Gradient Lengthening Effects: Evidence from Tagalog

Afton Coombs     University of Southern California     acoombs@usc.edu
GLOW2015 4/18/15
Research Questions

- Can qualitative and quantitative effects in language emerge from the same grammar, using the same formalism?
- Specifically: can qualitative and quantitative effects in the **prosodic domain** be captured by the same formalism?
Dynamical Systems

- Differential equation determines how a state changes based upon the previous state
- System itself is constant
- Potential function = $x^2/2$
Nonlinear Dynamical Systems

- A force function: \( f(x) = x^3 - x \)
- Corresponding potential: \( V(x) = \frac{x^4}{4} - \frac{x^2}{2} \)
- Differential equation determines how a state changes based upon its current state.
- Capture a number of biological functions, such as hand coordination and gait (Haken, Kelso, Bunz 1985)
Previous Proposals for Dynamical Systems as a Language Grammar

- Incomplete word-final devoicing in German (Port and Crawford 1989, Gafos and Benus 2006)
  - Word final voiced obstruents not completely neutralized to voiceless obstruents
  - Interaction between input faith and markedness of a final voiced obstruent

- Tashlhiyt Berber tonal alignment (Röttger et al 2013)
  - Rightward tendency of H tone in a certain sentence tune – both a final syllable preference and late alignment within the vowel
  - Crucially contrasts with other sentence tunes that align H tone earlier in both syllable and nuclear segment
Determining the attractor layout

- Control parameter changes the system overall:
  \[ V(x) = \frac{a * x^4}{4} - \frac{b * x^2}{2} + c * x \]
- Parameters \(a\) and \(b\) determine the number and location of stable states
- Allows double or single wells (simplest formalism)

\[ a=1, \ b=3, \ c=0 \quad \text{(bistable)} \]
\[ a=0, \ b=-1, \ c=0 \quad \text{(monostable)} \]
Determining the Attractor Layout

- a and b parameters determine the location and strength as well as number of stable states

\[ a=1, \quad b=3, \quad c=0 \]
(attractors = -2, 2)

\[ a=1, \quad b=7, \quad c=0 \]
(attractors = -3, 3)
Determining the Attractor Layout

- Parameter $c$ determines tilt
- $a=3$, $b=9$, $c=0$ (no tilt)
  \[ V(x) = \frac{a x^4}{4} - \frac{b x^2}{2} + c x \]
- $a=3$, $b=9$, $c=3$ (left tilt)
Connecting Model with Data

- Simulating pattern with an added noise factor produces expected probability distribution
- This can be compared to actual experimental distributions
Predicted Probability Distributions

Left tilt
a=1, b=3, c=3

Right tilt
a=1, b=3, c=-3

Righter tilt
a=1, b=3, c=-6
Background: Lengthening Effects

- Domain-final lengthening well-attested cross-linguistic phenomenon
  - Word boundaries (Oller 1973, Klatt 1976)
  - Phrase boundaries (Byrd and Saltzman 1998, Wightman 1992)
- Stress also linked to length in some languages (Hayes 1995)
Where Lengthening Effects Do Not Apply

- Avoiding footing/stress of a domain-final syllable (NonFinality Constraints: Prince and Smolensky 1993)
- Avoiding an “overlong” syllable (Alaskan Yupik: Hayes 1995)
Tagalog: No Lengthening of a Final Syllable?

- Generally allows stress on either the penult or ultima
- Traditionally analyzed as showing increased duration of a stressed penult, but not of a stressed ultima (Schachter and Otanes 1982, Soberano 1980)
  - \(^1\)CVː.CV
  - CV.\(^1\)CV
  - *CV.\(^1\)CVː
Nonlinear Dynamical Systems and Vowel Duration

- Two categories (long/short) captured by two modes
- Continuous change *within* a mode allows for a *principled* range of values

![Short Vowel](image1.png)  ![Long Vowel](image2.png)

**Short Vowel**

**Long Vowel**

**Histogram of solutions**

**Standardized Duration**
Nonlinear Dynamical Systems and Vowel Duration

Short vowel
\( a=1, b=3, c=3 \)

Long vowel
\( a=1, b=3, c=-3 \)

Longer vowel
\( a=1, b=3, c=-6 \)
Hypothesis

- Stressed ultimate vowels in Tagalog do show increased length compared to unstressed ultimate vowels
- Ultimate vowels in Tagalog show a lesser stress increase compared to penultimate vowels
- Penultimate vowels when stressed undergo a mode shift
Hypothesis

- Stressed ultimate vowels in Tagalog do show increased length compared to unstressed ultimate vowels.
- Ultimate vowels in Tagalog show a lesser stress increase compared to penultimate syllables.
  - Ultimate vowels when stressed show shift in the same mode.
Hypothesis: Predicted Probability Distribution of Tagalog Vowels

- Stressed ultimate vowels in Tagalog do show increased length compared to unstressed ultimate vowels.
- Ultimate vowels in Tagalog show a lesser stress increase compared to penultimate syllables.
Experimental Method

- **Ten words of type CaCa**
  - Five with penultimate stress and five with ultimate stress
  - C = stop in all words

- **Two carrier phrases**
  - One placing target word in medial context
    - Gusto kong sabihin mo ang _____ na matahimik.
    - want I say you <link>“_____” that quietly.
    - I want you to say “_____” quietly.
  - One placing target word in final context
    - Gusto kong sabihin mo ang "tabi" hindi "____.”
    - want I say you <link>“side” not “_____.”
    - I want you to say “tabi” not “_____”
Examples of Target Items

- **Phrase-medial ultimately stressed**
  - Gusto kong sabihin mo ang “taka” na matahimik.
  - I said say “taka” quietly.
  - “taka” = TAka ‘bamboo sticks’

- **Phrase-medial penultimately stressed**
  - Gusto kong sabihin mo ang “taka” na matahimik.
  - “taka” = taKA ‘surprise’

- **Phrase-final ultimately stressed**
  - Gusto kong sabihin mo ang "tabi" hindi ”taka.”
  - I said say “tabi” not “taka.”

- **Phrase-medial ultimately stressed**
  - Gusto kong sabihin mo ang "tabi" hindi ”taka.”
Method: Task

- 5 blocks of targets and fillers in pseudorandomized order
  - 20 CaCa targets in both carriers
  - 38 fillers in both carriers
- 6 native speakers of Tagalog participated
- Participants shown one slide presenting the word, its meaning, and its pronunciation.
- Then a second slide displaying the target phrase they are asked to say
- Participants spoke into a head-mounted microphone
Results

Mean Vowel Duration (ms) by Stress Condition (Penult)

Unstressed Penult

Stressed Penult

* = < 0.05
Results

Mean Vowel Duration (ms) by Stress Condition (Ultima)

* = < 0.05
Tagalog Data

Distribution of Standardized Values of Vowel Durations (ms)

Number of Tokens

Standardized Vowel Duration (ms)
Setting the Control Parameters: c values

Penultimate = 1.5
Ultimate = -4.5
Unstressed = 1.5
Stressed = -4.5  

(a = 3, b = 0.5)

<table>
<thead>
<tr>
<th></th>
<th>Stressed</th>
<th>Unstressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penultimate syllable</td>
<td>-3</td>
<td>3</td>
</tr>
<tr>
<td>Ultimate syllable</td>
<td>-9</td>
<td>-3</td>
</tr>
</tbody>
</table>
Model of Experimental Results

**Short mode c=3**
- Unstressed penult

**Long mode c=-3**
- Stressed penult

**Long mode c=-3**
- Unstressed ultima

**Long(er) mode c=-9**
- Stressed ultima
Probability Distribution of All Possible Vowel Durations in Tagalog
Examples of Other Predicted Languages

- A categorical positional effect but no categorical stress effect
- A categorical stress effect but no categorical positional effect
Examples of Other Predicted Languages

- No stress effect – iambic languages (Cahuilla, Seiler 1965)
  - Penultimate: -3
  - Unstressed: 0
  - Ultimate: 3
  - Stressed: 0

<table>
<thead>
<tr>
<th></th>
<th>Stressed</th>
<th>Unstressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penultimate syllable</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ultimate syllable</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>
Examples of Other Predicted Languages

- No word effect (English, Harris and Umeda 1974; Japanese, Nakai 2014)
  - Penultimate: 0
  - Unstressed: 3
  - Ultimate: 0
  - Stressed: -3

<table>
<thead>
<tr>
<th></th>
<th>Stressed</th>
<th>Unstressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penultimate syllable</td>
<td>-3</td>
<td>3</td>
</tr>
<tr>
<td>Ultimate syllable</td>
<td>-3</td>
<td>3</td>
</tr>
</tbody>
</table>
Conclusion

- Tagalog shows continuous effects of stress and duration that parallel a categorical shift.
- Such parallelism falls out naturally from this type of grammar.
- Potential for future analyses of prosodic systems (e.g. Nava 2011).
References