Experimental evidence for
# aggressive core-periphery phonology in Guaraní

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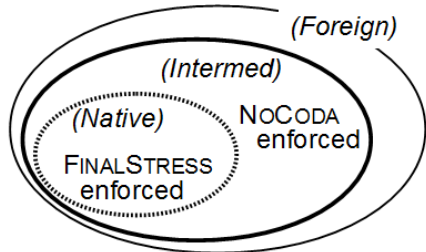
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Overview

- In a **nonce-loanword experiment** with **Guaraní** speakers, we find:
  - Impossible-nativization effects → evidence of *synchronic* **core-periphery structure**
  - Core-periphery structure **beyond** what the patterns in the lexicon would predict

- We conclude: Not only can core-periphery structure be **productive**, but speakers can **aggressively create** it, even in the absence of unambiguous evidence

- To our knowledge, this is the first **experimental** data on impossible nativizations

1. Loanword phonology: Is core-periphery structure productive?

(1)   Languages with large numbers of loanwords often have a **stratified lexicon**—lexical **subclasses** with **different phonological properties** (Mathesius 1934; Fries & Pike 1949; Chomsky & Halle 1968; Kiparsky 1968; Postal 1968; Saciuk 1969; Holden 1976)

    (a)   'Native' and 'Foreign' morphemes may differ

    (b)   Loanwords borrowed at different times or from different sources may differ

(2)   A stratified lexicon often has a **core-periphery structure** (Ito & Mester 1999, 2008)

    (a)   The **core** lexical stratum satisfies the most markedness (M) constraints

    (b)   More-**peripheral** strata allow more M constraints to be violated

(3)   Lexicon with a core-periphery structure: **Domain** of each M constraint is shown

    (a)   In the core stratum (*Native*), FINALSTRESS and NOCODA are both enforced
- Stress is final; codas are banned

    (b)   In an intermediate stratum (*Intermed*), NOCODA is enforced but FINALSTRESS is not
- Non-final stress is allowed; codas are banned

    (c)   In the most peripheral stratum (*Foreign*), neither M constraint is enforced
- Non-final stress is allowed; codas are allowed

(4)   Constraint domains translate to **constraint rankings** (Ito & Mester 1999)

    (a)   Markedness (M) constraint-domain set relations → M constraint rankings
- lexical items subject to NOCODA ⊃ subject to FINALSTRESS: NOCODA » FINALSTRESS

    (b)   Faithfulness (F) constraints for each stratum are ranked below the M constraints enforced in that stratum, and above M constraints not enforced
- FAITH(*Foreign*) » **NOCODA** » FAITH(*Intermed*) » **FINALSTRESS** » FAITH(*Native*)
- The I&M (1999) model has other implications for F rankings; see §4
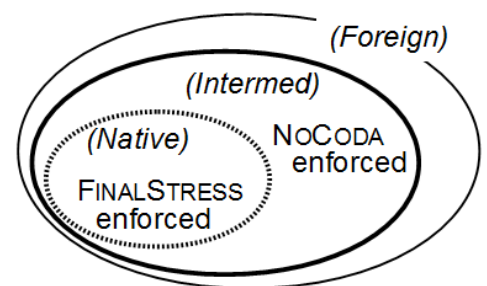
(5) Crucial question: Is core-periphery structure actually **productive**?

- A language might *appear* to have a lexicon with a core-periphery structure, but this might merely reflect diachronic residue (see Rice (2006) on Norwegian)

(a) When borrowing began, loans had to nativize both non-final stress and codas   { NOCODA,FINALSTRESS } » F̲A̲I̲T̲H̲

(b) Grammar changed, allowing non-final stress; new loans nativized only codas   NOCODA » F̲A̲I̲T̲H̲ » FINALSTRESS

(c) Grammar changed again, allowing codas   F̲A̲I̲T̲H̲ » {NOCODA,FINALSTRESS }

(d) State of the synchronic grammar: Non-final stress and codas are allowed

- There are no loans in the lexicon that have nativized stress and kept codas
- But this is merely because there was no time period where the grammar enforced FINALSTRESS without enforcing NOCODA
- Loans that (once) nativized stress or codas are now stored that way as URs

(6) I&M (1999) propose a diagnostic for productive core-periphery structure: I**mpossible-nativization effects**

- Suppose the language in (3) borrows a word with non-final stress and a coda

(a) The loan could nativize **both** structures (=assigned to *Native* stratum)

(b) The loan could nativize **neither** structure (=assigned to *Foreign* stratum)

(c) The loan could nativize **only the coda** (=assigned to *Intermediate* stratum)

(d) *BUT:* Nativizing **only the stress**, and *not* the coda, is **impossible**

- No stratum enforces only FINALSTRESS without also enforcng NOCODA
- Nativization of stress **implies** nativization of coda

(7) Compare the language in (5), where *apparent* core-periphery structure is only diachronic residue

(a) Synchronic grammar: FAITH » { NOCODA, FINALSTRESS }

(b) The grammar has no preference for a form that nativizes only a coda over a form that nativizes only stress → **no** impossible-nativization effects

(8) Do impossible-nativization effects actually exist?

- I&M (1999) report them in Japanese (but do not verify experimentally)

(9) Test case: Paraguayan **Guaraní** (Avañe'e), a Tupí-Guaraní language

- *ethnologue.com* reports:
  - 4,850,000 speakers (all countries)
  - 2,500,000 monolinguals (2002 census)
  - 60% of speakers are bilingual in Spanish

(a) Does the **lexicon** have a core-periphery structure? → Yes (§2)

(b) Do speakers show **productive** impossible-nativization effects? → Yes (§3)

- In fact: Impossible-nativization effects go *beyond* the core-periphery structure that can be induced from loanword patterns in the lexicon

> 2. Loan-corpus analysis: Implicational relationships in the Guaraní lexicon?

(10) **Goal:** To see whether nativization patterns in existing Guaraní loanwords from Spanish show **implicational relationships**

(11) Three structures prohibited in (non-loan) Guaraní but allowed in Spanish

Structure		Example: Spanish → Guaraní			Nativization strategies
(a) **Non-final stress**	*nativized*	[ké̱so]	→ [kesú]	'cheese'	Stress shift; (truncation)
	faithful	[tóɾo]	→ [tóɾo]	'bull'	
(b) **Coda**	*nativized*	[koɾáḻ]	→ [koɾá_]	'corral'	Deletion; Cσ]→glide
	faithful	[bɾasíḻ]	→ [vɾasíḻ]	'Brazil'	
(c) **Complex onset**	*nativized*	[g̱ɾésja]	→ [g̱ɨresjá]	'Greece'	Epenthesis; C₂→glide
	faithful	[g̱ɾásja]	→ [g̱ɾasjá]	'a joke; grace'	

- Exceptions to the generalization that stress is final do exist even among non-loan forms
- Syllables with glide-initial diphthongs (CGV) are allowed in both Guaraní and Spanish
- On Guaraní phonology, see Gregores & Suárez (1967); Rivas (1975); de Canese (1983)
- On Spanish phonology, see Harris (1986); Hualde (2005)

(12) Relevant markedness constraints (enforcing the non-loan Guaraní phonology)

    (a) NoCoda   Assign * for every syllable with a coda (Prince & Smolensky 1993/2004)

    (b) FinalStress   Assign * for every word that does not have primary stress on final syllable (Align-R(PrWd, stressed(=head) syllable); McCarthy & Prince 1993)

    (c) *ComplexOnset Assign * for every syllable with more than one segment in the onset (P&S)

2.1 Materials and methodology

(13) Data set: A corpus of **407 unique loanwords**

    (a)   Unique = unique *source→loan* mapping

    (b)   Combines the corpora of Spanish loanwords in Guaraní presented in Gregores & Suárez (1967), Pinta (2013), and Zarratea (2013), minus duplicates

(14) Research question: Are there any implications of the form, "Loans that nativize Y always nativize X, but not vice-versa"?

    (a)   Comparisons: **i.**   **non-final stress vs.   coda**

                               ii. **complex onset vs.   coda**

                               iii. non-final stress vs.   complex onset

    (b)   Preview of results: Only the first two comparisons reveal implications

(15) Corpus counts carried out two ways for the syllable-structure factors:

    (a)   Only *initial* complex onsets, *final* codas tallied [unambiguous syllabification]

    (b)   *All* complex onsets and codas tallied, *according to Spanish syllabification*

        - Not *guaranteed* to match how Guaraní speakers syllabify medial CCs
        - But *plausible*: Medial "codas" and "onset clusters" under this approach mostly show the same adaptation strategies as unambiguous ones

(16)   Statistical analysis: McNemar's test (exact binomial), which checks for a significant difference between two correlated proportions (McNemar 1947)
- All tests reported in §4.2 are two-tailed, because there is no prior expectation of which direction any implication between X and Y would take

2.2 Results: Summary

(17)   Summary of implications among nativization patterns in loan-corpus analysis:

(a)   Loanwords that nativize non-final stress **also** nativize codas

(b)   Loanwords that nativize complex onsets **also** nativize codas

(c)   Most loanwords with both complex onsets and non-final stress either *nativize both*, or *preserve both*
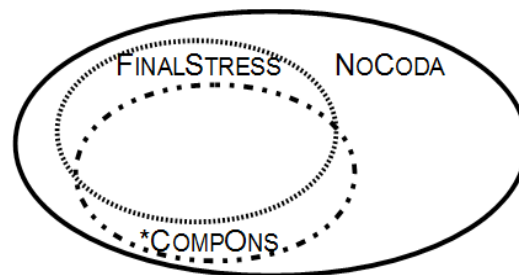
NoCoda » {FinalStress, *CompOns}

2.3 Results: Individual comparisons

(18)   **Nativizing non-final stress implies nativizing coda** | *counts:* all codas (final codas)
- Constraint ranking (if productive): **NoCoda » FinalStress**

	Nativizes coda: YES	Nativizes coda: NO
Nativizes stress: YES	27 (2)	1 (0)
Nativizes stress: NO	23 (9)	44 (2)

(a)   Nativizing only coda more likely than nativizing only non-final stress
$p=0.000003$ (all codas) | $p=0.0043906$ (final codas only)

(b)   So: If non-final stress is nativized, a coda is also almost always nativized

(19)   **Nativizing complex onset implies nativizing coda** | *counts:* all cases (init ons+fin coda)
- Constraint ranking (if productive): **NoCoda » *ComplexOnset**

	Nativizes coda: YES	Nativizes coda: NO
Nativizes onset: YES	6 (1)	0 (0)
Nativizes onset: NO	9 (4)	7 (1)

(a)   Nativizing only coda more likely than nativizing only complex onset
$p=0.003906$ (all cases) | $p=0.125$ (initial complex onsets+final codas only)
- Doesn't reach significance for 'edges only', but numerical trend is in same direction

(b)   So: Only a small number of loans in the corpus have both of these structures at the same time, but if a complex onset is nativized, a coda is also nativized

(20)   **No implication between complex onset and stress** | *counts:* all cases (initial onsets)
- No evidence for ranking between **FinalStress, *ComplexOnset**

	Nativizes stress: YES	Nativizes stress: NO
Nativizes onset: YES	11 (3)	4 (1)
Nativizes onset: NO	2 (2)	21 (9)

(a)   Most loans either adapt both properties or preserve both

(b)   Examples that adapt only one property are **not** more likely to nativize one or the other: $p=0.6875$ (all onsets) | $p=1$ (initial onsets only)

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3. Nonce-loan adaptation experiment

(21) *Goal:* To see whether Guaraní native speakers show evidence of **impossible-nativization effects** when choosing a "Guaraní form" for a nonce loan

- Is core-periphery phonology **productive** in Guaraní?

3.1 Materials and methodology

(22) Questionnaire design: Two-alternative forced-choice

12 pseudo-Spanish **nonce loans**: 3 constraint pairs × 4 nonce loans violating *both*

(a) NoCoda, FinlStr   [gól.de] (*golde*)
(b) NoCoda, *CompOns   [bla.sál] (*blazal*)
(c) FinlStr, *CompOns,   [tɾá.sja] (*tracia*)

- Nonce words were checked by a speaker of (Argentinian) Spanish for plausibility

(23) 2 "**nativizations**" per nonce loan, each removing *one* constraint violation

(a) NoCoda, FinlStr   [gól.de] → [gó.de] (*góde*) ~ [gol.dé]   (*goldé*)
(b) NoCoda, *CompOns   [bla.sál] → [bla.sá] (*blasá*) ~ [ba.la.sál] (*balasál*)
(c) FinlStr, *CompOns,   [tɾá.sja] → [tɾa.sjá] (*trasiá*) ~ [ta.ɾá.sja] (*tarásia*)

(24) Nonce loans and nativizations presented in Spanish and Guaraní orthography respectively (stress was indicated on all "Guaraní" nativizations)

(a) Task: Which is **most natural as a Guaraní form** of each "Spanish" word?
(b) Forced-choice design: response *has to* satisfy one constraint, violate the other
(c) For each pair of constraints, is the same constraint consistently satisfied?

(25) Participants: *n*=8

(a) Recruited via networking and social media
(b) Self-reported as Guaraní native speakers; also fluent in Spanish
(c) Nationality: Paraguay (6), Argentina (1), no response (1)


3.2 Interpretation and analysis

(26) How the results were interpreted

- A participant was said to have a **consistent preference** for a constraint pair if the *same* constraint was satisfied in 3/4 or 4/4 items testing that pair

(27) Statistical analysis

(a) All participants had some consistent preference for all constraint pairs, with one exception (participant 4 had no preference for NoCoda vs. FinalStress)
(b) This is a highly significant result by the exact binomial test
- Probability of choosing '*not 2/4*' by chance for a single constraint pair by a single participant is 0.625
- There were 24 such constraint-pair comparisons (3 pairs × 8 participants)
- Probability of choosing '*not 2/4*' by chance 23/24 times: ***p*=0.000194**

3.3 Results: Overview

(28) Summary of implications: Corpus analysis vs. nonce-loan experiment

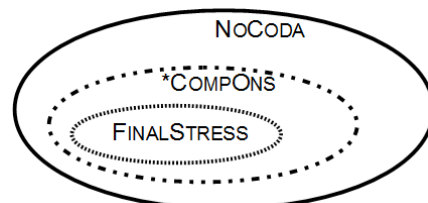Implications in corpus analysis:
NoCoda » {*CompOns, FinalStress}

- All participants had NoCoda » *CompOns
- Differed in relative rank of FinalStress
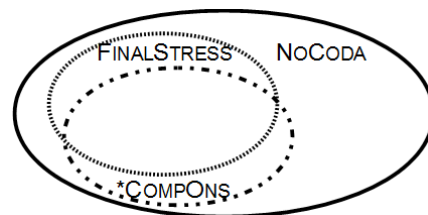
    (a)   Consistent with corpus analysis,
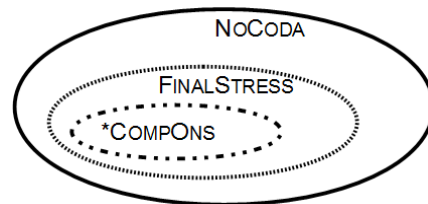   plus additional rankings:

        Participants 1, 6, 8
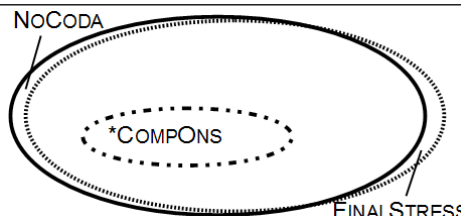   NoCoda » *CompOns » FinalStress

        Participant 5
        NoCoda » FinalStress » *CompOns

    (b)   Inconsistent with corpus analysis:
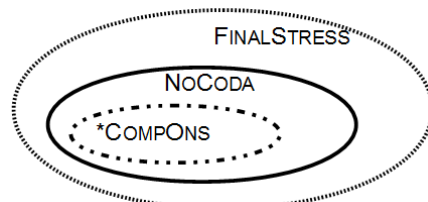   Does not have NoCoda » FinalStress

        Participant 4
        {<u>FinalStress</u>, NoCoda} » *CompOns

        Participants 2, 3, 7
        <u>FinalStress</u> » NoCoda » *CompOns

3.4 Results: Constraint preferences (=impossible-nativization effects)

(29) **All participants** showed a consistent preference for **NoCoda » *ComplexOnset**
- This ranking is also supported by the loan-corpus analysis in §4

Participant	1	2	3	4	5	6	7	8
NoCoda » *CompOns	3/4	4/4	4/4	4/4	4/4	4/4	4/4	4/4

(30) **Participants differed** with respect to **FinalStress and *ComplexOnset**
- No ranking is supported by the loan-corpus analysis in §4
- (a) Participants with FinalStress » *ComplexOnset

Participant	2	3	4	5	7
FinalStress » *CompOns	4/4	4/4	4/4	3/4	4/4

- (b) Participants with *ComplexOnset » FinalStress

Participant	1	6	8
*CompOns » FinalStress	4/4	4/4	4/4

(31) **Participants differed** with respect to NoCoda and FinalStress

- The loan-corpus analysis in §4 supports the ranking NoCoda » FinalStress

(a) Same as corpus: NoCoda » FinalStress

Participant	1	5	6	8
NoCoda » FinalStress	4/4	3/4	4/4	3/4

(b) Different from corpus: FinalStress » NoCoda, or no ranking

Participant	2	3	7	4
FinalStress »(?) NoCoda	4/4	4/4	4/4	2/4

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4. Discussion

4.1 Summary

(32) Participants in the nonce-loan study showed systematic impossible-nativization effects, which are evidence for **productive core-periphery phonology**

(a) Some of the impossible-nativization effects were **consistent** across all participants and **matched** a statistically significant effect (though with small numbers) in the loan corpus: NoCoda » *ComplexOnset

(b) Some of the impossible-nativization effects involved constraints whose relationship was **not determined** in the corpus: FinalStress, *ComplexOnset
- All participants showed a **ranking** for these constraints
- That ranking **differed** from one participant to the next

(c) Some of the effects involved constraints whose relationship was strongly **determined** in the loan corpus—but the ranking of these constraints also **differed** from one participant to the next: NoCoda (») FinalStress

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4.2 Implications (I): Accessible evidence for unfaithfulness

(33) For a language to have a stratified lexicon, learners must be exposed to some kind of *evidence* that different morphemes belong to different lexical classes (Pater 2010)

- Learners must have a basis for positing that some forms *actively* satisfy a particular markedness constraint M—at the expense of faithfulness

(a) Evidence from **active alternations** (I&M 1999, 2008)? E.g., if some morphemes are explicitly *seen* to lose a (potential) coda, while others keep codas

(b) Evidence based on **direct (bilingual) knowledge** of SrcLg?

(c) Other factors, including orthography? (I&M 1999, 2008)

- Caveat: Proposing that a learner can learn that there are multiple lexical classes is not the same as proposing that a learner knows the literal *history* of each morpheme

(34) The Guaraní results confirm that speakers can posit a stratified lexicon in the **absence** of stratum-specific phonological **alternations**

(a) There is a small amount of evidence from Guaraní that native and <Spanish morphemes pattern differently in *morphology* (Bakker & Hekking 2012)
- Causative prefix ^{m}bo-~mo- does not attach to verbs borrowed from Spanish
- Loan adverb suffix(?) -mente, if in fact productive in G, only combines with S adjectives

(b) However, there do not seem to be any *phonological* alternations showing that structures such as onset clusters, codas, or non-final stress are actively avoided in non-loan forms (in contrast to Japanese; I&M 1999)

(c) Possible explanation for Guaraní: **Access to loanwords' source forms**

- Large numbers of Guaraní speakers are bilingual in Spanish (all participants in the nonce-loan experiment were bilingual)
- If the lexical entry for a loanword includes information about the source-language form (Smith 2009), then the speaker has direct evidence for which forms are subject to a markedness constraint that can force unfaithfulness

(d) See also Hayes (in press) on a MaxEnt learner that can probabilistically assign English lexical items to 'Latinate' and 'Native' strata on the basis of static phonotactics alone

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4.3 Implications (II): Aggressive core-periphery phonology

(35) All the participants in the nonce-loan experiment have systematic preferences for which constraints to satisfy = productive impossible-nativization effects

(a) But many of these go beyond patterns attested in the loanword corpus

(b) **Where** do these speakers' impossible-nativization effects come from?

(36) All speakers had at least one productive ranking not supported by the loan corpus

(a) All speakers imposed a ranking between FINALSTRESS and *COMPLEXONSET, which are **unranked** in the loan corpus

(b) In addition, some speakers ranked FINALSTRESS » NOCODA, the **reverse** of a ranking supported by the loan corpus

- But: Do these 'extra' rankings merely indicate that the loan corpus is not truly representative of the actual loanwords in the full lexicon of Guaraní?

(c) Even if this is true, it is unlikely to be the whole story

(d) Speakers differed greatly in where they ranked FINALSTRESS with respect to the other two constraints—can this really be entirely attributed to individual differences in the inventory of lexically listed loans?

(37) Do markedness implications in the lexicon *ever* matter for synchronic core-periphery structure (at least when alternations are not present, as with Guaraní)?

- Or are these ignored by speakers, in a type of 'surfeit-of-the-stimulus' effect (Becker, Ketrez, & Nevins 2011)?

- One productive ranking matched the loan corpus: NOCODA » *COMPLEXONSET

(a) This markedness implication is attested in the loan corpus, but not as robustly as one that half the speakers actually *ignored* (NOCODA » FINALSTRESS)

- Is the lexicon actually the source of the NOCODA » *COMPONSET ranking?

(b) Alternative: Are speakers creating this ranking on the basis of their knowledge/experience that codas are **less easily perceptible** than onsets?

- I&M (1999) propose that some impossible-nativization effects in Japanese are due to markedness scales (*[si] » *[ti], so fricatives palatalize first)

(38) Upshot: Whether or not they are using markedness implications in the lexicon at all, the speakers in our study have a **productive core-periphery** phonology

→ Speakers can **aggressively create** a core-periphery phonology that includes markedness implications beyond those supported by evidence from the lexicon

(39) Aggressive core-periphery phonology may be related to a known phenomenon in loanword phonology, in which phonological adaptation of new loanwords can become **conventionalized** even when other adaptation strategies (or faithful retention of source-form structures) are also in principle available (Haugen 1950; Hyman 1970; Lovins 1975; Kenstowicz & Sohn 2001)

(a) In the case of Guaraní: Perhaps each speaker arrives at a decision that certain properties are "more crucial to fix" than others if a loanword is to be made Guaraní-like

• These decisions may or may not be consciously accessible

• These decisions might be based on lexical patterns, based on other linguistic experience, or even arbitrary

(b) Such knowledge is then linguistically represented as a markedness ranking within a core-periphery phonology

(40) Aggressive core-periphery phonology is interesting for **phonological theory**

(a) I&M (1999) show that the grammar needed to establish a phonology with synchronic core-periphery structure is rather complex

• **Distinct sets of faithfulness constraints** for each stratum

• **Limits on reranking** of faithfulness constraints between strata

(b) Our findings suggest that, despite this grammatical complexity, there is a learning bias in favor of core-periphery structure when loanwords are present (as Simonović 2009 proposes on theoretical grounds)

Acknowledgments

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