Tonal alignment under time pressure in the Bor dialects of Dinka

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What are the structural divisions in the tone space?

**Tone height features**

- Are problematic / irrelevant to phonological analysis (Mazaudon 1988; Clements, Michaud & Patin, to appear; Hyman 2010);
- Are not supported phonetically (Stevens 1989, Stevens & Keyser 2010).
But what about tone alignment?

- Speech perception: it takes a difference in alignment of ±50 ms over the vowel for two otherwise identical contours to be reliably distinguished (House 2004);

- Many consider distinctive alignment to be impossible.

- The tone inventory of tone inventory includes 3 level tonemes, and 2 rises, but **no underlying falls**.


\[
\begin{array}{c}
\text{L H} \\
\text{L} \\
\text{/kwa/} + \text{/toː/}
\end{array}
\Rightarrow
\begin{array}{c}
\text{L H L} \\
\text{/kwa toː/}
\end{array}
\]

‘give’ + ‘banana’ = ‘give a banana’
• Silverman (1997:479-480):
  - rightward High shift would result in loss of contrast if there also where underlying falls.
  - So only one falling pattern of alignment (HL) in the surface phonology.

• I will present counterevidence from Dinka. Here there is rightward High shift too – in spite of the existence of an underlying fall.
A distinction in alignment in falling tonemes in Dinka?
Dèen ǎ-ṣ̀ẹ̀laan ̀lèel
Deng DECL-see person:S isolate:3SG
‘Deng sees the person he isolated.’

Dèen ǎ-ṣ̀ẹ̀laan ̀lèel
Deng DECL-see person:S provoke:PASS
‘Deng sees the provoked person.’
Dèŋ ǎ-ţîŋ  ràaan  lèel
Deng DECL-see person:S isolate:3SG
‘Deng sees the person he isolated.’

Dèŋ ǎ-ţîŋ  ràaan  lèel
Deng DECL-see person:S provoke:PASS
‘Deng sees the provoked person.’

Figure – Averaged f0 traces on normalized time axis, showing the realization of HL vs. L following L. Traces averaged across 4 speakers.
Figure – Averaged f0 traces on normalized time axis, showing the realization of HL vs. L following L. Traces averaged across 4 speakers.
... ràaan lèel
person:s isolate:3SG
‘the person he isolated’

... ràaan lêel
person:s provoke:PASS
‘the provoked person’

ràaan ǎ–lèel
person:s DECL-isolate:3SG
‘He isolates a person.’

ràaan ǎ–lêel
person:s DECL-provoke:PASS
‘The person is being provoked.’

Figure – The realization of HL vs. L following L (left) and LH (right). Traces averaged across 4 speakers.
The contrast between Low(Fall) vs. Fall is found on short vowels as well:

ràaan ã́-lêl  
person:SG DECL-isolate:PASS  
‘You are isolating a person.’

ràaan ã́-lêl  
person:SG DECL-isolate:PASS  
‘The person is being isolated.’
There is a model of pitch perception that hypothesizes that such a contrast can be maintained: House (1990).
• Perception of falling f0 patterns (House 1990:133ff):

F0 contour

Segmental sequence

Perceptual feature

level movement

• This is a quantal threshold, in the sense of Stevens (1989).
• Are we overlooking a phonological parameter in the study of tone?
I carried out a production study on the distinction between two falling contours in Dinka.

Research prediction (based on House 1990):

- If Dinka has two phonologically distinct tone patterns characterised by an f0 fall, then the start of the f0 fall for the two patterns should remain at opposite sides of a threshold at about 30 ms into the vowel.
Methods
Pitch movements under time pressure (Caspers & van Heuven 1993; Xu 1998; Ladd, Faulkner, Faulkner & Schepman 1999):

• Investigate variability in alignment by controlling the segmental space and tonal specification.
• The phonological tone contrast:

<table>
<thead>
<tr>
<th></th>
<th>/L/ (falling allotone)</th>
<th>/HL/</th>
</tr>
</thead>
<tbody>
<tr>
<td>rèaan</td>
<td>ʔə́ːlèel</td>
<td>rèaan  ʔə́ːlèel</td>
</tr>
<tr>
<td>person:SG DECL-isolate:3SG</td>
<td>‘He is isolating a person.’</td>
<td>person:S DECL-provoke:PASS</td>
</tr>
</tbody>
</table>
• Time pressure was controlled through vowel length:

<table>
<thead>
<tr>
<th>Stem length</th>
<th>Prefix length</th>
<th>V-</th>
<th>VV-</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>ràaan ǎ–lèl</td>
<td>person:S DECL-isolate:2SG</td>
<td>‘You isolate a person.’</td>
</tr>
<tr>
<td>V</td>
<td>ràaan ǎ–lèel</td>
<td>person:S DECL-isolate:3SG</td>
<td>‘He isolates a person.’</td>
</tr>
<tr>
<td>VV</td>
<td>ràaan ǎ–lèeel</td>
<td>person:S DECL-provoke:3SG</td>
<td>‘He provokes a person.’</td>
</tr>
<tr>
<td>VVV</td>
<td>ròoor āa–lèl</td>
<td>men DECL:P-isolate:2SG</td>
<td>‘You isolate men.’</td>
</tr>
<tr>
<td>VVV</td>
<td>ròoor āa–lèel</td>
<td>men DECL:P-isolate:3SG</td>
<td>‘He isolates men.’</td>
</tr>
<tr>
<td>VVV</td>
<td>ròoor āa–lèeel</td>
<td>men DECL:P-provoke:3SG</td>
<td>‘He provokes men.’</td>
</tr>
</tbody>
</table>
Methods

- Dialect difference in phonological configuration: Bor North vs. Bor South.
Map of South Sudan region, showing Dinka dialects. The target dialects are highlighted:
Dialect difference in phonological configuration: HL on a short stem vowel only in Bor North – Bor South has LH instead:

*Bor North*  
ràaan  ě–lêl

*Bor South*  
ràaan  ě–lêl

person:SG  DECL-isolate:PASS

‘The person is being isolated.’
Methods

- 4 segmental sets, in which onset, vowel, and manner of the coda are kept constant:
  - lel–leel–leeel
  - maŋ–maaŋ–maaan
  - wel–weel–weeel
  - ŋop–ŋoop–ŋoooot

- 40 types in total: 4 segmental sets * 10 prosodies

- 13 speakers: 7 from Bor North, 6 from Bor South
Methods

- Spikes in the f0 traces were trimmed using the algorithm reported in Xu (1999).

Figure – f0 traces, before (grey) and after (black) application of Yi Xu’s trimming algorithm. This algorithm is available online as part of ProsodyPro [http://www.phon.ucl.ac.uk/home/yi/ProsodyPro/]

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Results
Results

- Three-level vowel length conditions big differences in duration (cf. Remijsen & Gilley 2008 on Luanyjang):

Figure: Vowel duration by vowel length (mn + 1sd)
Results

- Averaged f0 traces for Fall vs. Low\textsuperscript{Fall}:

  \begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{figure.png}
  \caption{Averaged f0 traces on normalised time axis.}
  \end{figure}

  - The difference in peak height is small (2Hz) and not significant.
• The differences in peak alignment between Low(Fall) and Fall lies around 44 ms.

Figure – Means and standard deviations for peak alignment in the Low(Fall) vs. Fall tonemes.
Results

- There is contextual variation in peak alignment of the Low(Fall):

A. By stem length

B. By stem length + prefix length

C. By stem length + dialect

[Graphs showing peak time variations]
Results

- Linear mixed effects model (Bates 2004) with dependent peak alignment – random factors Speaker (13), Set (4):

<table>
<thead>
<tr>
<th>Factor</th>
<th>Levels</th>
<th>t value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem length</td>
<td>V vs. VV</td>
<td>7.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>V vs. VVV</td>
<td>9.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>VV vs. VVV</td>
<td>3.1</td>
<td>0.0002</td>
</tr>
<tr>
<td>Toneme</td>
<td>Low^Fall vs. Fall</td>
<td>33.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Prefix length</td>
<td>V vs. VV</td>
<td>-3.1</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Dialect</td>
<td>SB vs. NB</td>
<td>-3.7</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

- All factors are significant, and the contrast between Low^Fall vs. Fall registers the biggest effect.
Conclusion
• (House 1990, 1996) postulated a [± movement] feature, whereby alignment early in the vowel patterns along with alignment in preceding onset.

• Corroborated in Dinka: the start of Low(Fall) aligns early on in the vowel or in the onset; the Fall toneme is aligned well into the vowel.


I gratefully acknowledge:

- Larry Hyman and Constance Kutsch-Lojenga. Their feedback spurred me to investigate the allophonic variation in the realisation of the Low toneme.

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- Yi Xu, for sharing his trimming tool; Mike Allerhand, for help with R.

- The speakers: Leek Deng Mawut, Abraham Leek Makuei, and Emmanuel Deng Jogaak for the Nyarweng dialect; Simon Yak Deng, Akol Kongoor Reech, Abraham Duot de Khueer, and Aluel Ajaang Jibil for the Twic dialect; John Penn de Ngong, Peter Garang Nyarjok, Abraham Pach Alier, Job Anyang Aluung, James Maker Riak, Mary Agotich Buol for the Bor (South) dialect.

- The Arts & Humanities Research Council (UK), for funding through two research grants.
Phonological evidence for distinction between Fall and $\text{Low}^{\text{Fall}}$

- A sandhi rule in Bor South turns any Fall (HL) tonemes into a High toneme, when it is not in prepausal position.

  $$/\text{High-Low}/ \rightarrow \text{H} / \_\_ \ #$$

- The $\text{Low}^{\text{Fall}}$ – falling allotone of Low – is not affected – see example and descriptive stats on following slide.
ràaan  ā–lèel  (é–těne)
person:S  DECL-set.apart:3SG  (EXT-here)
‘He isolates a person (here).’

ràaan  ā–lēel  (é–těne)
person:S  DECL-provoke:PASS  (EXT-here)
‘The person is provoked (here).’

Figure – Averaged f0 traces on a normalized time axis, showing the realization of /HL/ vs. /L/ following /LH/, embedded in final (left) vs. medial position (right). Traces are averaged across 4 speakers.
Map of South Sudan region, showing Dinka dialects. The target dialects are highlighted:
• Dialect difference in phonological configuration: HL on a short stem vowel only in Bor North – Bor South has LH instead:

\[
\begin{align*}
\text{Bor North} & \quad \text{ràaan} \quad ã–lël \\
\text{Bor South} & \quad \text{ràaan} \quad ã–lël
\end{align*}
\]

person:SG DECL-isolate:PASS
‘The person is being isolated.’
• Dispersion Theory (Liljencrants & Lindblom 1972): the realisation of categories evolves so as to maximise contrast relative to other categories in the same space.
• Example on vowel systems, from Becker-Kristal (2010):

Symmetrical systems (192 languages)  

Right-crowded systems (26 languages)  

Dispersion Theory
Becker-Kristal (2010) on /a/:

Symmetrical systems (192 languages)

Right-crowded systems (26 languages)

Dinka /HL/ from rightward High shift:

Figure: F0 peak time – vowel onset
Evidence for Dispersion Theory (Liljencrants & Lindblom 1972):

• Peak alignment of the fall allotone of Low is earlier in the Bor North dialect, where it contrasts with a later-aligned falling category on short vowels.

• The phonetic realisation of the fall allotone of Low in Bor North has evolved to maximise contrast.
### Results

Table – Means for peak alignment in Bor North, by vowel length (V, VV) and tone.

<table>
<thead>
<tr>
<th>Vowel length</th>
<th>Toneme</th>
<th>/L/ [fall]</th>
<th>/HL/</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>V</td>
<td>-9</td>
<td>33</td>
<td>42</td>
</tr>
<tr>
<td>VV</td>
<td>VV</td>
<td>-2</td>
<td>43</td>
<td>45</td>
</tr>
</tbody>
</table>
Methods

• In summary, the dataset hinges on manipulation of stem toneme, stem length, prefix length, and dialect:

\[
\begin{array}{ll}
\text{ŭ-cvc} & \text{ŭv-cvc} \\
\text{ŭ-cvvc} & \text{ŭv-cvvc} \\
\text{ŭ-cvvvc} & \text{ŭv-cvvvc} \\
\text{ŭ-cv̂c} & \text{ŭv-cv̂c} \quad \text{(Bor North only)} \\
\text{ŭ-cvvc} & \text{ŭv-cvvc} \\
\text{ŭ-cv̂vc} & \text{ŭv-cv̂vc} \quad \text{(Bor South only)} \\
\end{array}
\]