Contradictory markedness preferences across domains and the domain generalization bias

Jesse Zymet, UCLA

1. Introduction

Investigators have uncovered evidence for learning biases — biases inherent in learners that favor certain natural language phonologies over others.

- Simplicity bias (Moreton & Pater 2011)
- Naturalness bias (Hayes & White 2013)
- Similarity bias (White 2014)
- Domain generalization bias (see below)

**Broad questions:** How strong are these biases? In particular, to what extent can a learning bias be **defied** in a language?

Two cases of learning bias defiance come to mind:

- Unnatural constraints can be learned weakly (Hayes et al. 2009, Hayes & White 2013).
- Saltations — alternations that go against similarity bias — arise in languages, though by historical accident (Hayes & White 2015).

A family of findings now suggest the working of what I call domain generalization bias:


But I show two phonological systems **defy bias, displaying opposite drives across domains:**

- In Malagasy, *backness dissimilation* applies to the passive imperative suffix, yet roots show a moderately strong preference for *backness harmony*.
- A similar system arises in Yucatec Maya, and Mayan more broadly.

2.1 Suffixal backness dissimilation in Malagasy

Data/counts below extracted from Malagasy Dictionary and Encyclopedia of Madagascar (de la Beaujardière 2004), an online corpus containing around 86,000 Malagasy words.

- Available here: [www.malagasyword.org](http://www.malagasyword.org)
Inventory composed of four vowels (Parker 1883, de la Beaujardière 2004):

\[
i \quad u \\
e \\
a
\]

Figure 1: Malagasy vowel inventory

Backness cooccurrence avoidance arises in the suffixal domain.

Passive imperative suffix conditionally undergoes **backness dissimilation** (Parker 1883, Zymet 2015).

- \(-u\) surfaces as \(-i\) after stems containing \(u\), but is blocked by intervening front vowels.
- Conforms to patterns driven by Obligatory Contour Principle (Leben 1973 et seq).

- \(-u\) is underlying
  
  (1a) /bata+u/ \[bata-u]\ ‘lift’
  
  (1b) /fana+u/ \[fana-u]\ ‘heat’

- **Items undergoing local and nonlocal backness dissimilation**
  
  (2a) /babu+u/ \[babu-i]\ ‘plunder’
  
  (2b) /tuv+u/ \[tuv-i]\ ‘fulfill’
  
  (2c) /tuda+u/ \[tuda-i]\ ‘prevent’
  
  (2d) /u’nDan+u/ \[u’nDan-i]\ ‘bolster’

- **Front vowels block**
  
  (3a) /turi+u/ \[turi-u]\ ‘preach’
  
  (3b) /ure+u/ \[ure-u]\ ‘massage’

- The alternation is nearly categorical in local setting, semi-regular across central vowels, and is nearly categorically blocked by front vowels.

<table>
<thead>
<tr>
<th></th>
<th>(-u)</th>
<th>(-i)</th>
<th>Dissim. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No trigger</td>
<td>1877</td>
<td>7</td>
<td>0.0%</td>
</tr>
<tr>
<td>Local</td>
<td>4</td>
<td>989</td>
<td>99.6%</td>
</tr>
<tr>
<td>Nonlocal</td>
<td>196</td>
<td>201</td>
<td>50.9%</td>
</tr>
<tr>
<td>Intervening front vowel</td>
<td>399</td>
<td>2</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Table 1: Counts for Malagasy backness dissimilation
Backness dissimilation seems to be *productive* in Malagasy:  
- Dissimilation rates are overall drastic.  
- Alternation was observed across generations (Parker 1883, Richardson 1885, Abinal & Victorin 1888, Rakotosaona 1972, Hallanger 1974, Rajemisa 1985).

In addition, dissimilation applies when passive imperatives attach to loanwords (data from the World Loanword Database: [http://wold.cldr.org](http://wold.cldr.org)):

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ankahala+u/</td>
<td>/ankahala-u/</td>
</tr>
<tr>
<td>/hihis+u/</td>
<td>/hihis-u/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dissimilation</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/sutru+u/</td>
<td>/sutr-i/</td>
</tr>
<tr>
<td>/lambulambu+u/</td>
<td>/lambulambu-i/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blocking</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/burusi+u/</td>
<td>/burusi-u/</td>
</tr>
<tr>
<td>/futsi+u/</td>
<td>/futsi-u/</td>
</tr>
</tbody>
</table>

No other suffix with u to test whether dissimilation applies to multiple suffixes, but we do have some evidence for frontness dissimilation (Richardson 1885):

- Deletion applies to plain passive suffix -ina after e, but not after u:

<table>
<thead>
<tr>
<th>Underlying -ina</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/buban+ina/</td>
<td>/buban-ina/</td>
</tr>
<tr>
<td>/velum+ina/</td>
<td>/velum-ina/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deletion after e</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/bede+ina/</td>
<td>/bede-na/</td>
</tr>
<tr>
<td>/enge+ina/</td>
<td>/enge-na/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No deletion after u</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/babu+ina/</td>
<td>/babu-ina/</td>
</tr>
<tr>
<td>/beku+ina/</td>
<td>/beku-ina/</td>
</tr>
</tbody>
</table>

### 2.2 Phonotactic backness harmony in Malagasy

Corpus gives lots of harmonic roots:

<table>
<thead>
<tr>
<th>Hiring</th>
<th>Loaned from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>kiri</td>
<td>‘small hole’</td>
</tr>
<tr>
<td>lufu</td>
<td>‘persistance’</td>
</tr>
<tr>
<td>uzuna</td>
<td>‘curse’</td>
</tr>
<tr>
<td>ririnina</td>
<td>‘winter’</td>
</tr>
<tr>
<td>sartru</td>
<td>‘cape’</td>
</tr>
<tr>
<td>tevika</td>
<td>‘spasm’</td>
</tr>
<tr>
<td>tsindri</td>
<td>‘compression’</td>
</tr>
<tr>
<td>veli</td>
<td>‘blow’</td>
</tr>
</tbody>
</table>

Counts of tier-adjacent vowel pairs reveal no preference for disharmonic sequences in roots — rather, they display the opposite preference, for *harmonic sequences*, both locally and nonlocally.

- Majority of roots in the corpus are classified as noun (2,743 in total), adjective (728), or adverb (746); verb forms are derived from these roots through affixation.
Within noun roots
Within adj. roots
Within adv. roots
Within interj., conj., prep. roots
TOTAL

<table>
<thead>
<tr>
<th></th>
<th># harmonic VC₀V seq.s</th>
<th># disharmonic VC₀V seq.s</th>
<th># harmonic VC₀aC₀V seq.s</th>
<th># disharmonic VC₀aC₀V seq.s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within noun roots</td>
<td>786</td>
<td>602</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>Within adj. roots</td>
<td>185</td>
<td>183</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>Within adv. roots</td>
<td>312</td>
<td>188</td>
<td>109</td>
<td>49</td>
</tr>
<tr>
<td>Within interj., conj., prep. roots</td>
<td>96</td>
<td>41</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1379</td>
<td>1014</td>
<td>205</td>
<td>118</td>
</tr>
</tbody>
</table>

Table 2: Raw counts of (dis/)harmonic sequences in roots

There are over 300 more local harmonic sequences than there are local disharmonic sequences, and about 90 more nonlocal harmonic sequences than there are nonlocal disharmonic sequences.

Backness dissimilation is thus a DERIVED ENVIRONMENT EFFECT (Kiparsky 1973, 1993 et seq): it lacks a counterpart generalization in the lexicon.

Could these counts have arisen by chance?
- As I will argue below, more harmonic sequences are observed than chance predicts.

We calculate expected proportion of harmonic sequences given the frequency of instances of each of the vowel (see Appendix for details), and compare it to observed proportion.

<table>
<thead>
<tr>
<th></th>
<th>Expected rate</th>
<th>Observed rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local sequences:</td>
<td>51.6%</td>
<td>57.3%</td>
</tr>
<tr>
<td>Nonlocal sequences:</td>
<td>57.7%</td>
<td>63.5%</td>
</tr>
</tbody>
</table>

Table 3: Expected proportions of harmonic sequences in roots

To determine whether we’re observing more sequences than chance would predict, we run a Monte Carlo simulation (Kessler 2001; cf. Martin 2011). To do this for local vowel sequences:
- Gather pairs of tier-adjacent vowels; shuffle the V2s of each pair, concatenate each of them to a V1; calculate new harmony rate; repeat 10,000 times (see Appendix).

The graph below is a histogram of harmony rate frequency after 10,000 Monte Carlo trials.
Figure 2: distribution of harmony rates yielded by Monte Carlo trials, plus observed rate

The observed proportion of 57.3% is greater than any proportion yielded by Monte Carlo trial.

- i.e., observed proportion is significantly greater than chance would predict ($p < 0.0001$).
- Similar story for nonlocal harmony ($p = 0.01$): the observed proportion is substantially higher than chance proportion (63.5% vs. 57.7%).

These results suggest overrepresentation is not coincidental, but rather reflects a backness harmony preference in the lexicon.

But perhaps learners don’t actually pick up the harmony pattern? A generational study suggests otherwise:

- Roots in the online corpus are classified for which dictionary they appear in.
- The counts below show the asymmetry persists across multiple generations:

<table>
<thead>
<tr>
<th>Dictionaries</th>
<th># harmonic VC$_a$N seq.s</th>
<th># disharmonic VC$_a$N seq.s</th>
<th>Local harm rate</th>
<th># harmonic VC$_a$aC$_a$N seq.s</th>
<th># disharmonic VC$_a$aC$_a$N seq.s</th>
<th>Nonlocal harm rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richardson (1885)</td>
<td>223</td>
<td>165</td>
<td>57.5%</td>
<td>38</td>
<td>12</td>
<td>76.0%</td>
</tr>
<tr>
<td>Abinal (1888)</td>
<td>215</td>
<td>137</td>
<td>61.1%</td>
<td>43</td>
<td>8</td>
<td>84.3%</td>
</tr>
<tr>
<td>Rakotosaona (1972)</td>
<td>322</td>
<td>209</td>
<td>60.6%</td>
<td>79</td>
<td>42</td>
<td>65.3%</td>
</tr>
<tr>
<td>Hallanger (1974)</td>
<td>229</td>
<td>179</td>
<td>57.5%</td>
<td>25</td>
<td>7</td>
<td>78.1%</td>
</tr>
<tr>
<td>Rajemisa (1985)</td>
<td>925</td>
<td>723</td>
<td>56.1%</td>
<td>217</td>
<td>44</td>
<td>83.1%</td>
</tr>
</tbody>
</table>

Table 3: Backness harmony across generations

- If unproductive generalizations fade out over the years (cf. Martin 2007), then these numbers suggest harmony is productive.
Local summary:

- Malagasy enforces backness dissimilation in the suffix domain, with the passive imperative alternating at drastic rates.
- But roots show a strong harmony preference.

2.3 Malagasy is not alone: opposite restrictions systems in Mayan

Yucatec Maya shows opposite restrictions governing suffix vowels.
- Two morphemes harmonize for backness and height under certain conditions,
- while two other morphemes undergo dissimilation instead.

Intransitive suffixes take backness and height from stem-final vowel (7a, b) unless stem ends in a coda consonant, in which case suffix vowel defaults to [a] (7c, d) (Blair 1964, Krämer 2001).¹

Suffixal harmony

<table>
<thead>
<tr>
<th>(7a)</th>
<th>Intransitive imperfective</th>
<th>(7b)</th>
<th>Intransitive perfective</th>
</tr>
</thead>
<tbody>
<tr>
<td>?ah--al</td>
<td>wake.up-IMPF</td>
<td>?ah--ak</td>
<td>wake.up-SUBJ</td>
</tr>
<tr>
<td>?ok--ol</td>
<td>enter-IMPF</td>
<td>?ok--ok</td>
<td>enter-SUBJ</td>
</tr>
<tr>
<td>lub’--ul</td>
<td>fall-IMPF</td>
<td>lub’--uk</td>
<td>fall-SUBJ</td>
</tr>
<tr>
<td>wen--el</td>
<td>sleep-IMPF</td>
<td>wen--ek</td>
<td>sleep-SUBJ</td>
</tr>
<tr>
<td>ki:-m-il</td>
<td>die-IMPF</td>
<td>ki:-m-ik</td>
<td>die-SUBJ</td>
</tr>
</tbody>
</table>

Blocking by coda consonant

<table>
<thead>
<tr>
<th>(7c)</th>
<th>Intransitive imperfective</th>
<th>(7d)</th>
<th>Intransitive perfective</th>
</tr>
</thead>
<tbody>
<tr>
<td>t’ot-f’--al</td>
<td>harden-PASS-IMPF</td>
<td>tu:\k--n-ak</td>
<td>think-N-SUBJ</td>
</tr>
<tr>
<td>he:\k’--n-ak</td>
<td>break-N-SUBJ</td>
<td>ts’i:\b’-n-ak</td>
<td>write-N-SUBJ</td>
</tr>
</tbody>
</table>

On the other hand, two derivational suffixes dissimilate from the stem-final vowel:
- –ki:\-n–ku:\-n, used in the formation of deadjectival and denominal forms (glossed D below, following Krämer 2001),
- and –en–\-un, a participle formed from positional verbs used in reduplication.

Dissimilation driving –ki:\-n vs. –ku:\-n

| (8a) | uts-ki:\-n-t-ik | good-D-TR-IMPF |
| (8b) | haw-ku:\-n-t-ah | lie.down.face.up-D-TR-PERF |
| (8c) | sa:si-l-\-ku:\-n-s | light.up-D-CAUS-DET |

¹ If matching amongst vowels were simply the result of reduplication, one would expect both length and tone (the latter withheld from transcriptions above) to copy, but they do not (Krämer 2001; cf. Stanton & Zukoff 2016).
• Suffix form chosen is the one that differs from the preceding vowel in the value of [back], providing evidence for the working of backness dissimilation in the grammar.

_Dissimilation driving –en vs. –un_

(9a)  \text{haː-y-un-haːy} \quad \text{stretch-PART-RED = ‘stretch here and there’}
(9b)  \text{ke:b-un-ke:b} \quad \text{lean-PART-RED = ‘lean here and there’}
(9c)  \text{ʃoːl-en-ʃoːl} \quad \text{kneel-PART-RED = ‘kneel here and there’}
(9d)  \text{kuːl-en-kuːl} \quad \text{seat-PART-RED = ‘seat here and there’}
(9e)  \text{ʃiːl-en-ʃiːl} \quad \text{lie-PART-RED = ‘lie here and there’}

Here the story is somewhat more complicated:

• –en is default allomorph for the participial morpheme,
• but if the preceding vowel matches for both [back] and [high], then –un, is selected (see Krämer 2001 for an analysis based on underspecification).

Hence in Yucatec Maya, two suffixes harmonize for backness and height, while another suffix dissimilates for backness, and yet another for both backness and height.²


### 3. Domain generalization bias

**DOMAIN GENERALIZATION BIAS:** Learner tendency to favor phonological constraints that hold across morphological domains.

Though morphologically derived environment effects were purported to arise in some languages, Cho (2009) and Chong (2016) suggest some famous cases are either unstable or nonexistent.

Artificial language experiments suggest learners prefer grammars in which phonological constraints hold across domains:

• Myers & Padgett (2014) expose participants to phrase-final devoicing, who in turn generalize it to word-final devoicing.
• Chong (to appear) shows harmony alternations are more readily apprehended when roots show a harmony generalization.

Martin (2007, 2011) observes “leaking” — that is, a categorical phonotactic constraint weakly manifesting across compound boundaries:

• Navajo categorically enforces sibilant harmony in roots, while compounds with disagreeing sibilants are significantly underattested.
• Likewise, English bans geminates in roots, while compounds with geminates are significantly underattested.

² Note that not all suffixes harmonize or dissimilate: the perfective and transitive imperfective –\textit{ah} and –\textit{ik} always surface with these forms, and do not depend on the final stem vowel.
• See Brown & Yang (2016) for a similar story in Japanese.

Opposite restrictions in Malagasy and Mayan are mismatch cases that are more drastic than derived environment effects. It’s remarkable they even arise, given these findings.

4. MaxEnt grammar for Malagasy cooccurrence restrictions

Backness restriction in Malagasy is in large part gradient — I treat it within Maximum Entropy Harmonic Grammar (MaxEnt; Hayes & Wilson 2008).

In MaxEnt:
• Constraints are assigned a numerical “strength”, or weight, instead of being ranked.
• Output forms are assigned probabilities (\( P \)) instead of being partitioned into winners and losers.
• Probabilities are determined as a function of the weighted sum of the constraint violations, i.e. the harmony (\( H \)).

I use the MaxEnt Grammar Tool (Wilson 2006), which takes in UR-SR pairs, their frequencies, constraints and tableaux and returns optimal weights for the constraints.
• Available here: [http://linguistics.ucla.edu/people/hayes/MaxentGrammarTool/](http://linguistics.ucla.edu/people/hayes/MaxentGrammarTool/)

First to cover backness dissimilation. I reproduce below the pertinent data:

(9a) -\( u \) is underlying: \( /\text{bata}+u/ \rightarrow [\text{bata}-u] \) ‘lift’
(9b) Local dissimilation: \( /\text{bab}u+u/ \rightarrow [\text{babu}-i] \) ‘plunder’
(9c) Nonlocal dissimilation: \( /\text{tuda}+u/ \rightarrow [\text{tuda}-i] \) ‘prevent’
(9d) Front vowel blocking: \( /\text{turi}+u/ \rightarrow [\text{turi}-u] \) ‘preach’

We posit local and nonlocal variety of OCP, applying only across the suffix boundary:

(10a) OCP-L(back)/across+: \* \([\alpha\text{back}]_{-\text{low}}\) \( C_0+\left[\alpha\text{back}\right]_{-\text{low}}\)

OCP-NL(back)/across+: \* \([\alpha\text{back}]_{-\text{low}}\) \( C_0\alpha C_0+\left[\alpha\text{back}\right]_{-\text{low}}\)

And we have low-weighted IDENT, violated by alternating forms.

As for the harmony preference in roots, we posit local and nonlocal variety of AGREE (Lombardi 1999, Bakovic 2000), applying only within roots:

(10b) AGREE-L(back)/within roots: \* \([\alpha\text{back}]_{-\text{low}}\) \( C_0[\alpha\text{back}]_{-\text{low}}\)

AGREE-NL(back)/within roots: \* \([\alpha\text{back}]_{-\text{low}}\) \( C_0\alpha C_0[\alpha\text{back}]_{-\text{low}}\)
We feed into the MaxEnt learning tool the UR-SR mappings and frequencies below:

<table>
<thead>
<tr>
<th>Input</th>
<th>Candidate</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within root</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_1V_2$</td>
<td>uu, ii, ei, etc.</td>
<td>1379</td>
</tr>
<tr>
<td></td>
<td>ui, eu, iu, etc.</td>
<td>1014</td>
</tr>
<tr>
<td>$V_1aV_2$</td>
<td>uau, iai, etc.</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>uai, iau, etc.</td>
<td>118</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Candidate</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across suffix boundary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$u^+u$</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>$u+i$</td>
<td></td>
<td>989</td>
</tr>
<tr>
<td>$ua^+u$</td>
<td></td>
<td>196</td>
</tr>
<tr>
<td>$ua+i$</td>
<td></td>
<td>201</td>
</tr>
<tr>
<td>$ui^+u$</td>
<td></td>
<td>399</td>
</tr>
<tr>
<td>$ui+i$</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>no.trigger$^+u$</td>
<td></td>
<td>1877</td>
</tr>
<tr>
<td>...$^+i$</td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4: *Learner input for the Malagasy system*

- Root inputs reminiscent of Martin (2007).

With these constraints, MaxEnt predicted the observed frequencies well, returning the following weights:

\[ (11) \quad \begin{array}{c|c} \text{AGREE-}$L$-rt & 0.31 \\ \text{AGREE-}$NL$-rt & 0.55 \\ \text{OCP-}$L$-+ & 10.45 \\ \text{OCP-}$NL$-+ & 5.38 \\ \text{IDENT} & 5.34 \end{array} \]

Let’s see the grammar in action. Below is tableau for local dissimilation:

\[
\begin{array}{c|c|c|c|c}
\text{(e.g., /babu$^+u$/)} & \mathcal{P} & \mathcal{H} & \text{OCP- across$^+w$ = 9.95} & \text{IDENT $w$ = 4.84} \\
\text{/...uC}_0^+u/ & 0.01 & -9.95 & -1 * 9.95 & \\
\text{uC}_0^+u & 0.99 & -4.84 & -1 * 4.84 & \\
\end{array}
\]

Table 5a: *Tableau for local backness dissimilation*

- Grammar accurately predicts local dissimilation across 99% of the relevant forms.
- Nonlocal dissimilation tableau looks similar, accurately predicting a 51% rate.

But for root harmony over adjacent vowels, we have the following:

\[
\begin{array}{c|c|c|c|c}
/V_1V_2/ & \mathcal{P} & \mathcal{H} & \text{AGREE-}$L$/roots $w$ = 0.36 \\
uu, ii, ei, etc. & 0.59 & 0 & \\
ui, eu, iu, etc. & 0.41 & -0.36 & -1 * 0.36 \\
\end{array}
\]

Table 5b: *Tableau for front vowel blocking*
• Nonlocal harmony is captured similarly.

Blocking by front vowels is also modeled accurately: violation of higher weighted OCP-L/across+ and IDENT are traded for a violation of lower weighted OCP-NL/across+.

4.1 Overriding smoothing in Malagasy

On a deeper level, opposite restrictions systems complicate our understanding of domain generalization. Recall:

- Martin (2011) observes that strong phonotactic constraints can “leak” into the cross-boundary domain:
  - in Navajo sibilant harmony for instance, a categorical phonotactic generalization is mirrored by a statistical tendency across compound boundaries.
- Martin introduces a smoothing term into MaxEnt:
  - when learners weigh highly a phonotactic constraint, they also give weak positive weight to a domain-general constraint, thereby deriving tendencies in compounds.

For Malagasy we can invoke a suffixal OCP constraint together with a general OCP constraint, and the smoothing term would result in the learner weighing general OCP positively.

But the learner is free to counteract tendency simply by adjusting the weight of root-internal AGREE to the point of eclipsing general OCP, as the MaxEnt outputs below reveal:

<table>
<thead>
<tr>
<th>Within root</th>
<th>Across suffix boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁V₂</td>
<td>uu, ii, etc.</td>
</tr>
<tr>
<td></td>
<td>ui, eu, etc.</td>
</tr>
<tr>
<td></td>
<td>no.trig+u</td>
</tr>
</tbody>
</table>

Table 6a: Input with harmony preference

<table>
<thead>
<tr>
<th>Within root</th>
<th>Across suffix boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁V₂</td>
<td>uu, ii, etc.</td>
</tr>
<tr>
<td></td>
<td>ui, eu, etc.</td>
</tr>
<tr>
<td></td>
<td>no.trig+u</td>
</tr>
</tbody>
</table>

Table 6b: Input with no preference

Outputted grammars by MaxEnt match the desired frequencies nearly perfectly.

- The OCP drive is leaked into the root domain, and yet the overall result in (12a) is one in which opposing constraints result in tendency reversal,
- and in (12b) is one in which opposing constraints result in tendency cancellation, for better or for worse.
Thus the current representation of domain generalization bias in MaxEnt does not prevent derived environment effects most generally (cf. Martin 2011).

- Learner can simply weigh positively a counterconstraint to cancel out or reverse a generalization leaked into a domain.

Availability of natural counterconstraint to the learner might be what distinguishes Martin’s cases from mine:

- learners may fail to entertain constraints favoring disharmonic sibilants or geminates, they being unnatural and typologically unmotivated;
- but harmony and dissimilation in back vowels are observed crosslinguistically (Clements and Sezer 1982, Itô 1984),
- and so it is reasonable to think the learner could entertain constraints for the latter in hypotheses about morphological domains.

It very well could be that derived environment effects arise and persist only in cases where there exists independent crosslinguistic evidence for the working of two opposing constraints.

And perhaps those in which there does not exist a natural opposing constraint are relatively prone to breaking down, as in Chong (2016), or being generalized, as in Martin (2011).

5. Discussion and conclusion

How might the Malagasy system have arisen?

- Perhaps opposite restrictions play a part in marking the suffix boundary — a drive that would directly conflict with domain generalization bias.
- Or perhaps it was historical accident, e.g. backness dissimilation originates as *u+u, but is eventually generalized into *u(Cₐa)C₀+u.

  - Note [uu] is absent from roots, unless <h> is silent (e.g., <adoho>).
  - If true, then learners extrapolated in a way that defies domain generalization bias.

Are opposite restrictions systems really biased against? Two possibilities:

1) These systems are militated against by domain generalization bias. They are, after all, derived environment effects, and so this bias renders them rare.

2) These systems are not militated against by such learning bias.

  - This would mean that domain generalization bias is only a bias against one kind of derived environment effect,
  - namely, one in which structure X is underrepresented in Domain A but is neither under- nor overrepresented in Domain B.
  - This is in line with how smoothing works in MaxEnt grammar (Martin 2011).

These data undermine strength of domain generalization bias: Malagasy learner must be able to acquire opposite cooccurrence restrictions across domains.
6. Appendix

A. The expected proportion of local harmonic sequences to disharmonic sequences is determined as follows. Gather all vowel pairs in which either vowel belongs to \([i \ e \ u]\). We calculate:

\[
p(V_1 = [i] \text{ or } [e]) \cdot p(V_2 = [i] \text{ or } [e]) + p(V_1 = [u]) \cdot p(V_2 = [u])
\]

- e.g., \(p(V_1 = [i \ e]) = (\# \text{ instances } V_1 = [i \ e])/(\# \text{ instances } V_1 = [i \ e] + \# \text{ instances } V_1 = [u])\).

The same can be done for nonlocal sequences by gathering all sequences of the form \(V_1aV_2\), where \(V_1\) and \(V_2\) belong to \([i \ e \ u]\). The formula will be the same as above.

B. How does a Monte Carlo simulation work?

- Extract from roots all pairs of tier-adjacent vowels belonging to \([i \ e \ u]\):

  \[
  \begin{align*}
  \text{abili} & \rightarrow i_1i_1 \\
  \text{abuni} & \rightarrow u_2i_2 \\
  \text{afuvuani} & \rightarrow u_3u_3 \\
  \text{alahelu} & \rightarrow e_4u_4 \\
  \text{buerika} & \rightarrow u_5e_5, e_6i_6 \\
  \ldots & \rightarrow \ldots
  \end{align*}
  \]

- Make a new set of \(V_1\)-\(V_2\) pairs by fixing \(V_1\) and concatenating a random \(V_2\) from another pair:

  \[
  \begin{align*}
  i_1i_1 & \rightarrow i_1e_5 \\
  u_2i_2 & \rightarrow u_2u_4 \\
  u_3u_3 & \rightarrow u_3i_2 \\
  e_4u_4 & \rightarrow e_4i_1 \\
  u_5e_5 & \rightarrow u_5i_6 \\
  e_6i_6 & \rightarrow e_6e_5 \\
  \ldots & \rightarrow \ldots
  \end{align*}
  \]

- Calculate proportion of harmonic sequences in the new set. This proportion arose by chance given existing vowel frequencies, by randomly concatenating \(V_1\)s with \(V_2\)s.

- One Monte Carlo trial might produce 51% after random concatenation, another 53%, another 51.5%, another 49%, etc. Do this for 10,000 trials, and you have your bell curve.
References


