A production and perception study of tonal neutralization in Nanchang Chinese

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Lexical tones in Nanchang

[Graph showing lexical tones across different points with distinct markers for each tone.]
Stress types in disyllables in Nanchang Chinese

- Grammatical stress
- Lexical stress
Grammatical stress in Nanchang

- Evidence of Grammatical stress (Duanmu 2007):
  
  (2) [Verb Noun]  
  ‘plant’ ‘garlic’  
  (a) zhong-zhi da-suan  
  (b) zhong da-suan  
  (c) zhong suan  
  *(d) zhong-zhi suan

  (3) [Noun Noun]  
  ‘coal’ ‘store’  
  (a) mei-tan shang-dian  
  (b) mei-tan dian  
  (c) mei dian  
  *(d) mei shang-dian

In VN, $\sigma + \sigma \sigma$ ok, $^*\sigma\sigma + \sigma$
In NN, $\sigma\sigma + \sigma$ ok, $^*\sigma + \sigma\sigma$

- Grammatical stress in Nanchang
  
  Verb+Noun (VN): grammatical stress on $\sigma_2$
  
  Noun+Noun (NN): grammatical stress on $\sigma_1$
Lexical stress (full syllable vs. light syllable) in Nanchang

(1a) `toŋ42 `ɕi42
  东西
  east west
  ‘east west’

(1b) `toŋ42 ɕi42
  东西
  east west
  ‘thing’

- Full syllable: lexically stressed syllable
- Light syllable: lexically stressless syllable
Acoustic study of durational correlates of lexical stress and grammatical stress in Mandarin Chinese

- Light syllables are much shorter than full syllables. (Chen & Xu 2006).

- Rhyme duration of N in [V N] disyllabic phrases was found significantly longer than N in non-[V N] phrases (Lai et al 2010).
Relation between rhyme duration and distribution of tonal contrasts

- Cross-linguistically, the licensing of contour tones is closely related to the rhyme duration of syllables (Zhang 2002)
Hypothesis

- If stress (e.g., lexical stress or grammatical stress) has durational correlates, then the distribution of tonal contrasts is expected to be affected by the stress status of a syllable.
Research questions

- Does lexical stress in Nanchang have durational correlates?
- Does grammatical stress in Nanchang have durational correlates?
- Does tonal neutralization occur in lexically stressless syllables or lexically stressed but grammatically stressless syllables?
- If tonal neutralization occurred in a certain type of syllables acoustically, will such tonal neutralization be mapped onto native Nanchang speakers’ perception?
Layout of the current study

- Production study:
  - **Experiment 1**: Acoustic study of durational property of lexical stress and grammatical stress.
  - **Experiment 2**: Acoustic study of tonal contrasts in syllables with different stresses that have durational correlates.

- Perception study:
  - **Experiment 3**: Discrimination experiment to test whether native Nanchang speakers can distinguish underlying tones in syllables that are found to have shorter rhyme duration.
Experiment 1: Durational study of lexical stress and grammatical stress

Stimuli: three types of disyllables:

**VN** ($\sigma_1$ and $\sigma_2$ both bear lexical stress; $\sigma_2$ bears grammatical stress but $\sigma_1$ doesn’t) (e.g., 洗车)

**NN** ($\sigma_1$ and $\sigma_2$ both bear lexical stress; $\sigma_1$ bears grammatical stress but $\sigma_2$ doesn’t) (e.g., 货车)

**Lexically stressless (LS)** ($\sigma_1$ is lexically stressed while $\sigma_2$ is lexically stressless; neither syllables bears grammatical stress) (e.g., 哑巴)
Stress status of different syntactic structures

<table>
<thead>
<tr>
<th>Target syllable: $\sigma_2$</th>
<th>Lexical stress</th>
<th>Grammatical stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>VN</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>NN</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>LS</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Rhymes of the target syllables were controlled.
Mean rhyme durations of the second syllables in [VN], [NN], and LS.

Effect size (lexical stress) > Effect size (grammatical stress)

Lexical stress has more robust durational correlate than grammatical stress.
Experiment 2: Tonal contrast study in *lexically stressless* and *lexically stressed but grammatically stressless* syllables

- 21 word pairs ($\sigma_2$: lexically stressless vs. lexically stressed but grammatically stressless).

<table>
<thead>
<tr>
<th>Underlying tone in $\sigma_2$: Tone 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexically stressless 2$^{nd}$ syllable</td>
</tr>
<tr>
<td>冤家 yon42 ka42</td>
</tr>
<tr>
<td>亲家 t?in42 ka 42</td>
</tr>
</tbody>
</table>
Average f0 tracks of five underlying tones in lexically stressless syllables

Tone 42, 45 and 21 are neutralized whereas tone 24 and 213 are neutralized in terms of average f0 and tone shape.
Average f0 tracks of five underlying tones in lexically stressed but grammatically stressless syllables

Five lexical tones are different from each other in terms of average f0 and tone shape.
Summary of production study

- Both lexical stress and grammatical stress in Nanchang have durational correlates.

- Tonal contrasts are affected by lexical stress which has more robust durational correlates:
  - In lexically stressless syllables: 5 tonal contrasts reduced to 2.
  - In lexically stressed but grammatically stressless syllables: 5 tonal contrasts.

- It suggests that the rhyme duration of lexically stressed syllables is the baseline for carrying full set of tonal contrasts.
Experiment 3: Perception study of tonal neutralization in Nanchang

- Does the tonal neutralization pattern in the production map onto perception?

- Can native Nanchang speakers still tell tone 42, 21 and 45 apart in lexically stressless syllables? Can they tell tone 213 and 24 apart in lexically stressless syllables?
Stimuli used for perception study

- Word list design: 26 lexically stressless word pairs where $\sigma_2$ in both words are segmentally identical but with different underlying tones.

\[
\text{pa42 tsoŋ0 (213) vs. ka45 tsoŋ0 (42)}
\]

巴掌 'slap'  嫁妆 'dowry'

- The reason not to use minimal pairs: it's extremely difficult to find minimal pairs where $\sigma_2$ are lexically stressless.
Tonal discrimination task: ABX paradigm

- ABX: Word pairs in which $\sigma^2$ are both lexically stressless but with different underlying tones were played to the subjects and then the $\sigma^2$ either from word A or from word B was played to the subjects. Task: tell whether the monosyllable is from A or B.

- 12 native speakers of Nanchang participated in the discrimination experiment.
### Accuracy rates for different tonal contrasts.

<table>
<thead>
<tr>
<th>Tones of syll2 (lexically stressless) in word-2</th>
<th>42</th>
<th>45</th>
<th>21</th>
<th>24</th>
<th>213</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tones of syll2 (lexically stressless) in word-1</td>
<td></td>
<td></td>
<td>----</td>
<td>----</td>
<td>-----</td>
</tr>
<tr>
<td>42</td>
<td>58.3% (7 pairs)</td>
<td>66.7% (6 pairs)</td>
<td></td>
<td>79.5% (2 pairs)</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>50.3% (3 pairs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td>83% (1 pair)</td>
<td>50.0% (1 pair)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.8% (6 pairs)</td>
</tr>
<tr>
<td>213</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The number of word pairs that can be distinguished by native Nanchang listeners for different tonal contrasts.

Distinguishable word pair: at least 10 out of 12 speakers discriminated the word pair correctly, \( P(\chi^2) < .05 \)

<table>
<thead>
<tr>
<th>Tones of syll2 (lexically stressless) in word-2</th>
<th>42</th>
<th>45</th>
<th>21</th>
<th>24</th>
<th>213</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tones of syll2 (lexically stressless) in word-1</td>
<td>42</td>
<td>(0/7)</td>
<td>(2/6)</td>
<td></td>
<td>(1/2)</td>
</tr>
<tr>
<td>45</td>
<td></td>
<td>(0/3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td>(1/1)</td>
<td>(0/1)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3/6)</td>
</tr>
<tr>
<td>213</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Account for the mismatch between production and perception regarding tonal neutralization

- The production shows that the phonological context [-stress] causes different underlying tones to be merged—across the board effect (Levelt et al 1999).

- However, the production is an aggregate result: pitch averaged across 10 speakers and 4 words for each underlying tone on the lexically stressless syllables.
Account for the mismatch between production and perception regarding tonal neutralization

- The pitch of a particular underlying tone in a handful lexically stressless syllables in the production showed deviance from the averaged pitch.
**Word specific effect**

- The tonal neutralization pattern cannot be completely determined by [-stress] context in the production. The tonal reduction in certain words was realized differently from others.

- Similarly, certain lexically stressless words used for the perception study may have different acoustic properties from the rest of the words, thus, causing some words to be discriminated more easily than others.
Word specific effect in Nanchang

- Word specific effect can be realized through the following factors (Pierrehumbert 2002):
  - Word frequency
  - Contextual predictability
  - Pragmatics
  - Social class
  - Gender

- Word specific effect may explain why there is not a consistent tonal neutralization pattern in production and perception.
Conclusion

- Rhyme duration is correlated to tonal contrast reduction.

- In both production and perception, tonal neutralization occurred in lexically stressless syllables.

- The detailed mechanism of tonal reduction is not only affected by phonological feature such as [stress], but also influenced by other linguistic factors due to word specific effects.
Thank you