An Agreement-by-Correspondence Analysis of Máihìkì
Nasalization Harmony*

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ABC↔Conference
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1 Overview of Máihìkì

- Western Tukanoan, spoken in Peruvian Amazon NE of Iquitos
- Name of language: In orthography, Máñjì; in IPA, with only H tone marked [máñjì]
  Previous names (now considered pejorative): Orejón, Coto
- ∼100 speakers out of ∼400 ethnic Maijuna
- Endangerment Status: Most speakers are 50+ years-old; may still be some acquisition in Tòtoya
- Spoken in 4 main communities: Puerto Huamán, Nueva Vida, Sucusari, Tòtoya
- Slight dialectal variation: All data here from Nueva Vida

2 Phonological Profile

<table>
<thead>
<tr>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Postalveolar</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless Stop</td>
<td>p</td>
<td>t</td>
<td>k, k^w</td>
<td></td>
</tr>
<tr>
<td>Voiced Stop</td>
<td>b [b, ß, m]</td>
<td>d [d, r, n]</td>
<td>g [g, ñ], g^w</td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>tʃ [tʃ, ʃ]</td>
<td>dʒ [dʒ, j, ʃ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>s [s, ts]</td>
<td></td>
<td>h</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Máñjìki consonant inventory

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>i [i, ĭ]</td>
<td>u [u, ü]</td>
</tr>
<tr>
<td>Mid</td>
<td>e [e, ĭ]</td>
<td>o [o, ő]</td>
</tr>
<tr>
<td>Low</td>
<td>a [a, ā]</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Máñjìki vowel inventory

*Many thanks to Stephanie Farmer and Lev Michael for collecting massive amounts of data, introducing me to Máñjìki, and helping to put together this analysis. Thank you to Sharon Inkelas and Stephanie Shih for helpful discussion, especially of ABC. Thank you also to Ronald Sprouse for putting together a pneumotachograph and helping us visualize the results. Thanks are also due to audiences at presentations in the UC Berkeley Linguistics Department and at WSCLA 18 (2013) for their helpful comments. Many thanks also to the Máñjuna people, especially our consultants. This work was done as part of the Máñjìki Language Documentation Project, which is generously funded by NSF Grant #1065621. The usual disclaimers apply.
Nasalization is contrastive and treated as a morpheme-level feature: /gá/ ‘a water snail’ vs. /gá/ ‘meat’

- Nasal consonants and vowels are not underlying
- No velar nasal [ŋ], no voiceless nasals, no prenasalized stops
- Contrastive level tones on surface: H = ́v, L = ̀v
  - Tone does not influence nasality

### 2.1 Distribution of Oral and Nasal Syllables

- Relevant classes of surface segments for nasalization harmony:
  - T: p, t, k, kʷ, g, gʷ, tj, s
  - D: b, d, ɗ́
  - N: m, n, ɲ
  - V: i, i, u, e, o, a
  - ̃V: ́i, ́i, ̃u, ̃e, ̃o, ̃a
- Syllable structure is strictly (C)V
- Only one nasal segment per syllable

<table>
<thead>
<tr>
<th>attested oral</th>
<th>attested nasal</th>
<th>unattested nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>T̃V</td>
<td></td>
</tr>
<tr>
<td>DV</td>
<td>ÑV</td>
<td>*D̃V, *ÑV</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Distribution of oral and nasal syllables

- Non-attestation of *D̃V and *ÑV is explained by DV nasalizing to NV
- Are there really no ÑV syllables as in other Tukanoan languages?

### 2.2 Instrumental Evidence for *ÑV Gap

- After surface nasal consonants, no phonological contrast in nasality on vowels
  - No minimal or near-minimal pairs
  - Speakers’ judgments on vocalic nasality following surface nasal consonants are inconsistent
- Phonetic nasality of these vowels matters for phonological analysis:
  - If vowels after surface nasal consonants are phonetically nasal, there is Spreading
  - If they are oral, there is Consonant Harmony
- Stephanie Farmer and Lev Michael brought a pneumotachograph assembled by Ronald Sprouse to the field in the summer of 2012
- The pneumotachograph set-up:
  - Dual-chamber Rothenberg mask attached to a transducer that converted airflow measurements into electrical signals
  - Signals were processed through an analog-to-digital converter and sent to a laptop
- **The Question**: Do vowels after surface nasal consonants look more like unambiguously oral vowels or unambiguously nasal vowels?
  - Vowel nasalization is unambiguous in TV syllables
- Took uncalibrated measurements, since only relative airflow was needed
• An unambiguously nasal vowel, [ã], in tákë ‘monkey’:
  (Spectrogram on top, nasal airflow in the middle, oral airflow on the bottom)

• The vowel /a/ after a surface nasal consonant in mákã hã ‘it’s jungle’:

• Slight co-articulatory nasal airflow on vowels after surface nasal consonants, but much less nasal airflow than unambiguously nasal vowels

• Conclude that vowels after surface nasal consonants are phonologically oral
2.3 Distribution of Oral and Nasal Morphemes

- Of the 9 combinatorial possibilities for (disyllabic) oral morpheme shapes, all 9 are realized: TVTV, TVDV, DVTV, DVDV, TVV, DVV, VTV, VDV, and VV

- Of the 25 combinatorial possibilities for nasal morpheme shapes, however, only 9 are realized: T̃VT, TVNV, NVTV, NNVN, T̃ṼV, NVV, ̃VT, VNV, and ̃ṼV

<table>
<thead>
<tr>
<th>σ₁ = TV</th>
<th>σ₂ = TV</th>
<th>̃V</th>
<th>σ₂ = T̃V</th>
<th>σ₂ = NV</th>
<th>̃V</th>
</tr>
</thead>
<tbody>
<tr>
<td>tūk̀u</td>
<td>tūbì</td>
<td>‘star’</td>
<td>tòà</td>
<td>‘tree stump’</td>
<td>tînó</td>
</tr>
<tr>
<td>bēǩàt</td>
<td>bībè</td>
<td>‘tapir’</td>
<td>bàò</td>
<td>‘eagle’</td>
<td>—</td>
</tr>
<tr>
<td>̃öǩò</td>
<td>̃ódà</td>
<td>‘water’</td>
<td>̃éò</td>
<td>‘palm sp.’</td>
<td>̃ápà</td>
</tr>
<tr>
<td>t̃ákè</td>
<td>—</td>
<td>‘monkey sp.’</td>
<td>—</td>
<td>—</td>
<td>g̃ò</td>
</tr>
<tr>
<td>̃násò</td>
<td>—</td>
<td>‘monkey sp.’</td>
<td>̃mái</td>
<td>‘person’</td>
<td>̃nápà</td>
</tr>
<tr>
<td>̃êkè</td>
<td>—</td>
<td>‘toad sp.’</td>
<td>—</td>
<td>—</td>
<td>̃àò</td>
</tr>
</tbody>
</table>

Table 4: Attested words showing licit combinations of oral and nasal syllables in morphemes

- These data suggest a 1-to-1 correspondence between oral and nasal morphemes, given in the table below:

<table>
<thead>
<tr>
<th>oral morpheme</th>
<th>TVTV</th>
<th>TVDV</th>
<th>DVTV</th>
<th>DVDV</th>
<th>TVV</th>
<th>DVV</th>
<th>VTV</th>
<th>VDV</th>
<th>VV</th>
</tr>
</thead>
<tbody>
<tr>
<td>nasal morpheme</td>
<td>T̃VT</td>
<td>TVNV</td>
<td>NVTV</td>
<td>NNVN</td>
<td>T̃ṼV</td>
<td>NVV</td>
<td>̃VT</td>
<td>VNV</td>
<td>ṼV</td>
</tr>
</tbody>
</table>

Table 5: Correspondence between oral and nasal morphemes

3 Pre-Theoretical Description

- [NAS] is underlyingly a floating, morpheme-associated feature that triggers nasalization harmony

- Floating [NAS] docks to the leftmost suitable host
  - T segments never nasalize
  - Voiced obstruents (D segments) are preferred over vowels (V) as hosts
  - If there is a voiced consonant in the second syllable of the morpheme, it nasalizes instead of the leftmost vowel, i.e. /[NAS] t̃ódó/ → [t̃ínó] ‘heal (tr.),’ not *[t̃ínó]

- When [NAS] docks to a voiced obstruent (D), that voiced obstruent surfaces as a nasal consonant
  - The next voiced obstruent to the right, if there is one, also surfaces as a nasal consonant

- Morpheme boundaries block the “spread” of nasality to voiced obstruents to the right, e.g. /[NAS] d̃zá-dái/ → [jiá-rài] ‘visit’ (lit. see-come)\(^1\)
  - Maximal morpheme seems to be disyllabic for harmony purposes
  - Morphemes that seem to be longer usually involve frozen morphology which is respected by harmony

- When [NAS] docks to a vowel, it docks to the leftmost vowel
  - If the leftmost vowel is directly adjacent to another vowel, that other vowel also nasalizes, i.e. /[NAS] ̃VV/ → *[VV] → [VV] as in /̃áò/ → [áò] ‘food’

\(^1\)[r] is the intervocalic allophone of /d/.
Nasalization can also spread through /h/ to a following vowel, i.e. /NAS vhV/ → *[˘vhV] → [˘hv˘] as in /NAS gú˘h/ → [˘gh] ‘tooth’

- /h/ itself is often highly nasalized, regardless of position: Rhinoglottophilia (Matisoff 1975)?

- Any intervening consonant other than /h/ blocks the spread of vowel nasalization

4 Agreement-by-Correspondence Analysis

4.1 Analyzing Máihíki Nasal Consonant Harmony

- Constraint that establishes correspondence between voiced obstruents is CORR[+voi, -cont]µ

  (1) CORR[+voi, -cont]µ
  Assign one violation for each local pair of voiced, non-continuant segments within a morpheme that do not correspond.²

- Hansson (2001:297-298) restricted domain of correspondence according to phonological constituents
- Here, restricted to a morpheme.

- CORR[+voi, -cont]µ establishes correspondence; IDENT-XX[NAS] enforces agreement in nasality

  (2) IDENT-XX[NAS] (adapted from Hansson 2007:405)
  Let Xₐ and Xₜ be segments in the output, such that:
  a. Xₐ is a correspondent of Xₜ, and vice versa
  b. Xₐ linearly precedes Xₜ in an output string, and
  c. there exists no Xₑ such that Xₑ linearly interrupts Xₐ and Xₜ (Xₐ < Xₑ < Xₜ) with Xₑ corresponding with either Xₐ or Xₜ (but not both).
  Assign one violation if Xₐ is [αF] and Xₜ is not [αF].

- IDENT-XX[NAS] enforces agreement between local pairs of corresponding phonemes (Hansson 2007)

- CORR[+voi, -cont]µ and IDENT-XX[NAS] are equally ranked, and dominate IDENT-IO/OI[NAS]

  (3) IDENT-IO/OI[NAS]
  For every [NAS] feature in the input, a corresponding [NAS] feature must exist in the output, and for every [NAS] feature in the output, a corresponding [NAS] feature must exist in the input.

- To prevent floating nasality feature from being deleted, MAXFLT([NAS]) is undominated.

  (4) MAXFLT([NAS]) (adapted from Wolf 2005:370)
  Assign one violation mark for every floating [NAS] feature in the input that is not realized in the output.

- Ranking to derive core nasal consonant harmony phenomena:

  MAXFLT([NAS]), CORR[+voi, -cont]µ, IDENT-XX[NAS] ≫ IDENT-IO/OI[NAS]

  (5) Deriving core nasal consonant harmony phenomena (nápa ‘hair’)

<table>
<thead>
<tr>
<th>/[NAS] dadʒa/</th>
<th>MAXFLT ([NAS])</th>
<th>CORR[+voi, -cont]µ</th>
<th>IDENT-XX[NAS]</th>
<th>IDENT-IO/OI[NAS]</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ a. n₁aj₁a</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>b. n₁adʒ₁a</td>
<td></td>
<td></td>
<td>1!</td>
<td>1</td>
</tr>
<tr>
<td>c. d₁aj₁a</td>
<td></td>
<td></td>
<td>1!</td>
<td>1</td>
</tr>
<tr>
<td>d. d₁adʒ₁a</td>
<td>1!</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>e. dadʒa</td>
<td>1!</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>f. nápa</td>
<td>1!</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

²In constraints, the letter µ signifies “morpheme” rather than “mora.”
4.2 Analyzing Máíhíki Vowel Nasalization Harmony

- Máíhíki vowel nasalization harmony can be analyzed parallel to nasal consonant harmony and using many of the same constraints.
- To allow nasalization to spread through /h/, both vowels and /h/ are in correspondence.
- We treat /h/ as non-consonantal, and group vowels and /h/ with the feature [-consonantal].
- Correspondence between [-cons] phonemes is strictly local.

\[(6) \text{ CORR}[\text{-cons}] X-Xu \]
Assign one violation for each strictly adjacent pair of non-consonantal segments within a morpheme that do not correspond.

- Can rank \text{ CORR}[\text{-cons}] X-Xu with \text{ CORR}[+voi, -cont]u and derive strictly local nasal harmony, as in the word gûhi ‘tooth’

\[(7) \text{ Deriving strictly local nasal harmony phenomena} \]

<table>
<thead>
<tr>
<th>/\text{ [NAS]} \text{ guhi/}</th>
<th>\text{ MAXFLT} \text{ ([NAS])}</th>
<th>\text{ CORR}[\text{-cons}] X-Xu</th>
<th>\text{ IDENT-XX[NAS]}</th>
<th>\text{ IDENT-IO/OI[NAS]}</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ a. gûihi</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>b. gûihi</td>
<td></td>
<td></td>
<td>2!</td>
<td></td>
</tr>
<tr>
<td>c. gûihi</td>
<td></td>
<td>2!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. guih</td>
<td>l!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary ranking:

\text{ MAXFLT ([NAS]), CORR}[+voi, -cont]u, CORR[\text{-cons}] X-Xu, IDENT-XX[NAS] \gg IDENT-IO/OI[NAS]

4.3 Residual Issues

4.3.1 Impossible Segments

- *[\text{DOR, NAS}]
  Assign one violation mark for each occurrence of a dorsal nasal segment (such as ñ).  
  - Prevents /g/ and /g[\text{w}]/ from nasalizing
- *[\text{-voi, +cons, NAS}]
  Assign one violation mark for each occurrence of a voiceless nasal segment.
  - Prevents voiceless consonants from nasalizing

4.3.2 Preferred Hosts

- To express preference for voiced obstruents as hosts for nasalization, nasalized vowels must be disfavored when there is a voiced obstruent (D segment) available
- Must prevent forms like *[gîdo] from /\text{[NAS]} \text{ gîdo}/u

\[(8) \text{ Deriving the preference for nasalizing voiced obstruents over vowels (gînò ‘stone, rock’)} \]

<table>
<thead>
<tr>
<th>/gîno/</th>
<th>*[\text{DOR, NAS}]</th>
<th>*[\text{-cons, NAS}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ a. gîno</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. gîdo</td>
<td>l!</td>
<td></td>
</tr>
<tr>
<td>c. ñîdo</td>
<td>l!</td>
<td></td>
</tr>
</tbody>
</table>
• *[cons, NAS] must be ranked below IDENT-XX[NAS] so that vowels can nasalize during strictly local nasal harmony

• Summary ranking:

\[ \text{*[DOR, NAS], *[voi, +cons, NAS], MAXFLT ([NAS]), CORR[+voi, -cont]_\mu, CORR[-cons]X-X_\mu, IDENT-XX[NAS]} \]
\[ \gg *[cons, NAS], IDENT-IO/OI[NAS] \]

4.3.3 Alignment

• In a form like tâkê ‘monkey species,’ only the leftmost vowel will bear nasality, which means that for strictly local nasal harmony, spreading is left-to-right

  - ALIGN-L([NAS],\mu)  
    (adapted from McCarthy and Prince 1993 via McCarthy 2011)

  Assign one violation mark for every segment that intervenes between the feature [NAS] and the left edge of the morpheme.

(9) Preventing rightmost vowel from nasalizing (tâkê ‘monkey species’)

<table>
<thead>
<tr>
<th>/[NAS] take/</th>
<th>*[voi, +cons, NAS]</th>
<th>MAXFLT ([NAS])</th>
<th>*[cons, NAS]</th>
<th>ALIGN-L([NAS],\mu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ a. tâke</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>b. takê</td>
<td></td>
<td>1</td>
<td>3!</td>
<td></td>
</tr>
<tr>
<td>c. take</td>
<td>1!</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. take</td>
<td></td>
<td>1!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• *[cons, NAS] must be ranked above ALIGN-L([NAS],\mu) to ensure that alignment does not force vowels to be nasalized instead of voiced obstruents

• The final constraint ranking for analyzing Máinhêki nasalization harmony is:

\[ \text{*[DOR, NAS], *[voi, +cons, NAS], MAXFLT ([NAS]), CORR[+voi, -cont]_\mu, CORR[-cons]X-X_\mu, IDENT-XX[NAS]} \]
\[ \gg *[cons, NAS] \]
\[ \gg ALIGN-L([NAS],\mu), IDENT-IO/OI[NAS] \]

5 Conclusions

• Máinhêki has non-local consonant harmony in complementary distribution with strictly local vowel (+ /h/) harmony for the same feature: Nasality ([NAS])

• The ABC framework was built to handle non-local harmony, but can also handle local harmony

  - ABC’s original architecture invited extensions to the theory, which has led to analyses of vowel harmony (Rhodes 2010) and CV interactions (Shih 2013)

• ABC’s ability to handle different types of harmonies simultaneously allow it to account for Máinhêki nasalization harmony when conventional approaches fail

• Typologically, the Máinhêki nasalization harmony system is a rare (possibly even unique) kind of harmony system globally

• Within Tukanoan, the Máinhêki system is unique:

  - Most other Tukanoan languages have pervasive nasal spreading that spreads through both consonants and vowels in the same morpheme (e.g. Barasana in E. Tukanoan)

• The Máinhêki system points to interesting historical changes, for example:
– Vowels after nasal consonants ceased to be realized as phonetically nasal
– If voiceless segments in Proto-Tukanoan were transparent to nasal vowel harmony (as in Barasana), they have become opaque in Máññiki (or else they became transparent in Barasana)

• It is possible that other Tukanoan languages have systems similar to Máññiki, but detailed phonetic and phonological fieldwork has yet to reveal them

References


SHIH, STEPHANIE S. 2013. Consonant-tone interaction as Agreement by Correspondence. Ms. Stanford University and University of California, Berkeley.


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Appendix: Overlaid Nasal Airflow Traces

- Nasal airflow traces overlaid and aligned at the start of the initial vowel (center) for máká ‘jungle’ (top waveform and spectrogram) and tákè ‘monkey species’ (lower waveform and spectrogram)

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