Seeking adequacy in describing the tonal system of Du'an Zhuang: Using phonetic evidence for tonal descriptions
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1. Introduction

1.1 A description of the tonal system of Du’an Zhuang based on phonetic measurement is presented.
   - Of 55 minority languages in China, Zhuang (Tai-Kadai family) has the largest number of speakers.
   - The variety spoken in Wuming is considered the standard variety (Wei & Qin, 1980).
   - However there is a vast degree of dialectal difference within Zhuang (mutual unintelligibility).

1.2 Recent research on understudied languages has similarly focused on phonetic measurements.

1.3 We aim to describe tonal differences between Du’an Zhuang and Wuming Zhuang via phonetic measurement.
   - There is a 4-way pitch contrast and a 2-way phonation contrast in Du’an Zhuang

2. Tone in Chinese and Southeast Asian languages

2.1 Tonal systems in Southeast Asian languages
   - Monosyllabicity; a greater contrastive burden is placed on tone as well as laryngeal contrasts.
   - A larger number of contrastive tones: Burmese has 3 contrastive tones, Thai has 5 tones, Vietnamese has 6 tones.

2.2 Modern descriptions use Chao Tone Letters (Chao, 1930).
   - Tone is represented using the numbers 1 (lowest pitch) through 5 (highest pitch).
   - I.e. 3 means the syllable starts with high pitch and falls to a mid-level pitch.

2.3 Wei & Qin (1980) summarize the tonal system of Zhuang as shown below.

<table>
<thead>
<tr>
<th>Tone</th>
<th>Wei &amp; Qin</th>
<th>Chao Tones for Du'an Zhuang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[51]</td>
<td>Tone 1</td>
</tr>
<tr>
<td>2</td>
<td>[55]</td>
<td>Tone 2</td>
</tr>
<tr>
<td>3</td>
<td>[53]</td>
<td>Tone 3</td>
</tr>
<tr>
<td>4</td>
<td>[54]</td>
<td>Tone 4</td>
</tr>
<tr>
<td>5</td>
<td>[35]</td>
<td>Tone 5</td>
</tr>
</tbody>
</table>

2.4 Tones 1 to 5 are the label for unchecked syllables.
   - Tones 6 & 7 are label for checked syllables

2.5 Tones 3 & 6 have identical F0 tracks; a phonation contrast exists: tone 3 is creaky and tone 6 is modal.
   - Both are 51, with durations nearly equivalent.
   - Tone 3 mean: 0.175 ms, SD = 0.091
   - Tone 6 mean: 0.177 ms, SD = 0.068

2.6 In Du’an Zhuang, spectral tilt is significantly lower (p<0.05) in Tone 3 (0.53 dB) than in Tone 6 (14.91 dB),
   indicating tone 3 is creaky and tone 6 is modal.
   - Spectral tilt measurements for tone 5 (5.14 dB) are lower than tone 1 (9.59 dB), but this difference is less meaningful.
   - Tone 3 and 7 short are both 55; Tone 7 long and tone 5 are both 35.
   - Tones 6, 8 short, and 8 long are all 33.

2.7 Wei & Qin’s chart allows for as many as 10 contrastive tones.
   - Tone 3 and 7 short are both 55; Tone 7 long and tone 5 are both 35.
   - Tones 6, 8 short, and 8 long are all 33.

2.8 Wei & Qin also assume a tonal register split:
   - This split originates from the traditional descriptions of Chinese tone (4 tones split into two).
   - Tones 2, 4, 6, and 8 are lower register, with tones 1, 3, 5, and 7 as the respective upper register equivalents.

3. Tone in Du’an Zhuang: an acoustic analysis

3.1 Tones 1 to 6 (Unchecked syllables)

3.1.1 Mean Pitch Tracks in Du’an Zhuang (Tones 1 to 6, unchecked syllables)
   - Frequency in Hz on Vertical Axis; Time in ms on Horizontal Axis

3.1.2 Tones 1 & 5: phonetically rising in Wuming; in Du'an Zhuang, tone 1 is rising-falling & tone 5 is level.
   - Spectral tilt measurements for tone 5 (5.14 dB) are lower than tone 1 (9.59 dB), but this difference is less meaningful.

3.1.3 Comparison of Chao Tones for Wuming & Proposed Chao Tones for Du'an Zhuang

<table>
<thead>
<tr>
<th>Tone</th>
<th>Wuming Zhuang</th>
<th>Du’an Zhuang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[51]</td>
<td>Tone 1</td>
</tr>
<tr>
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</tr>
<tr>
<td>3</td>
<td>[53]</td>
<td>Tone 3</td>
</tr>
<tr>
<td>4</td>
<td>[54]</td>
<td>Tone 4</td>
</tr>
<tr>
<td>5</td>
<td>[35]</td>
<td>Tone 5</td>
</tr>
</tbody>
</table>

3.1.4 There is no evidence of a split register tonal system in Du’an Zhuang.

3.2 Tones 7 and 8 (Checked syllables)

3.2.1 Vowels with tones 7 & 8 (with obstruent codas) are significantly shorter in duration than the unchecked syllables,
   - but the phonetic evidence presented here suggests that they are allotones of tones 1 to 6.
   - Vowel length is predictably shorter in syllables with obstruent codas (Hubbard 1995 among others).
   - Tones 7 & 8 Short do appear to be significantly shorter than the long versions, however, suggesting a vowel length contrast exists in checked syllables only.

3.2.2 Tone 7 Short starts high, but unlike Wuming Zhuang where it is a level tone, it is a falling tone in Du’an Zhuang.
   - Tone 7 Short is equivalent to a shortened allotone of Tone 3/Tone 6 33.
   - The presence of a coda accounts for the shorter duration.
Tones in unchecked syllables and checked syllables

Tone 7 and 8 (in checked syllables) are most likely to be allotones of unchecked syllables. We observed three distinctive allotones in checked syllables.

**Near Minimal pairs with the shape, [na]**

### Comparison of Chao Tones for Wuming & Du’an Zhuang in Checked Syllables (tone 7 and tone 8)

<table>
<thead>
<tr>
<th>Word</th>
<th>Wuming Zhuang Wei &amp; Qin (1980)</th>
<th>Du’an Zhuang Our proposal</th>
<th>Du’an Zhuang Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Short</td>
<td>55</td>
<td>53</td>
<td>upper falling</td>
</tr>
<tr>
<td>7 Long</td>
<td>35</td>
<td>31</td>
<td>lower falling</td>
</tr>
<tr>
<td>8 Short</td>
<td>33</td>
<td>31</td>
<td>lower falling</td>
</tr>
<tr>
<td>8 Long</td>
<td>33</td>
<td>31</td>
<td>lower falling</td>
</tr>
</tbody>
</table>

### Discussion

- **Tone 2 – Tone 4 Contrast in Du’an Zhuang**
  - The difference between tone 2 and tone 4 lies in the phonation and the timing of the falling.
  - Tone 2 has modal phonation and has a late phonetic fall; it corresponds to [31] in Wuming Zhuang.
  - Tone 4 has creaky phonation and has an early phonetic fall; it corresponds to [42] in Wuming Zhuang.
  - Cf. Rose (1990) found that creaky phonation manifests with an early fall in pitch.

- **Level tones in Wuming correspond to the 51 tone in Du’an**
  - Du’an Zhuang has creaky phonation for Wuming Zhuang tone 3; modal phonation for tone 6.
  - Register contrast in Wuming Zhuang corresponds to a phonation contrast in Du’an Zhuang.

- **Phonation vs. Tone Contrasts**
  - Tones 3 & 6 have identical F0 profiles but distinct phonations.
  - Tones 2 & 4 have F0 profiles that differ in fall timing; phonation is somewhat distinct.
  - Tones 1 & 5 have distinct F0 profiles but fairly similar phonations.
  - Hypothesis: In Du’an Zhuang, a phonation contrast is in the process of replacing the register contrast.