Autosegmental Phonology: Tone

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Concatenative Approaches to Nonconcatenative Morphology
EGG 2008
Early History of Autosegmental Morphology

Goldsmith (1976)  Autosegmental approach to tone
McCarty (1979)    Autosegmental approach to Roots & Patterns
Marantz (1982)    Autosegmental approach to reduplication
Definition of Tone

Pitch contrast, which is distinctive for words/word forms
## Tone in Chinese

<table>
<thead>
<tr>
<th>Segments</th>
<th>Tone</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ma</td>
<td>high</td>
<td>‘mother’</td>
</tr>
<tr>
<td>ma</td>
<td>mid-high</td>
<td>‘hemp’</td>
</tr>
<tr>
<td>ma</td>
<td>mid-low-high</td>
<td>‘horse’</td>
</tr>
<tr>
<td>ma</td>
<td>high-low</td>
<td>‘scold’</td>
</tr>
</tbody>
</table>
Phonetic Implementation of Pitch

Pitch $\approx$ Vibration speed of vocal chords

high $\approx$ high speed

low $\approx$ low speed
# Level Tones vs. Contour Tones

<table>
<thead>
<tr>
<th>Level Tones</th>
<th>Contour Tones</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant pitch)</td>
<td>(change of pitch)</td>
</tr>
<tr>
<td>high</td>
<td>rising</td>
</tr>
<tr>
<td>low</td>
<td>falling</td>
</tr>
<tr>
<td>mid</td>
<td>rising/falling</td>
</tr>
</tbody>
</table>

**Typology:** Contour tones imply level tones
## Notation of Tones

<table>
<thead>
<tr>
<th></th>
<th>IPA</th>
<th>IPA (Africa)</th>
<th>East Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>˥</td>
<td>á</td>
<td>555</td>
</tr>
<tr>
<td>low</td>
<td>˩</td>
<td>à</td>
<td>11</td>
</tr>
<tr>
<td>mid</td>
<td>˧</td>
<td>ā</td>
<td>33</td>
</tr>
<tr>
<td>rising</td>
<td>˦</td>
<td>ǎ</td>
<td>35</td>
</tr>
<tr>
<td>falling</td>
<td>ʔ</td>
<td>â</td>
<td>53</td>
</tr>
</tbody>
</table>
## Tone as a Morpheme: Hausa Verbal Nouns

| Segments | Ton     |  | Segments | Ton     |  |
|----------|---------|  |----------|---------|  |
| ja:      | high   | ‘to drink’ | ja:      | falling | ‘drinking’ |
| tʃsi     | high   | ‘to eat’    | tʃi:     | falling | ‘eating’    |
Tone as a Morpheme: Somali Case

<table>
<thead>
<tr>
<th></th>
<th>Nominative</th>
<th>Vocative</th>
<th>Genitive</th>
<th>Absolutive</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘males’</td>
<td>rag</td>
<td>—</td>
<td>rág</td>
<td>rág</td>
</tr>
<tr>
<td>‘billy-goat’</td>
<td>orgi</td>
<td>órgi</td>
<td>orgí</td>
<td>órgi</td>
</tr>
<tr>
<td>‘mothers’</td>
<td>hooyooyin</td>
<td>hóoyooyin</td>
<td>hooyooyín</td>
<td>hooyoóyín</td>
</tr>
<tr>
<td>‘family’</td>
<td>xaas</td>
<td>—</td>
<td>xaás</td>
<td>xáas</td>
</tr>
<tr>
<td>No H</td>
<td>Initial V</td>
<td>Final V</td>
<td>Penultimate V</td>
<td></td>
</tr>
</tbody>
</table>

(Hyman, 1981; Banti, 1988; Yip, 2002)
### Tone as a Morpheme: Mende Noun Classes

<table>
<thead>
<tr>
<th>Tonal Level</th>
<th>Word 1</th>
<th>Tonal Level</th>
<th>Word 2</th>
<th>Tonal Level</th>
<th>Word 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1σ</td>
<td>kó 'war'</td>
<td>2σ</td>
<td>pélé 'house'</td>
<td>3σ</td>
<td>háwámá 'waistline'</td>
</tr>
<tr>
<td>L</td>
<td>kpà 'debt'</td>
<td></td>
<td>bèlè 'trousers'</td>
<td></td>
<td>kpàkàlì 'tripod chair'</td>
</tr>
<tr>
<td>HL</td>
<td>mbû 'owl'</td>
<td></td>
<td>ngílà 'dog'</td>
<td></td>
<td>félàmà 'junction'</td>
</tr>
<tr>
<td>LH</td>
<td>mbà 'rice'</td>
<td></td>
<td>nàvó 'money'</td>
<td></td>
<td>ndàvúlá 'sling'</td>
</tr>
<tr>
<td>LHL</td>
<td>mbã 'companion'</td>
<td></td>
<td>njàhâ 'woman'</td>
<td></td>
<td>nìkílì 'groundnut'</td>
</tr>
</tbody>
</table>
What makes Tonal Morphology Problematic?

- Tone is pronounced simultaneously with segments/syllables.

- Tone might be considered a phonological feature of segments or syllables.

- Hence expressing morphology by a change of the tone/pitch contour of a word doesn’t seem to add material, but to change it.

- Hence tonal morphology seems to be inherently non-concatenative.

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Autosegmental Phonology: Tone
The Absolute Slicing Hypothesis (Goldsmith, 1976)

In traditional phonology, a phonological representation is a complete transitive order of segments.

This means that for all sounds in the representation:

- Either Sound\textsubscript{1} precedes Sound\textsubscript{2}, or Sound\textsubscript{2} precedes Sound\textsubscript{1}.

  (Two sounds cannot be simultaneous, be unordered or follow each other)

- If Sound\textsubscript{1} precedes Sound\textsubscript{2}, and Sound\textsubscript{2} precedes Sound\textsubscript{3}, then Sound\textsubscript{1} precedes Sound\textsubscript{3}. 


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Autosegmental Phonology: Tone
Weakening the Absolute Slicing Hypothesis in Autosegmental Phonology (Goldsmith, 1976)

- A phonological representation consists of a fixed number of subrepresentations
- The Absolute Slicing Hypothesis holds for each sub-representation, but not for the overall representation
- Relative linearization of subrepresentations is achieved by association between the units of single subrepresentations
The Autosegmental Representation of Tone

- Tone and segments/syllables are represented on different ‘tiers’, separate planes in a three-dimensional space.
- Linked (associated) elements of different tiers are pronounced as a unit.
- A single tone may be linked to more than one syllable. A single syllable may be linked to more than one tone (resulting in a contour tone).
1 Tone – Many Syllables: Mende

kó = kó

háwámá = ha wa ma
1 Syllable – Many Tones: Mende

nàvó = \[
\begin{array}{c}
\text{L} \\
\text{na} \\
\text{H} \\
\text{vo}
\end{array}
\]

mbǎ = \[
\begin{array}{c}
\text{L} \\
\text{mba} \\
\text{H}
\end{array}
\]
Autosegments Make Tone Concatenative: Hausa
Autosegments Make Tone Concatenative: Mende

\[
\begin{align*}
&H \\
&+ \\
&\text{ha} \quad \text{wa} \quad \text{ma} \\
\Rightarrow \quad &\text{ha} \quad \text{wa} \quad \text{ma}
\end{align*}
\]
## Phonological Evidence: Tone Mobility in Chizigula

<table>
<thead>
<tr>
<th>Tone-less Verbs</th>
<th>H-Tone Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ku-damanj</td>
<td>ku-lombéz-a</td>
</tr>
<tr>
<td>‘do’</td>
<td>‘ask’</td>
</tr>
<tr>
<td>ku-damanj-iz-a</td>
<td>ku-lombez-éz-a</td>
</tr>
<tr>
<td>‘do for’</td>
<td>‘ask for’</td>
</tr>
<tr>
<td>ku-damanj-iz-an-a</td>
<td>ku-lombez-ez-án-a</td>
</tr>
<tr>
<td>‘do for each other’</td>
<td>‘ask for each other’</td>
</tr>
</tbody>
</table>
Phonological Evidence: Tone Mobility in Chizigula

\[ ku-l\text{ombéz-a} \Rightarrow ku-lombéz-a \]

\[
\begin{array}{c}
\text{H} \\
\mid \\
\text{ku lom be za} \Rightarrow \text{ku lom be za}
\end{array}
\]
Phonological Evidence: Stability in Thai Secret Language

kl-uáì h-̀̀̀m ⇒ kl-̀̀m h-uáì ‘banana’

t-én r-ām ⇒ t-ám r-ēn ‘dance’

→ Rhimes are exchanged, tones stay where they are
Phonological Evidence: Stability in Thai Secret Language

t-éñ  r-āṃ  ⇒  t-áṃ  r-ēñ

H  T  M  ⇒  H  T  M
  |   |        |   |
t-en  r-am  ⇒  t-am  r-en
Phonological Evidence: Tone Polarity in Margi

[á dlà gú] ‘you fall’
[á wì gú] ‘you runn’
[á g à gú] ‘you reach’
[à sá gù] ‘you go astray’
[à tsú gù] ‘you beat’
[à hú gù] ‘you take’
[á věl gù] ‘you fly’

(Kenstowicz & Kisseberth, 1979:43)
Phonological Evidence: Tone Polarity in Margi

\[\text{a dlà gu} \implies \text{á dlà gú}\]
\[\text{a sá gu} \implies \text{à sá gù}\]
\[\text{a sa gù} \implies \text{a sa gù}\]
Phonological Evidence: Tone Polarity in Margi

\[ \text{a vě gu} \Rightarrow \text{á vě gù} \]

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Derivations in Autosegmental Morphology

- **Wellformedness Constraints**: general requirements and preferences for the linking between tones and syllables

- **Repair Mechanisms**: derivational rules which ensure that the Wellformedness Constraints are (more or less) obeyed
Constraints on Possible Representations

- **Hard Constraints:**
  - must be obeyed at all levels of representation
  - cannot be violated by input or output
  - cannot be produced by any phonological process

- **Soft Constraints:**
  - can in principle be violated
  - But as soon as a violation occurs, repair mechanisms ensure that the violation is removed as far as this does not result in violating hard constraints

- **Preferences:**
  - can in principle be violated & do not trigger repair,
  - but are observed by repair mechanisms as far as this does not result in violating hard or soft constraints
The central **Hard** Constraint: No Crossing

Association Lines are not allowed to cross:

\[ \begin{array}{c}
\text{L} \\
\text{na} \\
\text{H} \\
\text{vo} \\
\end{array} \]

If \( T_1 \) precedes \( T_2 \) on Tier\(_a\) and
If \( S_1 \) precedes \( S_2 \) on Tier\(_b\)
then linking \( T_1 \) to \( S_2 \)
excludes linking \( T_2 \) to \( S_1 \)
The Central **Soft** Constraints

There should be no unassociated structure

i.e.

- Every tone should be associated to at least one syllable
- Every syllable should be associated to at least one tone
The Central **Preference**

Association should be as unique as possible

i.e.

- Every tone should be associated to **at most** one syllable
- Every syllable should be associated to **at most** one tone
The Repair Algorithm (Goldsmith, 1976)

1. If there are unassociated syllables and tones:
   - Associate tones and syllables 1:1 from left to right (if possible without violating hard constraints)

2. Else: If there are unassociated tones:
   - Associate every unassociated tone T to the syllable to which the tone immediately preceding T is associated (if possible without violating hard constraints)

3. Else: If there are unassociated syllables:
   - Associate every unassociated syllable S to the tone to which the syllable immediately preceding S is associated (if possible without violating hard constraints)
Deriving Hausa

\[ \text{sha} \quad + \quad \text{L} \quad \Rightarrow \quad \text{sha} \]

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Autosegmental Phonology: Tone
### Deriving Mende Noun Classes

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Association Algorithm: Mende

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{ha} & \quad \text{ha} \\
\text{wa} & \quad \text{wa} \\
\text{ma} & \quad \text{ma} \\
\Rightarrow & \quad \Rightarrow \\
\text{ha} & \quad \text{ha} \\
\text{wa} & \quad \text{wa} \\
\text{ma} & \quad \text{ma} \\
\end{align*}
\]
\[(1.)\]

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{ha} & \quad \text{ha} \\
\text{wa} & \quad \text{wa} \\
\text{ma} & \quad \text{ma} \\
\Rightarrow & \quad \Rightarrow \\
\text{ha} & \quad \text{ha} \\
\text{wa} & \quad \text{wa} \\
\text{ma} & \quad \text{ma} \\
\end{align*}
\]
\[(3.)\]
Association Algorithm: Mende

\[
\begin{array}{c|c|c|}
 & \text{L} & \text{H} & \text{L} \\
\hline
\text{nja} & \text{ha} & \Rightarrow & \text{nja} & \text{ha} \\
\end{array}
\quad (1.)
\]

\[
\begin{array}{c|c|c|}
 & \text{L} & \text{H} & \text{L} \\
\hline
\text{nja} & \text{ha} & \Rightarrow & \text{nja} & \text{ha} \\
\end{array}
\quad (2.)
\]

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Autosegmental Phonology: Tone
### Deriving Tone in Chinese

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</tr>
<tr>
<td>ma</td>
<td>mid-low-high</td>
<td>‘horse’</td>
</tr>
<tr>
<td>ma</td>
<td>high-low</td>
<td>‘scold’</td>
</tr>
</tbody>
</table>
One More Soft Constraint:
The Obligatory Contour Principle (OCP)

Adjacent identical tones are disallowed:

*H H

*L L
Repair Strategy for the OCP

If there are two adjacent identical tones:
  ▶ Merge them into a single tone
The Motivation of the OCP in Mende

- Mende doesn’t have tone plateaus in non-final syllables. Assume that this is an important property of the system we want to derive.

- This follows if we assume the tonal patterns we stated up to this point, but a tonal pattern violating the OCP (e.g. H H L) could lead to a violation of the generalization (e.g. for a three-syllabic noun).

- However, if OCP-violations are automatically repaired any time the OCP is violated, H H L would be transformed into H L before any damage could be done.
Evidence for the OCP: Tone Polarity in Margi

\[ a \text{ dlà gu} \Rightarrow \text{ á dlà gú} \]
\[ a \text{ sá gu} \Rightarrow \text{ à sá gù} \]
\[ a \text{ sa gu} \Rightarrow \text{ a sa gu} \]
Predictions of the Association Algorithm

- Contour tones are avoided if possible
- Tone plateaus are avoided if possible
- Contour Tones prefer to appear at the right word edge
- Tone plateaus prefer to appear at the right word edge
## Contours and Tone Plateaus in Mende

<table>
<thead>
<tr>
<th></th>
<th>1 $\sigma$</th>
<th>2 $\sigma$</th>
<th>3 $\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>kó ‘war’</td>
<td>pélé ‘house’</td>
<td>háwámá ‘waistline’</td>
</tr>
<tr>
<td>L</td>
<td>kpà ‘debt’</td>
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</tr>
</tbody>
</table>
Further Questions

- is there also Right-to-Left Association
- Can unassociated tones remain in the output
- Can unassociated tones be deleted
What changed: Concatenation

- Concatenation remains the same:
  Affixes, roots and stems are combined in a specific linear order: Only the phonological consequences change

- If two morphemes $M_1$ and $M_2$ are combined and share material on the same tier, the order of concatenation determines the phonological order

- However, if $M_1$ do not share phonological material on any tier concatenation doesn’t impose by itself a phonological ordering
  This is achieved by the phonological repair mechanisms
What changed: Phonological Alternation

- The model of phonological alternation has changed from a completely segmental one to one where specific features share more autonomy.

- However, there is independent evidence for this independence in the phonology of tone, vowel harmony, and other areas.
Phonological Tone Spreading: Chilungu (Yip:68)

<table>
<thead>
<tr>
<th>zugrundeliegend</th>
<th>Infinitiv</th>
<th>“to be enough”</th>
<th>“to thatch”</th>
<th>“to boil over”</th>
<th>“to sort out”</th>
</tr>
</thead>
<tbody>
<tr>
<td>vul</td>
<td>kú-vúl-à</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi:mb</td>
<td>kú-ví:mb-à</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fulumj</td>
<td>kú-fúlúmj-à</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>so:bolol</td>
<td>kú-só:bolól-à</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Turkish [BACK] vowel harmony

(Mailhot & Reiss 2007: 33)

<table>
<thead>
<tr>
<th>Nom pl.</th>
<th>Gen. sg.</th>
<th>Gen.pl.</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ip-ler</td>
<td>ip-in</td>
<td>ip-ler-in</td>
<td>‘rope’</td>
</tr>
<tr>
<td>b. kiz-lar</td>
<td>kiz-in</td>
<td>kiz-lar-in</td>
<td>‘girl’</td>
</tr>
<tr>
<td>c. sap-lar</td>
<td>sap-in</td>
<td>sap-lar-in</td>
<td>‘stalk’</td>
</tr>
<tr>
<td>d. yüz-ler</td>
<td>yüz-ün</td>
<td>yüz-ler-in</td>
<td>‘face’</td>
</tr>
<tr>
<td>e. son-lar</td>
<td>son-un</td>
<td>son-lar-in</td>
<td>‘end’</td>
</tr>
</tbody>
</table>
Advantages of Doing Vowel Harmony Autosegmentally

- Spreading (= harmony) becomes the most natural process for vowel-vowel alternation which corresponds closely to the typological facts.

- Accounts for the directionality of vowel harmony.

- Vowel harmony can be modeled as a completely local process.

- Exceptions to harmony can be captured by prespecification (e.g. $\text{begAn-lyor-Im} \Rightarrow \text{begeniyorum}$; Kabak & Vogel, 2001:344).