Introduction

- **Phonological neutralization:** “forms which are distinguishable phonetically and phonologically in certain contexts and/or levels of representation are under certain other well-defined circumstances totally indistinguishable at the level of phonetics” (Dimnesen, 1985: 265).

- **Main features of the neutral tone:** short duration and pitch

  The duration of a neutral tone is around 50%-60% of the full tones (Cao, 2002; Chen & Xu, 2006; Lin & Yan, 1980)

  Whatever the contour of the base form of the neutral tone is, the neutral tone’s contour is determined by the preceding full tone. (Cao, 2002; Chen, 2008; Chen & Xu, 2006; Lee & Zee, 2008)

- **Contradiction:** There are four types of neutral tones according to the phonetic environments in terms of the pitch because T0 after different full tones have different pitch values. In terms of the duration, tonal neutralization occurs only in one environment, i.e., four full tones are indistinguishable after any full tones, because of the shorter duration.

Perceptual Experiment on the Duration of T0

- **Purpose:** Explore whether T0 whose duration is lengthened can be perceived as a full tone, such as T3, or T4, or a neutral tone naturally.

- **Subject:** Twenty subjects whose native language is Mandarin Chinese

- **Stimuli:** There are six modified tones and four original tones in carrier sentences in this experiment. In total there are 10 sentences for native speakers to listen to. Sentence 1 to 4 are related to the original neutral tones. Sentences 5-8 are related to the double-duration neutral tones in place of the original neutral tones. Sentences 9-10 have the double-duration neutral tones in place of the full tones, i.e. T3 and T4.

- **Results:**

  Table 4. Means of naturalness for the modified words

<table>
<thead>
<tr>
<th>Modified tones (underlined)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1+T00₂</td>
<td>6.74</td>
<td>0.93</td>
</tr>
<tr>
<td>T2+T00₂</td>
<td>6.74</td>
<td>0.65</td>
</tr>
<tr>
<td>T3+T00₂</td>
<td>6.58</td>
<td>1.02</td>
</tr>
<tr>
<td>T4+T00₂</td>
<td>6.95</td>
<td>0.23</td>
</tr>
<tr>
<td>T00₀+T₀</td>
<td>6.05</td>
<td>1.39</td>
</tr>
<tr>
<td>T00₀+T₀</td>
<td>6.47</td>
<td>1.02</td>
</tr>
</tbody>
</table>

- **Results:** Table 3. Perceptual results of T0 with modified pitch

<table>
<thead>
<tr>
<th>Target tones</th>
<th>T1+T0</th>
<th>T2+T0</th>
<th>T3+T0</th>
<th>T4+T0</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (T0 originally after T1)</td>
<td>90%</td>
<td>15%</td>
<td>5%</td>
<td>30%</td>
</tr>
<tr>
<td>B (T0 originally after T2)</td>
<td>0</td>
<td>85%</td>
<td>0</td>
<td>30%</td>
</tr>
<tr>
<td>C (T0 originally after T3)</td>
<td>0</td>
<td>0</td>
<td>70%</td>
<td>0</td>
</tr>
<tr>
<td>D (T0 originally after T4)</td>
<td>10%</td>
<td>0</td>
<td>25%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Conclusion and Discussion

- **Conclusion:** Pitch is dominant in the perception of the neutral tone while duration is not. Therefore, the tonal neutralization occurs in four phonetic environments.

- **Comparing T0 with Sandhi tones in WU**

  Hirayama (1992) suggested that tone sandhi (wide usage) in northern Wu dialects shares similar features with the neutral tone in Mandarin.

- **A falling tendency?**

  Chen and Xu (2006) concluded that the neutral tone has a falling tendency according to the three consequent neutral tones. Actually, in Shanghai dialect, the last tone in the four consequent sandhi tones also has a falling tendency (Table 5). In this sense, the sandhi tones also have a falling tendency when the pitch of these tones depends on the previous full tones.

Perceptual Experiment on Pitch of T0

- **Purpose:** Explore whether pitch is dominant in perceiving T0.

- **Subject:** Twenty subjects whose native language is Mandarin Chinese

- **Stimuli:** carrier sentence: “_____ dou1 qu4 shang4ban1 le.” (Even _____ went to work).

  Table 1. Neutral tones in four stimuli

<table>
<thead>
<tr>
<th>word</th>
<th>Meaning (Base Form)</th>
<th>Pinyin (Base Form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>哥哥</td>
<td>brother</td>
<td>ge1ge1</td>
</tr>
<tr>
<td>格格</td>
<td>princess</td>
<td>ge2ge2</td>
</tr>
<tr>
<td>葛葛</td>
<td>Gege (name)</td>
<td>ge3ge3</td>
</tr>
<tr>
<td>个个</td>
<td>everyone</td>
<td>ge4ge4</td>
</tr>
</tbody>
</table>

  Table 2. Stimuli: modified tones in bi-syllabic words

  Words (origin) | Meaning (origin) | Pinyin (origin) | Pinyin (modified) |
  ------------- | ----------------|----------------|------------------|
  哥哥 | brother | ge1ge1 | ge1ge0₁ |
  哥哥 | brother | ge1ge0₂ | ge1ge0₂ |
  哥哥 | brother | ge1ge0₃ | ge1ge0₃ |
  哥哥 | brother | ge1ge0₄ | ge1ge0₄ |
  格格 | princess | ge2ge0₁ | ge2ge0₁ |
  格格 | princess | ge2ge0₂ | ge2ge0₂ |
  格格 | princess | ge2ge0₃ | ge2ge0₃ |
  格格 | princess | ge2ge0₄ | ge2ge0₄ |
  葛葛 | Gege (name) | ge3ge0₁ | ge3ge0₁ |
  葛葛 | Gege (name) | ge3ge0₂ | ge3ge0₂ |
  葛葛 | Gege (name) | ge3ge0₃ | ge3ge0₃ |
  葛葛 | Gege (name) | ge3ge0₄ | ge3ge0₄ |
  个个 | everyone | ge4ge0₁ | ge4ge0₁ |
  个个 | everyone | ge4ge0₂ | ge4ge0₂ |
  个个 | everyone | ge4ge0₃ | ge4ge0₃ |
  个个 | everyone | ge4ge0₄ | ge4ge0₄ |

- **Results:** Table 3. Perceptual results of T0 with modified pitch

<table>
<thead>
<tr>
<th>Words (origin)</th>
<th>Meaning (origin)</th>
<th>Pinyin (origin)</th>
<th>Pinyin (modified)</th>
</tr>
</thead>
</table>
  哥哥 | brother | ge1ge1 | ge1ge0₁ |
  哥哥 | brother | ge1ge0₂ | ge1ge0₂ |
  哥哥 | brother | ge1ge0₃ | ge1ge0₃ |
  哥哥 | brother | ge1ge0₄ | ge1ge0₄ |
  格格 | princess | ge2ge0₁ | ge2ge0₁ |
  格格 | princess | ge2ge0₂ | ge2ge0₂ |
  格格 | princess | ge2ge0₃ | ge2ge0₃ |
  格格 | princess | ge2ge0₄ | ge2ge0₄ |
  葛葛 | Gege (name) | ge3ge0₁ | ge3ge0₁ |
  葛葛 | Gege (name) | ge3ge0₂ | ge3ge0₂ |
  葛葛 | Gege (name) | ge3ge0₃ | ge3ge0₃ |
  葛葛 | Gege (name) | ge3ge0₄ | ge3ge0₄ |
  个个 | everyone | ge4ge0₁ | ge4ge0₁ |
  个个 | everyone | ge4ge0₂ | ge4ge0₂ |
  个个 | everyone | ge4ge0₃ | ge4ge0₃ |
  个个 | everyone | ge4ge0₄ | ge4ge0₄ |

Conclusion and Discussion

- **Conclusion:** Pitch is dominant in the perception of the neutral tone while duration is not. Therefore, the tonal neutralization occurs in four phonetic environments.

- **Comparing T0 with Sandhi tones in WU**

  Hirayama (1992) suggested that tone sandhi (wide usage) in northern Wu dialects shares similar features with the neutral tone in Mandarin.

- **A falling tendency?**

  Chen and Xu (2006) concluded that the neutral tone has a falling tendency according to the three consequent neutral tones. Actually, in Shanghai dialect, the last tone in the four consequent sandhi tones also has a falling tendency (Table 5). In this sense, the sandhi tones also have a falling tendency when the pitch of these tones depends on the previous full tones.

Table 5. Tone sandhi in Shanghai dialect.

<table>
<thead>
<tr>
<th>bi-syllables</th>
<th>tri-syllables</th>
<th>five syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>55+21</td>
<td>55+33+21</td>
<td>55+33+33+33+21</td>
</tr>
<tr>
<td>33+44</td>
<td>33+55+21</td>
<td>33+55+33+33+21</td>
</tr>
<tr>
<td>22+44</td>
<td>22+55+21</td>
<td>22+55+33+33+21</td>
</tr>
<tr>
<td>33+44</td>
<td>33+55+21</td>
<td>33+55+33+33+21</td>
</tr>
<tr>
<td>11+23</td>
<td>11+22+23</td>
<td>22+55+33+33+22</td>
</tr>
</tbody>
</table>

Note: adapted from Shanghai Shuqu Fangyanzhi, 1988:24.

- **Is T0 independent or dependent?**

  A neutral tone is affected by the tone that is carried by the first syllable. The initial and the final are independent in a syllable carrying T0.