fən.daq)				-1	-1	-16	≈0
c. (fan.dəq)			-1	-1	-1	-26.6	≈0
d. (f.nad)		-1		-1		-25.4	≈0
e. (f.nad).q	-1					-18.9	≈0

Analysis: Finding weights

- Weights were not set manually (22)
- **Simulation:**
  - Computed using a Shiny app (Nirheche, 2024) designed to run MaxEnt simulations.
  - Uses L-BFGS-B optimization to minimize prediction error
- **Training data:** paradigm of root-plural mappings (CCC, CVC, CCCC, etc.).

Constraint	Weight
*CC#	18.9
MAX	17.4
OCP(V)	11.5
MINORIAMB	10.9
INITIALIAMB	10.6
NONFINALITY	8
DEP	8
INITIALTROCHEE	0
IDENT[cons]	0

Thank You

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