A Harmonic Grammar Analysis of Tonal Patterns in L2 Acquisition of Mandarin by English Native Speakers
-- A Case Study of Kevin Rudd and Mark Zuckerberg

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Highlights:

- We present a rarely reported case of the gradual development of L2 grammars of high level tone (T1) and the interaction of syllabicity and T1 acquisition.

- We propose an initial stage of L2 grammars of Mandarin T1 based on attested two intermediate stages and final state.

- This paper shows that it’s possible to implement HG-GLA approach in L2 acquisition to account for the development of L2 grammars.
1. Previous studies

• The order of acquisition: T1, T4 >> T2, T3 (Li & Thompson 1977, Yue 1986, Chen 1997 and Zhu & Todd 2000 etc.).

• The difficulty of acquisition: T1 >> T4. **Tonal Markedness Scale** (TMS, *Raising Tone >> * Falling Tone >> * Level Tone) is relevant in Mandarin tonal acquisition by English native speakers (Zhang 2007).

• Accuracy: T1, T4 >> T3, T2 (Guo & Tao 2008 and Hao 2011).

• There is no significant difference among L2 learners’ tonal errors (Miracle 1989).
1. Previous studies

- Optimality Theory analysis:
  
  Tonal Markedness Scale, Positional Faithfulness constraints and Obligatory Contour Principle can account for the disyllabic tonal grammars produced by English native speakers (Zhang 2007).

  Besides positional faithfulness constraints, Li (2015) also applied positional licensing constraint to account for her observation that T1 is produced as T4 only when it appear on the initial stressed syllable of a word.
2. Data

• Data used in this paper are transcribed from Mandarin interviews and speeches of two famous Mandarin learners, Kevin Rudd and Mark Zuckerberg.

• https://www.youtube.com/watch?v=Bro4mkb_VKc
• https://www.youtube.com/watch?v=GzFQNryBf5A
• https://www.facebook.com/zuck/videos/10101708164336771/
• https://www.facebook.com/zuck/videos/10102638915613751/
## Appendix

<table>
<thead>
<tr>
<th>T1</th>
<th>Tone 1, high level tone</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>Tone 2, rising tone</td>
</tr>
<tr>
<td>T3</td>
<td>Tone 3, low falling (then raising) tone</td>
</tr>
<tr>
<td>T4</td>
<td>Tone 4, high falling tone</td>
</tr>
</tbody>
</table>

- [普通话] word: the underlined character is the target T1 syllable; "[]" means the boundary of a word
- [开始][工作]: the underlined and bold character means where the error happens -- L2 learners substitutes T1 as T4.

### Data transcribed from interview and speech of Kevin Rudd

1. **Interview of Kevin Rudd** (5 minutes in total)
   [https://www.youtube.com/watch?v=Bro4mkb_VKc](https://www.youtube.com/watch?v=Bro4mkb_VKc)

   我的 [普通话] [说] 得 [非常] 不好，越来越差。

   我还是一个 [百分之百] 老外。

   [因此]，有 [很多] 的 [中文字]，我 [都] 不懂，但是，我试一试。

   是，肯定，我们两个 [国家] 的政治系统，是不一样的。我们政治价值，也有一点儿不一样。
2. Data

- The data shows two interesting phenomena:
  ① in terms of the percentage of errors about T1 production: 16% (Rudd) < 92% (Zuckerberg);
  ② syllabification matters:

<table>
<thead>
<tr>
<th>Table 1: Percentage of errors about T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors on Monosyllabic words</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Errors on Polysyllabic words</td>
</tr>
</tbody>
</table>
2. Data

• This numeric evidence show that:
  ① at least on T1 acquisition, Rudd’s Mandarin proficiency is much closer to native speaker level than Zuckerberg’s;
  ② Rudd and Zuckerberg can represent two different Intermediate Faith (IF) stages in L2 grammars of T1 of Mandarin.

• IF-1 stage: Zuckerberg’s data;
  IF-2 stage: Rudd’s data.
3. Data analysis and discussion

- **One approach:**
  Harmonic Grammar - Gradual Learning Algorithm (HG - GLA) (Jesney & Tessier 2011)

- **One tool:**
  MaxEnt grammar Tool (Hayes 2009)

- **Three stages:**
  IF-1 → IF-2 → Final state (T1: HH).

- **Four candidates:**
  low level tone (LL), falling tone (HL), raising tone (LH), high level tone (HH).
3. Data analysis and discussion

- Five constraints:
  * LH: don’t allow raising tone;
  * HL: don’t allow falling tone;
  * Level Tone: don’t allow level tone;
  * HH(POLY): don’t allow high level tone in a polysyllabic word;
  IDENT (T): the L2’s output should be identical to the tone of the target syllable.
<table>
<thead>
<tr>
<th>C1</th>
<th>-11</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>-1</td>
<td>100</td>
</tr>
<tr>
<td>C3</td>
<td>0</td>
<td>10000000</td>
</tr>
<tr>
<td>C4</td>
<td>-3.5</td>
<td>1000</td>
</tr>
<tr>
<td>C5</td>
<td>0</td>
<td>1000</td>
</tr>
</tbody>
</table>
MaxEnt Grammar

<table>
<thead>
<tr>
<th>Input: Input1</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output1-1</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Output1-2</td>
<td>0.92</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>output1-3</td>
<td>0.08</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Output1-4</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

weights after optimization:

Constraint1 (mu=-11.0, sigma^2=1000.0)  11.038501088547791
Constraint2 (mu=-1.0, sigma^2=100.0)  0.996148932269955
Constraint3 (mu=0.0, sigma^2=1.0E7)  6.4463640247396565
Constraint4 (mu=-3.5, sigma^2=1000.0)  0.8418966332058978
Constraint5 (mu=0.0, sigma^2=1000.0)  3.779549536972518

Input: Candidate: Observed: Predicted:

|Input1 | Output1-1 0.0 | 0.0039574202465952404 |
|Input1 | Output1-2 0.92| 0.921320026012334 |
|Input1 | Output1-3 0.08| 0.07468246038745743 |
|Input1 | Output1-4 0.0 | 4.009335361337053E-5 |
|Input2 | Output2-1 0.0 | 0.0036021150450875014 |
|Input2 | Output2-2 0.84| 0.8386020488712753 |
|Input2 | Output2-3 0.16| 0.15775934239247996 |
|Input2 | Output2-4 0.0 | 3.6493691157260226E-5 |
3. Data analysis and discussion

- IF-1 stage (Zuckerberg’s data): falling tone preferred
3. Data analysis and discussion

- **IF-2 stage (Rudd’s data):**
  
  high level tone is preferred, but in a polysyllabic word, the percentage of producing HH tone as falling tone is more than 15%.

<table>
<thead>
<tr>
<th></th>
<th>* LH</th>
<th>* HL</th>
<th>* Level</th>
<th>*HH POLY</th>
<th>IDENT</th>
<th>H</th>
<th>OP</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>-3.9</td>
<td>-3.9</td>
<td></td>
<td>-5.8</td>
<td>-9.7</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>HL</td>
<td>-1.3</td>
<td></td>
<td></td>
<td>-5.8</td>
<td>-7.1</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HH</td>
<td>-3.9</td>
<td>-1.6</td>
<td></td>
<td>-3.9</td>
<td>97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>-13</td>
<td></td>
<td></td>
<td>-5.8</td>
<td>-18.8</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
3. Data analysis and discussion

- **End-state:**
  the intended winner (T1) always wins.

<table>
<thead>
<tr>
<th></th>
<th>* LH</th>
<th>* HL</th>
<th>*Level</th>
<th>*HH\text{POLY}</th>
<th>IDENT</th>
<th>H</th>
<th>OP</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH</td>
<td>-14</td>
<td>-5.3</td>
<td>-5</td>
<td>-7.6</td>
<td>-8.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LL</td>
<td></td>
<td>-5</td>
<td>-5.5</td>
<td>-7.6</td>
<td>-12.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HL</td>
<td></td>
<td>-5.3</td>
<td>-5</td>
<td>-7.6</td>
<td>-12.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LH</td>
<td></td>
<td>-14</td>
<td>-5</td>
<td>-7.6</td>
<td>-21.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(6) the syllable with T1 in a monosyllabic word
3. Data analysis and discussion

From IF-1 to the end state, the weights of constraints:

- increasing: *LH, *HL, *IDENT
- decreasing: combination of *Level and *HH(poly)

Learners become increasingly faithful to T1 and tend to accept high level tone during this learning process.
3. Data analysis and discussion

• **Proposed Initial stage:**
  either HL or LH

• Given the gradual development of L2 grammars, compared with IF-1 stage, in initial stage:
  lower: *LH, *HL, *IDENT
  higher: combination of *Level and *HH(poly)
(8) the syllable with T1 in a monosyllabic word

<table>
<thead>
<tr>
<th>HH</th>
<th>* LH</th>
<th>* HL</th>
<th>*Level</th>
<th>*HH_POLY</th>
<th>IDENT</th>
<th>H</th>
<th>OP %</th>
<th>PP %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>-1</td>
<td>-7</td>
<td>-7</td>
<td>-1</td>
<td>-8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HL</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>0</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH</td>
<td>-1</td>
<td>-7</td>
<td>-7</td>
<td>-2</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>0</td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Data analysis and discussion

Contradictory arguments to some previous studies:

• Tonal Markedness Scale (TMS):
  In IF-1 stage and IF-2 stage, the weights of *Level is always higher than the weights of *HL, not what TMS (*Raising Tone >> * Falling Tone >> * Level Tone) predicts.

• L2 Acquisition order of Mandarin tones:
  Instead of first T1 and T4, then T2 and T3, it is possible to argue that T1 is more difficult than T4 for English native speakers, like Shen claimed in 1989.
4. Conclusion and future research

This case study mainly provides us three insights:

• It is possible to implement HG-GLA approach in L2 acquisition to account for the development of L2 grammars.

• Based on HG-GLA approach and data from attested intermediate stages and final state, we can reconstruct initial stage for adult L2 acquisition.

• TMS might not fit with L2 acquisition.
4. Conclusion and future research

Future research:

• Whether speakers of other languages (like Korean) also present the similar L2 tonal patterns as English native speakers.

• Whether T2, T3 are also usually produced as falling tones at the intermediate stages

• Whether HG-GLA model can account for the L2 acquisition of tone sandhi.
Selected Reference


• Li, Tianshu, 2015. An Optimality-Theoretical Analysis of the Tonal pattern in the Near - Native Mandarin by English L2 learner (forthcoming).


• Zhang, Hang, 2007. A Phonological study of Second Language Acquisition of Mandarin Chinese tones, MA dissertation, the University of North Carolina at Chapel Hill.
Thank you!

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