Tone melodies in the age of Surface Correspondence

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Tone

• The behavior of tone systems was a central motivation for Autosegmental Phonology (AP; Goldsmith 1976; Leben 1978)
• AP: a theory of phonological representations and rules operating over representations

\[
\begin{align*}
V & C V \\
H & \times & \times & \times & \times \\
\end{align*}
\]

• Designed around tone, then extended to the (tamer) behavior of vowels and consonants

Tone in Optimality Theory

• Tone has played a relatively peripheral role in the development of Optimality Theory (Prince & Smolensky 1993)
• In the area of vowel and (especially) consonant harmony, AP has been supplanted by Agreement by Correspondence Theory (ABC), or Surface Correspondence (e.g., Hansson 2001, Rose & Walker 2004, Bennett 2013)
• ABC is segment-based; correspondence constraints refer to segments, not autosegments
• Where does this leave tone?

This talk

• Uses Agreement by Correspondence theory and subsegmental Q theory (ABC+Q) to model the attested distribution of tone in Mende, a language originally thought to support AP representations
• Argues that ABC+Q provides a better account of a so-called tone melody language than a traditional AP melody account does
Tone melodies

- The association of autosegmental tone melodies to tone-bearing units is a canonical example of what AP was designed to do.
- Universal tone association conventions:
  - Associate tones to TBUs in a 1-1, L-R manner
  - Spread the rightmost tone to any remaining toneless TBUs
  - Dock any leftover tones to the rightmost TBU
- Obligatory Contour Principle: no adjacent identical autosegments

Tone melodies

- The OCP and Universal Association Conventions team up to produce the famous Mende 5-way tone melody pattern (Williams 1971; Leben 1973, 1978) (also attested in Kukuya; Hyman 2007)

<table>
<thead>
<tr>
<th>Melody in UR</th>
<th>σ</th>
<th>σσ</th>
<th>σσσ</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>H</td>
<td>H.H</td>
<td>H.H.H</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L.L</td>
<td>L.L.L</td>
</tr>
<tr>
<td>H L</td>
<td>HL</td>
<td>H.L</td>
<td>H.L.L</td>
</tr>
<tr>
<td>L H</td>
<td>LH</td>
<td>L.H</td>
<td>L.H.H</td>
</tr>
<tr>
<td>L H L</td>
<td>LHL</td>
<td>L.HL</td>
<td>L.H.L</td>
</tr>
</tbody>
</table>

Challenges for melody account

- Mende has melodies beyond than the 5 canonical ones (Dwyer 1978)
- Melody complexity is correlated with word length
- The alignment of melody tones frequently violates the universal conventions (Dwyer 1978), forcing exceptional underlying representations (Leben 1978)
Data: a Mende lexicon

- Data: 4,000 words from dictionary (Innes 1969)
- ~2,700 of the words are nouns (the category for which the AP melody analysis was said to hold)
- ~92% of nouns are 1–3 syllables long (n=2,493).
- Morpheme breaks not indicated, but the main source of morphological complexity in nouns appears to be total reduplication in 4-syllable words. We are not addressing 4-syllable words today.

Challenges for melody account

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- Melody complexity is correlated with word length
- The alignment of melody tones frequently violates the universal conventions (Dwyer 1978), forcing exceptional underlying representations (Leben 1978)

Tone melodies in the lexicon

- A search of the 2700 nouns in the Mende lexicon reveals many melodies. Disregarding alignment to syllables and just focusing on the overall contours of the melody, we find the following.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>25</td>
<td>251</td>
<td>25</td>
</tr>
<tr>
<td>H</td>
<td>53</td>
<td>531</td>
<td>101</td>
</tr>
<tr>
<td>LH</td>
<td>27</td>
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<td>31</td>
<td>243</td>
<td>127</td>
</tr>
<tr>
<td>LHL</td>
<td>9</td>
<td>276</td>
<td>204</td>
</tr>
<tr>
<td>HLH</td>
<td>0</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>LHLH</td>
<td>0</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>HLHL</td>
<td>0</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>LHLHL</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Black indicates a melody licensed in the original AP analysis
Red indicates melody not predicted

Tone melodies in the lexicon

- Could add more melodies to the original AP account.
- H L LH HL LHL HLH LHL HLHL HLHL LHLHL
- But: the AP account still misses the target on melody complexity and on tone alignment
Tone melody complexity

- Leben states: “By regarding the tone pattern as phonologically separate from the segments in these words, we capture the fact that a given pattern can occur regardless of how many syllables a word has” [Leben 1978:186]
- But: the corpus also reveals that the longer the word, the more likely a complex melody
- The independence of melodies in the original AP account does not predict this

Tone melody complexity

- Word length correlates with melody complexity more than would be expected in an AP approach
Tone alignment

- Mende has melodies beyond the 5 canonical ones (Dwyer 1978)
- Melody complexity is correlated with word length
- The alignment of melody tones frequently violates the universal conventions (Dwyer 1978)....

```
ngílà  ngángó  ndávúlá  lélémá
H     L     L     H     L
'dog'  'tooth' 'sling' 'praying mantis'
```

Tone alignment

- ... forcing exceptional rules and underlying representations (Leben 1978)
- New association convention: a final H links to the final TBU
- Some H tones are exceptionally linked in UR

```
ngílà  ngángó  ndávúlá  lélémá
H     L     L     H     L     H
‘dog’  ‘tooth’  ‘sling’  ‘praying mantis’
```

H tones linked in UR to syllables where Association Conventions wouldn’t link them

Tone alignment

```
ngílà  ngángó  ndávúlá  lélémá
H     L     L     H     L     H
‘dog’  ‘tooth’  ‘sling’  ‘praying mantis’
```

New, Mende-specific Association Convention links final H to final TBU

Tone alignment

- ... forcing exceptional rules and underlying representations (Leben 1978)
- New association convention: a final H links to the final TBU
- Some H tones are exceptionally linked in UR

```
ngílà  ngángó  ndávúlá  lélémá
H     L     L     H     L     H
‘dog’  ‘tooth’  ‘sling’  ‘praying mantis’
```

Universal Association Conventions do the rest of the work
Tone alignment

• But the issue of unpredictable tone alignment goes beyond just these examples (e.g., Dwyer 1978, Conteh et al. 1983)

A fresh look at tone

• Goal: instead of tone melodies and tone assignment rules, govern tone patterns via a set of correspondence constraints
• These constraints involve proximity and similarity
• Claim: the resulting model better predicts the observed surface tone patterns in the lexicon, compared to the AP tone melody model

Mende noun tones

<table>
<thead>
<tr>
<th>Syll Melody</th>
<th>n</th>
<th>Syll Melody</th>
<th>n</th>
<th>Melody</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>53</td>
<td>L</td>
<td>25</td>
<td>H.L.H</td>
<td>12</td>
</tr>
<tr>
<td>HL</td>
<td>31</td>
<td>LHL</td>
<td>5</td>
<td>H.L.HL</td>
<td>8</td>
</tr>
<tr>
<td>LH</td>
<td>27</td>
<td>LHL</td>
<td>4</td>
<td>H.L.HL</td>
<td>7</td>
</tr>
<tr>
<td>H.H</td>
<td>531 2</td>
<td>LHL.LH.LHL</td>
<td>1</td>
<td>H.L.H.H</td>
<td>6</td>
</tr>
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<td>L.H</td>
<td>380</td>
<td>LHLHL.H</td>
<td>1</td>
<td>H.L.L</td>
<td>5</td>
</tr>
<tr>
<td>L.L</td>
<td>251</td>
<td>LHL</td>
<td>4</td>
<td>H.L.HL</td>
<td>4</td>
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<td>212</td>
<td>LHL</td>
<td>4</td>
<td>H.L.HL</td>
<td>4</td>
</tr>
<tr>
<td>L.H.L</td>
<td>204 8</td>
<td>L.H.L</td>
<td>142</td>
<td>H.L.L</td>
<td>4</td>
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<tr>
<td>U.L.L</td>
<td>64</td>
<td>H.H.H</td>
<td>101</td>
<td>H.L.L</td>
<td>3</td>
</tr>
<tr>
<td>H.H.L</td>
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<td>L.L.L</td>
<td>63</td>
<td>L.L.H</td>
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<tr>
<td>H.L.L</td>
<td>14</td>
<td>H.L.H</td>
<td>58</td>
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</tr>
<tr>
<td>U.H.H</td>
<td>11</td>
<td>L.H.H</td>
<td>1</td>
<td>H.L.L</td>
<td>1</td>
</tr>
<tr>
<td>H.H.L</td>
<td>11</td>
<td>H.L.L</td>
<td>1</td>
<td>H.L.L</td>
<td>1</td>
</tr>
<tr>
<td>U.H.L</td>
<td>8</td>
<td>L.L.L</td>
<td>31</td>
<td>H.L.H.L</td>
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<tr>
<td>L.L.H</td>
<td>7</td>
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<td>H.L.H</td>
<td>1</td>
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<td>H.L.H</td>
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<td>1</td>
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<td>H.L.HL</td>
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<td>U.H.LL</td>
<td>17</td>
<td>U.H.LL</td>
<td>1</td>
</tr>
</tbody>
</table>

ABC

• Agreement by Correspondence (ABC) — originally developed for long distance consonant agreement, but since extended to vowel harmony and other local harmonies.
• ABC’s purview: interactions between syntagmatic units.
• Key claim of ABC: units which are both sufficiently similar and sufficiently close to one another will correspond and thus interact.
  – Correspondence between elements which are similar yet not identical is unstable.
  – Assimilation and dissimilation are repairs for unstable correspondence.

ABC’s purview: interactions between syntagmatic units.
**Q-theory**

Key claim of Q theory (cf. Steriade’s 1993 Aperture Theory): each segment (‘Q’) is decomposed into a small number of sequenced, featurally uniform subsegments (‘q’)

\[ Q(q_1 q_2 q_3) \]
\[ V(v_1 v_2 v_3) \]
\[ C(c_1 c_2 c_3) \]

**The tone-bearing unit (TBU) in Q-theory**

- Contour tones in Q theory:
  \[ V(H^1 L^2 H^3) \]
  \[ V(L^1 L^2 H^3) \]
  \[ V(H^1 H^2 H^3) \]
  etc.

- In Q theory, each q subsegment is featurally uniform
- “Contours” are Q’s whose q’s do not all agree tonally

**Mende noun tone**

Highly proximal q’s (those within the same syllable) tend to agree in tone – contours are less frequent than level-toned syllables.

**Tone in ABC+Q: correspondence under proximity and/or similarity**

- **CORR-qq**
  q subsegments correspond & agree in tone

- **CORR-[q::q]_o**
  Adjacent q subsegments within a syllable correspond & agree in tone

- **CORR-[q_w::q_w]_o**
  Adjacent q subsegments within a nonfinal (‘weak’) syllable agree in tone

*NB: Scaling of proximity and similarity is standard in ABC*
Tone in ABC+Q

<table>
<thead>
<tr>
<th></th>
<th>CORR-[q_w::q_{w_{ref removes} q}]</th>
<th>CORR-q::q</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L.HL (=l₁₁₁₁₁₁)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>b. L.H.L (=l₁₁₁₁₁₁)</td>
<td>W1</td>
<td>2</td>
</tr>
</tbody>
</table>

- CORR constraints penalize any change of tone across consecutive q’s
- The penalty is higher if the tone change takes place within a (nonfinal) syllable

Mende noun tone

In polysyllabic words with a complex (non-level) tone melody, it is more common for tone to change across than within syllables.

Tone in ABC+Q: correspondence penalized across syllables

- qq-Edge σ
  Adjacent q subsegments should not correspond across a syllable boundary

<table>
<thead>
<tr>
<th></th>
<th>qq-Edge σ</th>
<th>CORR-[q_w::q_{w_{ref removes} q}]</th>
<th>CORR-q::q</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L.HL (=l₁₁₁₁₁₁)</td>
<td>204</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>b. L.H.L (=l₁₁₁₁₁₁)</td>
<td>64</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. L.H.HL (=l₁₁₁₁₁₁)</td>
<td>8</td>
<td>W1</td>
<td>1</td>
</tr>
</tbody>
</table>

On Edge constraints, see Bennett 2013

Resulting prediction: tone melody complexity, # of syllables should correlate

<table>
<thead>
<tr>
<th></th>
<th>freq</th>
<th>qq-Edge σ</th>
<th>CORR-[q_w::q_{w_{ref removes} q}]</th>
<th>CORR-q::q</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L.H (=l₁₁₁₁₁₁)</td>
<td>380</td>
<td>W1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>b. L.L (=l₁₁₁₁₁₁)</td>
<td>251</td>
<td>W1</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>a. L.H.L (=l₁₁₁₁₁₁)</td>
<td>142</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. L.L.H (=l₁₁₁₁₁₁)</td>
<td>63</td>
<td>W1</td>
<td>L1</td>
<td></td>
</tr>
<tr>
<td>c. L.H.H (=l₁₁₁₁₁₁)</td>
<td>40</td>
<td>W1</td>
<td>L1</td>
<td></td>
</tr>
<tr>
<td>d. L.L.L (=l₁₁₁₁₁₁)</td>
<td>25</td>
<td>W2</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>e. L.H.L.H (=l₁₁₁₁₁₁)</td>
<td>12</td>
<td>W1</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Mende nouns: a bias against HLH

LHL sequences outnumber HLH sequences – to a greater extent in a smaller span than in a larger span.

**Figure:** LHL vs. HLH, at increasing distances.

Mende nouns: the H bias

All-H words outnumber all-L words.

**Figure:** The H bias, by word length.

Capturing level H and LHL biases

- **HAVE-H**
  - A word should have a H q subsegment

- **CORR-q[H]:∞:q[H]**
  - H-toned q subsegments must correspond (at any distance)

- **q[H]q[H]-qADD**
  - Corresponding H-toned q subsegments must be adjacent

ABC+Q and AP-style analyses compared

<table>
<thead>
<tr>
<th>ABC+Q</th>
<th>AP, from 1970’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corr-qq</td>
<td>ALIGN-R(H,H, L,L)</td>
</tr>
<tr>
<td>Corr-[q,q]q</td>
<td>ALIGN-R(H,L, LH)</td>
</tr>
<tr>
<td>q,q Edge σ</td>
<td>OCP</td>
</tr>
<tr>
<td>Corr-q[H]:∞:q[H]</td>
<td><strong>AP, updated</strong></td>
</tr>
<tr>
<td>q[H]q[H]-qADD</td>
<td>*CONTOUR</td>
</tr>
<tr>
<td>HAVE-H</td>
<td>*TROUGH (*HLH)</td>
</tr>
<tr>
<td></td>
<td>HAVE H</td>
</tr>
</tbody>
</table>

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Comparing analyses

- Maximum Entropy Harmonic Grammar (MaxEnt) models (Goldwater & Johnson 2003; Wilson 2006; et seq.):
  - ABC+Q
  - AP

Comparing analyses

- Input: number of syllables per word
- Output candidates: possible combinations of surface tone patterns

<table>
<thead>
<tr>
<th>Input Candidates</th>
<th>Candidates</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ σ σ</td>
<td>H.H.H</td>
</tr>
<tr>
<td></td>
<td>L.H.L</td>
</tr>
<tr>
<td></td>
<td>HL.HL.HL</td>
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<tr>
<td>L.L.L</td>
<td>H.L.H</td>
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<tr>
<td></td>
<td>HL.HL.L</td>
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<td>H.H.HL</td>
<td>L.L.HL</td>
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<td></td>
<td>HL.HL.H</td>
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<td>H.H.L</td>
<td>L.H.H</td>
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<td></td>
<td>HL.L.HL</td>
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<td>H.HLL</td>
<td>L.H.HL</td>
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<td></td>
<td>HL.HL.HL</td>
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<td>H.L.L</td>
<td>L.H.HL</td>
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<tr>
<td></td>
<td>L.HL.HL</td>
</tr>
<tr>
<td>HL.L.L</td>
<td>LH.H.H</td>
</tr>
<tr>
<td></td>
<td>etc...</td>
</tr>
</tbody>
</table>

Comparing analyses

- MaxEnt ranks probabilities (i.e., comparative grammaticality) of outcome candidates in variable data.

\[
Pr(x) = \frac{\exp(-\mathcal{H}(x))}{\sum_{y \in \Omega} \exp(-\mathcal{H}(y))},
\]

where \(x\) = output candidate,
\(\mathcal{H}\) = harmony score of a given candidate \((w \cdot C)\), and
\(y\) = possible output candidate in the entire candidate set \(\Omega\) for a given input.
Results

Predicted surface tone patterns

Surface tone melodies for 1 syllable words:

Results

Predicted surface tone patterns

Surface tone melodies for 1 syllable words:

Results

Predicted surface tone patterns

Top surface tone melodies for 1 syllable words:

Results

Predicted surface tone patterns

Top surface tone melodies for 2 syllable words:

Results

Predicted surface tone patterns

Surface tone melodies for 3 syllable words:
Results

**Predicted surface tone patterns**

Surface tone melodies for 3 syllable words:

Discussion

**Alignment**

- **Observed:**
  - L.L.H, H.H.L are more frequent than L.H.H, H.L.L.
  - 10.06, 9.27% 6.39, 6.07%

- **AP** analysis doesn’t predict this:
  - Universal L → R association convention predicts the opposite.
  - Leben posited special rule + underlyingly linked tones to get L.L.H versus L.H.H, but these were supposed to be exceptional (and less frequent).
  - Cross-linguistically, tones tend to be R-aligned, rather than L-aligned (Cahill 2007).

- **ABC+Q** analysis doesn’t predict any alignment differences (for now).
  - Delayed peak/transition likely arise from perceptual issues of tone.
  - i.e., preferred site for tonal transitions might be as close to the final syllable boundary as possible.
Models don’t quite capture the full extent of the overattestation of level H surface patterns.

- Potentially a multiplicative effect of Have H at each domain (word, syllable, segment).
- Or a compounded effect licensed by the dispreference for H tones with intervening Ls.

However: the longer the word, the more likely the level H preference gets trumped by other factors, i.e., qq-EDGE σ.
- Predicted under ABC+Q account, not under AP.
Results

Complexity of surface tone patterns

Complex surface tone melodies (e.g., HLH, LHL):

Two-tone surface melodies (e.g., HL, LH):
Conclusion

• Examine surface tone melody patterns in classic “melody tone” language: Mende.
• Capture tone melody facts without recourse to representational mechanisms of AP.
• Proposed alternative: surface-oriented, correspondence-driven optimization in ABC+Q.
  – Based on general (potentially phonetically-grounded) properties of similarity and proximity interaction.
  ⇒ ABC
  – With representational “null hypothesis”.
  ⇒ +Q

Conclusion

• ABC+Q does not need to make overt reference to melodic units.
• AP needs to reference contours and melodies as units, even though they’re not supposed to be units.

Contours

— *CONTOUR achieved via CORR-q::q, where close proximity begets tone agreement.
— COINCIDE(contour) achieved via CONT-[qH::qH], where close proximity within weaker prosodic positions begets tone agreement (i.e., less contrast).

Melodies

— *HLH/*TROUGH achieved via qq-Limiter constraints (q[H]q[H]-q[H])
— Parallels in the segmental domain (e.g., Bennett 2013)
— Provides a united analysis of tone plateauing (see Shih & Inkelas, in prep)
— Similar subphonemic agreement work (e.g., Lionnet 2014)

Conclusion

• Stochastic ABC+Q analysis predicts both lexical distribution and surface tone melody patterns.
• No need to a priori limit the melodic inventory.
  ⇒ Melody inventory is emergent from the grammar.
• In line with OT goal of a united analysis of morpheme structure constraints and phonological alternations.
  • Melody inventory = morpheme structure constraints

Conclusion

• ABC+Q does not need to make overt reference to melodic units.
• AP needs to reference contours and melodies as units, even though they’re not supposed to be units.
Conclusion

- In ABC+Q:
  - similarity- and proximity-driven tone agreement captures contour and melody behaviors (contour, trough avoidance)
  - similarity- and proximity-driven tone disagreement captures scaling of melodic complexity with increasing number of syllables in words.

⇒ Single mechanism of surface correspondence underlies both effects.

Thank you!

Acknowledgements to Larry Hyman and Laura McPherson for preliminary discussion.

Slides available:
(References upon request)