Why are three-level vowel length distinctions rare?

Insights from Luanyjang Dinka

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What approaches can help the linguist to discover unexpected phenomena?

While theory and typology are valuable tools, they can constrain the researcher’s awareness.
What approaches can help the linguist to discover unexpected phenomena?

While theory and typology are valuable tools, they can constrain the researcher’s awareness.

In the study of sound systems, knowledge of articulatory / auditory phonetics offers an additional framework of reference.
Can languages have three-level vowel length distinctions (V vs. VV vs. VVV)?
The dominant view on quantity distinctions in theoretical phonology is that they are maximally binary:

“A nuclear node may dominate at most two skeletal slots.”

[Kenstowicz & Rubach 1987:476
see also e.g. Chomsky & Halle 1968, Prince 1980, Bye 1997, Odden 1997, Duanmu to appear]
Nonetheless, three-way length distinctions (V vs. VV vs. VVV) have been postulated for several languages: Estonian, certain dialects of North German, Mixe, and Dinka.
A study of quantity in Dinka (joint research with Leoma Gilley)

- Lexical & morphological quantity
- Competing analyses of phonological quantity
- Testing the competing hypotheses
- Conclusions and implications
Dinka is:

- a Nilo-Saharan language
- spoken in Southern Sudan

by ± 2 million people (Ethnologue).

**Figure 1:** The Dinka language area, marked on the Nile tributary network.
Dinka – Suprasegmental inventory

• 7 vowel phonemes: /i,e,ɛ,a,ɔ,o,u/

• 4 lexical tones (High, Low, Rise, Fall)

• 2 voice qualities (modal vs. breathy)

• 3 or 4 categories of quantity

For minimal-set (sound) examples of these contrasts, you can download a pdf with embedded sound files from: http://www.ling.ed.ac.uk/~bert/nilotic_output.html
Lexical and morphological quantity
Lexical and morphological quantity

- Quantity distinctions are important in morphological paradigms –

Example with finite verb:

2nd singular  
à-kòl
You take out the thorn.

3rd singular  
à-kòol
He takes out the thorn.
Lexical and morphological quantity

• Quantity distinctions are important in morphological paradigms –

Example with infinitive verb:

Negation  Acóol a-cìi  kòow kól
A. AGR-NEG thorn take_out:NEGATION
Acol does not take out a thorn.

Past       Acóol a-cí    kòow kôol
A. AGR-PAST thorn  take_out:PAST
Acol has taken out a thorn.
In summary, verbs can appear in a shorter grade and in a longer grade:

<table>
<thead>
<tr>
<th>Morphological quantity</th>
<th>Short grade</th>
<th>Long grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>2\textsuperscript{nd} sg.</td>
<td>\textit{kòl}</td>
<td>\textit{kòol}</td>
</tr>
<tr>
<td>Negation</td>
<td>\textit{kól}</td>
<td>\textit{kôol}</td>
</tr>
<tr>
<td>Past</td>
<td>\textit{kól}</td>
<td>\textit{kôol}</td>
</tr>
</tbody>
</table>
Lexical and morphological quantity

- But there is also lexical quantity:

<table>
<thead>
<tr>
<th>Morphological quantity</th>
<th>Lexical quantity</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>{kol}</td>
<td>{kool}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘take out’</td>
<td>‘adopt’</td>
<td></td>
</tr>
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</tr>
<tr>
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<td>3\textsuperscript{rd} sg.</td>
<td>kòol</td>
<td>kòool</td>
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</table>
Lexical and morphological quantity

In summary

• **Lexical quantity**: there are short stems (SS) and long stems (LS).

• **Morphological quantity**: both SS and LS stems appear in a short grade (SG), and in a long grade (LG).
<table>
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<td>adopt</td>
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<tr>
<td>&quot;làaŋ&quot;</td>
<td>&quot;láaaŋ&quot;</td>
</tr>
<tr>
<td>overburden</td>
<td></td>
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Competing hypotheses
Competing hypotheses

• What is the relation between lexical-morphological quantity and phonological quantity?

• In other words: how many phonemic levels of quantity does Dinka have?

• What is the most appropriate phonological representation?
Competing hypotheses

The three vowel-length hypothesis (3VL)
Torben Andersen (1987):
Agar Dinka has 3 levels of vowel length –
V vs. VV vs. VVV
### Competing hypotheses

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<td>V</td>
<td>VV</td>
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<td>VVVV</td>
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Andersen’s hypothesis in moraic theory (Hyman 1985, Hayes 1989):

NB The mora ($\mu$) is a language-specific weight unit
A challenge to Andersen’s 3VL hypothesis:


- Several of these describe the nature of the very short vowels as ‘stressed’.
Competing hypotheses

• Short grade (of short stems):
  - centralised vowel quality  e.g. /ŋéŋ/ 📝
  - more salient coda  e.g. /kìr/ 📝
  - sounds louder

• Phonologically, it could be interpreted as a distinction in coda length.
Alternative hypothesis (2VL+2CL)

Based on Gilley (2003):

Lexical length is vowel length, but the morphological grades are marked by a separate quantity distinction. In other words, there are two binary quantity distinctions:

VCC vs. VC vs. VVCC vs. VVC
## Competing hypotheses

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<table>
<thead>
<tr>
<th>làŋ</th>
<th>láanŋ</th>
<th>làaŋ</th>
<th>láaaŋ</th>
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<th>kól</th>
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<td>take out</td>
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<th>VCC</th>
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</table>

| laŋŋ     | láŋ     | làaŋŋ   | láaŋ     |
| berry:PL  | berry:SG | overburden |

| kól      | kôl     | kòoll   | kóol     |
| take out |          | adopt   |

VCC      VC  
VVCC     VVC
Competing hypotheses

- This alternative hypothesis could be expressed in moraic theory as follows:

\[
\begin{array}{c|c|c}
\text{Short Stem} & \text{Long Stem} \\
\hline
\text{Short Gr.} & \text{Long Gr.} & \text{Short Gr.} & \text{Long Gr.} \\
C & V & C & C \\
| & | & | & |
\mu & \mu & \mu & \mu \\
\hline
\end{array}
\]
## Competing hypotheses

<table>
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<tr>
<th>Lexical/ Morphological quantity</th>
<th>Phonological quantity</th>
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<tr>
<td></td>
<td>3VL</td>
</tr>
<tr>
<td>Short St.- Short Gr.</td>
<td>kol CVC</td>
</tr>
<tr>
<td>Short St.- Long Gr.</td>
<td>kool CVVC</td>
</tr>
<tr>
<td>Long St.- Short Gr.</td>
<td>kool CVVC</td>
</tr>
<tr>
<td>Long St.- Long Gr.</td>
<td>kooool CVVVC</td>
</tr>
</tbody>
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Testing the hypotheses
Assumption underlying the test:

Differences in phonetic duration reflect differences in moraic structure in segmentally identical material.

(Broselow, Chen & Huffman 1997)
Testing the hypotheses

- 3VL predicts:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>SS-SG</th>
<th>SS-LG</th>
<th>LS-SG</th>
<th>LS-LG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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Testing the hypotheses

- 3VL predicts:
Testing the hypotheses

• The alternative hypothesis predicts:

\[
\begin{align*}
SS & \rightarrow SS \\
SS & \rightarrow LG \\
LS & \rightarrow SG \\
LS & \rightarrow LG
\end{align*}
\]
Testing the hypotheses

Methodology of the acoustic analysis

• We collected …
Testing the hypotheses

- 20 complete (four-member) semi-minimal sets

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<tr>
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<th>ลา่าน</th>
<th>โค่ล</th>
<th>โค้อล</th>
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<td>berry:SGg</td>
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Testing the hypotheses

• 20 complete (four-member) minimal sets

• including six different vowels (/i,e,a,ɔ,o,u/) and of four coda types (nasal, liquid, rhotic, stop)

• elicited in medial and final contexts

• from 12 speakers of the Luanyjang (Luac) dialect
Dinka – language situation

Figure 2: Map of Dinka dialects, based on Roettger & Roettger (1989).
Testing the hypotheses

Measurements:

- Durations of nucleus and coda
- Vowel quality (F1 and F2)
- Several intensity-related measurements
Figure 3: Means and standard deviations for vowel duration, across speakers. Separate graphs for coda type.
Lexical and morphological quantity

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**Figure 3:**
Means and standard deviations for vowel duration, across speakers. Separate graphs for coda type.
Figure 4: Means and standard deviations for coda duration, across speakers. Separate graphs by coda type. Sentence-medial context only.
Figure 5:
Means values for first and second formant (F1 and F2), by vowel and by level of lexical / morphological quantity. Across speakers.
**Figure 6:** Three intensity-related measurements

- **Vowel intensity**
- **Coda intensity**
- **Spectral tilt**
Summary of the results

• In terms of vowel duration, the levels of Lexical/ Morphological separate into three categories:

  SS-SG vs. (SS-LG & LS-SG) vs. LS-LG

• Vowel quality singles out the short grade of short stems (SS-SG).

• No consistent effects for coda duration or intensity.
Discussion
The phonetic evidence from the Luanyjang dialect supports the 3VL hypothesis (Andersen 1987).
• Any hope for the alternative hypothesis – 2VL+2CL?

Yes –

• in Luanyjang, if the distinction between SS-LG and LS-SG gets neutralised in the contexts we have considered.

• Or in another dialect.
Why are 3-level vowel length systems rare?
Why are 3-level vowel length systems rare?

• 2VL:
  \( V \) vs. \( VV \) = 1:2

<table>
<thead>
<tr>
<th>2VL</th>
<th>Vowel duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>76</td>
</tr>
<tr>
<td>VV</td>
<td>158</td>
</tr>
</tbody>
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Why are 3-level vowel length systems rare?

- 2VL: 
  \[ V \text{ vs. } VV = 1:2 \]

- Dinka: 
  \[ V \text{ vs. } VV \]
  \[ VV \text{ vs. } VVV \]
  \[ 1:1.5 \]
Why are 3-level vowel length systems rare?

• The range of vowel duration is the same between 2VL and 3VL systems: approx. 70 – 150 ms.

• As a result the levels are closer together in 3VL systems 1:1.5, as compared to 1:2 in 2VL.

• If we would squeeze in a fourth level within the same range, the difference between levels would approach the just-noticeable difference (JND) – approx. 7-20%.
Why are 3-level vowel length systems rare?

• Maintaining the distance between length categories already comes at a cost: short (V) vowels are centralised.

• This means that the V-VV distinction could be reinterpreted diachronically as one of vowel quality (hypocorrection).
Why are 3-level vowel length systems rare?

• Odden (1997: 167): if we drop the binarity constraint on vowel length, there is no principled limit.

• Our study suggests that:
  - The binarity constraint is untenable
  - The phonetics impose a principled limit (3 levels).
Why are 3-level vowel length systems rare?

- Odden (1997: 167): if we drop the binarity constraint on vowel length, there is no principled limit.

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(1) Speech production (range of nucleus duration is roughly constant across vowel length systems).

(2) Speech perception (JND of 7-20%)
Why are 3-level vowel length systems rare?

• Odden (1997: 167): if we drop the binarity constraint on vowel length, there is no principled limit.

• Our study suggests that:
  - The binarity constraint is untenable
  - The phonetics impose a principled limit (3 levels).

• Similarly, the difference in no. of levels between length vs. tone distinctions can be related to differences in JND (7-20% vs. 0.5%, respectively).
Many thanks to…

- Caguor Adong Manyang, whose input and support have been crucial to the success of this project.
- Bob Ladd, Peter Ladefoged, and Alice Turk, for thought-provoking discussions on this topic over the years.
- Tim Mills, for a script to collect the A1*-A2* values.
- The Arts & Humanities Research Council and The British Academy, for funding this research.
Vowel-intrinsic variation in duration is present across quantity conditions:
The size of final lengthening increases in a non-linear fashion as a function of phonemic quantity:

![Graph showing the relationship between lexical and morphological quantity and mean duration](chart.png)

- SS-SG
- SS-LG
- LS-SG
- LS-LG

Mean ± 1 SD Nucleus duration (s): 1:09, 1:18, 1:14, 1:35