PHONOLOGICAL TEAMWORK IN LAAL ROUNding HARMONY: AN ABC ANALYSIS

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UC Berkeley
“phonological teamwork”
- i.e. processes involving more than one necessary trigger

Specifically: multiple-trigger assimilation involving subphonemic/subfeatural cumulative effects
Introduction

- Similar to Cantonese inter-coronal fronting
  (Flemming 1997, 2001)

\[ *\text{T}_u\text{T} > \text{T}_y\text{T} \] (morpheme structure constraint)

- \( k^h\text{yt} \) ‘decide’
- \( k^h\text{ut} \) ‘bracket’
- \( t^h\text{uk} \) ‘bald head’
- \( t^h\text{yt} \) ‘take off’
- \( *t^h\text{ut} \)
Introduction

- Flemming’s (1997: 11)

“cases of doubly-conditioned assimilation (...) provide evidence that coarticulation is relevant to uncontroversially phonological processes, and therefore must be represented in the phonology.”

(cf. also Steriade’s (2009) P-map)
Introduction

IN THIS TALK:

- CASE STUDY:
  - Rare doubly triggered rounding harmony in Laal
  - Laal: isolate, Chad (ca. 750 speakers)

- ANALYSIS:
  - Agreement by Correspondence (ABC, modified)

- I WILL SHOW THAT:
  - There is phonology below the phonological feature
  - ABC can handle this subfeatural phonology
  - ABC can handle local effects of assimilation as well as long-distance assimilation
1. Laal doubly triggered rounding harmony
1. Laal doubly triggered rounding harmony

- Words are maximally disyllabic: `CV₁(C)` . `CV₂(C)`

<table>
<thead>
<tr>
<th>hi</th>
<th>i ü i u</th>
</tr>
</thead>
<tbody>
<tr>
<td>mid</td>
<td>e üo ø o</td>
</tr>
<tr>
<td>lo</td>
<td>ia üa a ua (&lt;ɛ)</td>
</tr>
</tbody>
</table>

- Front  - Front

V₁

<table>
<thead>
<tr>
<th>i -- i u</th>
</tr>
</thead>
<tbody>
<tr>
<td>e -- ø o</td>
</tr>
<tr>
<td>-- a --</td>
</tr>
</tbody>
</table>

+ Front  - Front

V₂
1. Laal doubly triggered rounding harmony

Double trigger

\[ \text{C}_1 \rightarrow \text{V}_1 \rightarrow (\text{C}_2) \rightarrow \text{C}_3 \rightarrow \text{V}_2 \]

\[ \Rightarrow \text{V}_1 \rightarrow [\text{rd}] \]

Diagrams of frontness and height:

- **Front:** 
  - hi: i, ü
  - mid: e, üo
  - lo: ia, üa

- **Not-front:** 
  - i
  - e
  - a

\[ \text{V}_1 \rightarrow \text{V}_2 \]

Vowels:

- p, b, ɓ
- mb, m, w

[labial] or [round] or [α height, -front]
1. Laal doubly triggered rounding harmony

1) Lab, $V_2[rd]$, Height, -Front $>\quad$ Rounding:

a. /ɓᵻr + -ú/ $>\quad$ ṃùr-ú $\quad$ ‘hook-pl’

b. /wèər + -ó/ $>\quad$ wòòr-ó $\quad$ ‘mongoose-pl’

c. /tèb + -ó/ $>\quad$ tòb-ó $\quad$ ‘fish(sp.)-pl’

d. /círm- + -ú/ $>\quad$ cúrm-ú $\quad$ ‘tree(sp.)-pl’

e. /páb + -ó/ $>\quad$ pób-ó $\quad$ ‘cobra-pl’
1. Laal doubly triggered rounding harmony

2) No Rounding:

a. /gōbēr/ > gōbēr  ‘cloud’ (*gōbōr)

b. /mēm-ēr/ > mēm-ēr  ‘my gd-mother’  *V₂[rd]

c. /gīn+ -ù/ > gīn-ù  ‘net-pl’  *Lab

d. /bēr+ -ú/ > bēr-ú  ‘plant.sp-pl’  *Height

e. /bīrū / > bīrū  ‘burn’  *-Front
1. Laal doubly triggered rounding harmony

- Note: the doubly triggered rounding harmony is only attested in stratum 1:

  - Root-internal (MSC)

  - Root + number marking suffixes (mainly nouns + a few verbs)
1. Laal doubly triggered rounding harmony

Spread [round] from V2 to V1:
• if V1 and V2 = [α height, -front]
• if C1, C2, and/or C3 = [labial]

Mere descriptive generalization, not explanatory.
2. Subphonemic similarity threshold
2. Subphonemic similarity threshold

V1 needs the coarticulatory rounding of the neighboring consonant to become a target of Rounding Harmony.

⇒ V1 > [rd]
2. Subphonemic similarity threshold

\[
\text{Similarity: } V_1 \leftrightarrow V_2
\]

\[
/b\text{ì}r\text{ú}/ \rightarrow \text{bùrú}
\]
2. Subphonemic similarity threshold

Similarity:
\[ V_1 \leftrightarrow V_2 \]

**Subphonemic:**
\[ V_1 = \text{non-round (coarticulatory rounding)} \]
\[ V_2 = \text{[round]} \]

\(/b\text{t}r\text{ú}/ \rightarrow \text{bùrú} \)
2. Subphonemic similarity threshold

**Similarity:**
\[ V_1 \leftrightarrow V_2 \]

**Threshold:**
\[ V_1 \] must be rounded enough (cumulative coarticulation)

**Subphonemic:**
\[ V_1 = \text{non-round (subphonemically rounded)} \]
\[ V_2 = [\text{round}] \]

\[ /b̃t̃r̃ũ/ \rightarrow bùrú \]
2. Subphonemic similarity threshold

CV coarticulation: /ɨ/ + C[+labial]

I = ɨ

°I = ɨ + Lab

Measurements =
center of vowel,
far from transitions
2. Subphonemic similarity threshold

- Second threshold: rounding similarity (qualitative)

/ɓᵻᵽ r ú/ \rightarrow [bùrú]

[ɑheight, -front]
2. Subphonemic similarity threshold

- ‘ostriches’: two alternate forms:

   a. /báéég-ú/  \[\rightarrow\] báéégú

   b. /báéég-ó/  \[\rightarrow\] bóógó
2. Subphonemic similarity threshold

- Rounding enhancement and rounding similarity

“worst” round V

“best” round V

2. Subphonemic similarity threshold

- Subphonemic rounding similarity

“worst” round V

“best” round V
### 2.3 Rounding Similarity Scale

#### Rounding similarity scale

<table>
<thead>
<tr>
<th>Degree of similarity</th>
<th>Property</th>
<th>Similar to [u]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonemic level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>[rd]</td>
<td>u</td>
</tr>
<tr>
<td><strong>Subphonemic level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>rd/[-front]/height</td>
<td>i&lt;sup&gt;o&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>rd/height</td>
<td>i&lt;sup&gt;o&lt;/sup&gt;, i&lt;sup&gt;o&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>rd/[-front]</td>
<td>i&lt;sup&gt;o&lt;/sup&gt;, e&lt;sup&gt;o&lt;/sup&gt;, a&lt;sup&gt;o&lt;/sup&gt;</td>
</tr>
<tr>
<td>1</td>
<td>rd</td>
<td>V&lt;sup&gt;°&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
## 2.3 Rounding Similarity Scale

- **Rounding similarity scale (threshold = level 4)**

<table>
<thead>
<tr>
<th>Phonemic level</th>
<th>Degree of similarity</th>
<th>Property</th>
<th>Similar to [u]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>[rd]</td>
<td>u</td>
</tr>
<tr>
<td>Subphonemic level</td>
<td>4</td>
<td>rd/[-front]/height</td>
<td>i°</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>rd/height</td>
<td>i°, i°</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>rd/[-front]</td>
<td>i°, ə°, a°</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>rd</td>
<td>V°</td>
</tr>
</tbody>
</table>
## Rounding Similarity Scale

- **Level 5 acts like a magnet**

<table>
<thead>
<tr>
<th>Similarity scale</th>
<th>a. /gĩn-ù/</th>
<th>b. /mèg-ú/</th>
<th>c. /bìrú/</th>
<th>d. /bìr-ú/</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 [round]</td>
<td>g i n u</td>
<td>m æ g u</td>
<td>b i r u</td>
<td>u</td>
</tr>
<tr>
<td>4 rd + [-fr]/height</td>
<td></td>
<td></td>
<td></td>
<td>i°</td>
</tr>
<tr>
<td>3 rd + height</td>
<td></td>
<td></td>
<td>i°</td>
<td></td>
</tr>
<tr>
<td>2 rd + [-fr]</td>
<td></td>
<td>æ æ°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 rd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1 rd</td>
<td>i</td>
<td></td>
<td>i°</td>
<td></td>
</tr>
</tbody>
</table>
3. Agreement by Correspondence
Main insights: agreement is driven by a similarity threshold effect

- **Similarity**: Harmony = agreement between segments in a correspondence relation based on similarity.

- **Threshold**: unstable correspondence (Inkelas and Shih 2013b):
  - some segments are similar enough to interact,
  - but too uncomfortably similar to co-exist;
  - two possible repairs: harmony and disharmony
3 Agreement by Correspondence

ABC is used for:

- Long-distance C agreement  (Hansson 2001; Rose & Walker 2004)
- V Harmony  (Sasa 2009; Walker 2009; Rhodes 2012)
- Long-distance C Dissimilation  (Bennett 2013)
- Local effects of assimilation/dissimilation  (Inkelas & Shih 2013a,b; Shih 2013)
3.1 **CORR-XX** and **IDENT-XX** redefined

- **CORR-XX**: establishes correspondence between phonologically similar segments (i.e. shared phonological features).

- **IDENT-XX**: enforces identity in a particular feature between two segments in correspondence.
### 3.1 Corr-XX and Ident-XX redefined

**Corr-XX (P ≥ n)**
Segments in an output string are in correspondence if their similarity in the phonetic property P is at least n on the P-similarity scale.

\[ [F] \subseteq P \]

**Ident-XX [F]**
Segments in an output string agree in the phonological feature [F]
1) if they are in the correspondence relation defined as Corr-XX(P ≥ n),
2) and if [F] ⊆ P.
3.1 corr-xx and ident-xx redefined

- Laal Rounding Correspondence Hierarchy.

<table>
<thead>
<tr>
<th>Similarity scale</th>
<th>Correspondence hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree 4: rd/[-front]/height</td>
<td>CORR-VV(rd ≥ 4)</td>
</tr>
<tr>
<td>Degree 3: rd/height</td>
<td>CORR-VV(rd ≥ 3)</td>
</tr>
<tr>
<td>Degree 2: rd/[-front]</td>
<td>CORR-VV(rd ≥ 2)</td>
</tr>
<tr>
<td>Degree 1: rd</td>
<td>CORR-VV(rd ≥ 1)</td>
</tr>
</tbody>
</table>
3.1 \textbf{CORR-XX and IDENT-XX redefined}

- \textbf{CORR-XX} and \textbf{IDENT-XX} are co-dependent

\[
\begin{align*}
\text{IDENT}_\alpha \text{-VV [RD]} & \quad \leftrightarrow \quad \text{CORR}_\alpha \text{-VV (RD} \geq 4) \\
\text{CORR}_\alpha \text{-VV (RD} \geq 3) & \\
\text{CORR}_\alpha \text{-VV (RD} \geq 2) & \\
\text{CORR}_\alpha \text{-VV (RD} \geq 1) & 
\end{align*}
\]
### 3.2 ABC Analysis

- **Analysis:** /bùr-ú/ $\rightarrow$ bùrú ‘fish hooks’

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>a. bì°r-ú</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. bùr-ú</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. bì°r-ú</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>d. bùr-ú</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e. bì°r-í</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3.2 ABC Analysis

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. mèⁿ-ù</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. müön-ù</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>c. mèⁿ-ì</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis: /mèn-ù/ \(\rightarrow\) mènù ‘hoes’
4. A purely phonological alternation
4. A purely phonological alternation

☐ Is this alternation:
  ☐ purely phonetic?
  ☐ purely phonological?
  ☐ both: phonology has access to phonetic information?
4. A purely phonological alternation

□ Argument 1:

Slow speech rate / pause between σ 1 and σ 2 does not undo the harmony

→ it is not the actual coarticulatory effect and phonetic realization that are driving the harmony
4. A purely phonological alternation

- Argument 1:

  Slow speech rate / pause between $\sigma_1$ and $\sigma_2$ does not undo the harmony

  $\rightarrow$ it is not the actual coarticulatory effect and phonetic realization that are driving the harmony
4. A purely phonological alternation

Argument 2: Opacity of intervening /w/:

a. /wə̀r + -ó/  >  wòòr-ó  ‘mongoose-pl’

b. /sáw + -ò/  >  sáw-ò  ‘warthogs’  (*sówò)

c. /máw + -ó/  >  máw-ó  ‘scorpions’  (*mówó)

NB: Also a general MSC: *Uw

(no exception in 2200 word lexicon)
4. A purely phonological alternation

Undominated *Uw constraint:

<table>
<thead>
<tr>
<th>/ɓɪɖ-ú/</th>
<th>*Uw</th>
<th>IDENT-IO_{RD}</th>
<th>CORR_{\alpha-\text{VV}(\text{RD} \geq 4)}</th>
<th>IDENT_{\alpha-\text{VV}_{[RD]}}</th>
<th>IDENT-\text{OI}_{[RD]}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. mọ^{-o}w-ó</td>
<td>*!</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. mów-ó</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. mọ^{-o}w-ọ</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. mọ^{-o}w-ọ</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>e. mó^{-o}w-ọ</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Interesting case where the system “chooses” to keep the unstable correspondence, the “uncomfortable” level of similarity unchanged.
4. A purely phonological alternation

- Argument 3: stratum-dependent

In stratum 2, rounding harmony is systematic and unconditional. E.g. verb + object suffix:

a) /tîr + -ùn/ > túr-ùn  ‘put her across’  *Lab
b) /dèg + -òn/ > dòg-òn  ‘drag her’  *Lab
c) /dèg + -nǔ/ > dòg-nǔ  ‘drag us (ex.)’  *Lab, *Height
d) /léér + -nǔ/ > lüóór-nǔ  ‘wrap us’  *Lab, *Height, *-Front

Coarticulation and phonetic realization are expected to be identical in both strata!
5. An alternative (and very tentative) ABC analysis
5. Alternative analysis

/ɓìr-ú/ → bùrú

- Hypothesis:
  - V1 [ɨᵻ] does not assimilate to V2 [u]
  - ... but to /u/ in the inventory:
    - i.e. [ɨᵻ] and [u] are not perceptually contrastive enough, and [ɨᵻ] is reinterpreted as [u].s
4. Alternative analysis

- Contrast as a systemic property (Flemming 2001, 2004; Hayes & Steriade 2004:24-25)

- “Constraints favoring distinct contrasts are constraints on the differences between forms rather than on the individual forms themselves” (Flemming 2004:232) → “paradigmatic constraints”, which evaluate whole sets of possible forms, rather than single output forms.
4. Alternative analysis

- i.e. Comparison between each segment in the output form and the full phonological inventory. E.g. for vowels:
4. Alternative analysis

- i.e. Comparison between each segment in the output form and the full phonological inventory. E.g. for vowels:

```
i ü i i
e üo ə o
ia üa a ua
bìr à ɓìr ú
```

Notes: 
- The symbols represent phonetic values.
- The comparison highlights differences between the output form and the full inventory.
4. Alternative analysis

- PROPOSAL: Output-to-Inventory Correspondence

\[ \text{CORR}_\alpha - V_{\text{out}} V_{\text{inv}} (\text{RD} \geq 4) \]

\[ \text{b̃t}^o_\alpha \text{ru} \iff \{ u_\alpha \} \]
## 4. Alternative analysis

<table>
<thead>
<tr>
<th>/ɓᵢᵣ-ú/</th>
<th>IDENT-IO[RD]</th>
<th>CORR_{V_{out} V_{inv}}^{α} (RD ≥ 4)</th>
<th>IDENT_{α-VV}[RD]</th>
<th>IDENT-IO[RD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ɓᵢᵣ-ú ↔ {u}</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ɓᵢᵣ-ú ↔ {u}</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. ɓᵢᵣ-ú ↔ {u_{α}}</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. ɓᵢᵣ-ú ↔ {u_{α}}</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>e. ɓᵢᵣ-ú ↔ {...}</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSION
Laal doubly triggered rounding harmony is an argument in favor of the inclusion of subphonemic / subfeatural information in phonology.
Conclusion

- Enrichment of ABC:
Conclusion

- Enrichment of ABC:
  - ABC accounts for subphonemic/sub-featural similarity effects
Enrichment of ABC:

- ABC accounts for subphonemic/sub-featural similarity effects
- Both local and long-distance effects of assimilation can be insightfully captured by one and the same model
Conclusion

- **Enrichment of ABC:**
  - ABC accounts for *subphonemic/sub-featural* similarity effects
  - Both *local* and *long-distance* effects of assimilation can be insightfully captured by one and the same model
  - Potentially interesting account of paradigmatic similarity effects (*à la* Flemming)
Conclusion

- Enrichment of ABC:
  - ABC accounts for subphonemic/sub-featural similarity effects
  - Both local and long-distance effects of assimilation can be insightfully captured by one and the same model
  - Potentially interesting account of paradigmatic similarity effects (à la Flemming)

- If ABC is a theory of similarity driven processes, it should be able to account for processes driven by perceptual distinctiveness and contrast effects.
THANK YOU!
References 1/1

- Inkelas, Sharon and Stephanie Shih. 2013. ABC+Q: Contour segments and tones in (sub)segmental Agreement by Correspondence. Paper presented at Phonology 2013, UMass, 8-10 Nov. 2013.
- Inkelas, Sharon and Stephanie Shih. Unstable surface correspondence as the source of local conspiracies. Paper to be presented at NELS 44, University of Connecticut, Oct. 18-20, 2013.


Shih, Stephanie. 2013. Consonant-tone interaction as Agreement by Correspondence.


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- Audiences at UC Berkeley, Stanford University, UMass, LSA 2014 and OCP11.

- This work is supported by the Volkswagen Foundation DOBES program (grant #85538)
Appendix: Lowering of the threshold

- One exception with a front vowel:
- pír-ú \[\rightarrow\] pũũrú ‘compounds’

<table>
<thead>
<tr>
<th>Similarity scale</th>
<th>a. /bírú/ ‘to burn’</th>
<th>b. /pír-ù/ ‘compounds’</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 [round]</td>
<td>b í r ú</td>
<td>p ü ü r ú</td>
</tr>
<tr>
<td>4 rd/[-fr]/height</td>
<td>j°</td>
<td></td>
</tr>
<tr>
<td>3 rd/height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 rd/[-fr]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 rd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1 rd</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix: Lowering of the threshold

- Different co-indexation:

- $\text{IDENT}_{\alpha} - \text{VV [RD]}$ ↔ $\text{CORR}_{\alpha} - \text{VV (RD} \geq 4)$

- $\text{CORR-VV (RD} \geq 3)$

- $\text{CORR-VV (RD} \geq 2)$

- $\text{CORR-VV (RD} \geq 1)$
Appendix: Lowering of the threshold

- + re-ranking $\text{CORR}_\alpha - \text{VV}(\text{RD} \geq 3)$:

  a. $\text{CORR} - \text{VV}(\text{RD} \geq 4)$

    $\text{IDENT-OI}[\text{RD}]$

    $\text{CORR}_\alpha - \text{VV}(\text{RD} \geq 3)$
Appendix: Lowering of the threshold

+ re-ranking $\text{CORR}_\alpha$-$\text{VV}(\text{RD} \geq 3)$:

a. $\text{CORR}$-$\text{VV}(\text{RD} \geq 4)$
   \[\text{IDENT-OI}[\text{RD}]\]
   $\text{CORR}_\alpha$-$\text{VV}(\text{RD} \geq 3)$

b. $\text{CORR}$-$\text{VV}(\text{RD} \geq 4)$
   \[\text{IDENT-OI}[\text{RD}]\]
   $\text{CORR}_\alpha$-$\text{VV}(\text{RD} \geq 3)$
Appendix: Lowering of the threshold

a. /bìrú/ → bìrú  ‘burn’

<table>
<thead>
<tr>
<th>/bìr-ú/</th>
<th>IDENT-IO[RD]</th>
<th>CORR_α-VV(RD ≥ 4)</th>
<th>IDENT_α-VV[RD]</th>
<th>IDENT-OI[RD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. bìr-ú</td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
</tr>
<tr>
<td>b. bür-ú</td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td>*!</td>
</tr>
<tr>
<td>c. bìr-í</td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td>*!</td>
</tr>
</tbody>
</table>
Appendix: Lowering of the threshold

a. /bìrú/ → bìrú ‘burn’

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>a. bìrú</td>
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<td></td>
<td>*</td>
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<tr>
<td>b. bùrú</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. bìrí</td>
<td></td>
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<td>*</td>
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</table>

b. /pìrú/ → pûûrû ‘compounds’

<table>
<thead>
<tr>
<th>/pìrú/</th>
<th>IDENT-IO[RD]</th>
<th>CORR-VV(RD ≥ 4)</th>
<th>CORRα-VV(RD ≥ 3)</th>
<th>IDENTα-VV[RD]</th>
<th>IDENT-OI[RD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. pìíαr-ú</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. pûûr-ú</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. pìíαr-í</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. pìíαr-úα</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>e. pûûαrúα</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>