Perceptual Tone Spaces and Taiwan Min Sandhi Rules

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Taiwan Min Sandhi Rules

- **Sandhi rules**
  - **13 → 33 ← 55 5**
    ↓ ↑ ↑↓
    31 → 53 3
- **Sandhi domain**
  - /lɔ/ in juncture form: / pe^{55} $ts^{h}ai^{31}$ $lɔ^{53}$ / [pe^{33} $ts^{h}ai^{53}$ $lɔ^{53}$] "Cabbage Stew"
  - /lɔ/ in sandhi form: / $lɔ^{53}$ pe^{55} $ts^{h}ai^{31}$/ [$lɔ^{55}$ pe^{33} $ts^{h}ai^{31}$] "Stew Cabbage"
- **Sandhi rules relate tones with acoustical similarities**
- **Goal: Psychological reality of Min sandhi chain**

Allophonic alternation & tone perception

- **Tone Sandhi Rule**
  - **GANDOUR, J. (1983)**
    - **Cantonese: 53 → 55**
    - **Mandarin: 214 → 35**
  - **HUANG, T. (2004)**
    - **Rugao Mandarin : no sandhi rule**
    - **Beijing Mandarin : 214 → 35**
  - **Min sandhi chain in perceptual tone spaces**

Factors Influencing Speech Perception

- **1. Properties of auditory system**
  - **Speech vs. non-speech stimuli**
- **2. Phonological inventory**
  - **Pitch accent language vs. tone language listeners**
- **3. Allophonic variation**
  - **No sandhi rule vs. different sandhi rule vs. sandhi rule.**
    - » **Johnson, K., Babel, M. (2010)**

Experimental Design

- **Independent variables**
  - **Stimuli types**
  - **language backgrounds**
- **Dependent variables**
  - **Error rates**
  - **Tone distributed in a loop pattern resembling Min sandhi chain**

Method :Listeners

- **13 Swedish listeners : pitch accent language**
  - **Exposure to different lexical tones, accent I and II**
  - **No exposure to tone sandhi rules**
- **10 Taiwan Mandarin listeners : tone language**
  - **Exposure to different lexical tones**
  - **Exposure to different tone sandhi rules**
  - **Exposure to mutually unintelligible Taiwan Min**
- **14 Taiwan Min listeners: tone language**
  - **Exposure to Min lexical tones**
  - **Exposure to Min sandhi chain**
  - **Speak Mandarin**

Method: Stimuli /kun/

- **Juncture Tones**
  - **surname: /a 55 kun 55/ [a33 kun55]**
- **Sandhi Tones**
  - **/kun53 tsui 53/ [kun 55 tsui 53] “boiled water”滾水**
- **Citation tones**
  - **[kun 55] “man” 君**
- **Hummed Tone**
  - **Pitch information extracted from citation form and resynthesized into hummed tones.**

Method: Stimuli (2)

- **AX tonal pairs in 5 sessions**
  - **Juncture tone vs. Juncture tone**
  - **Sandhi tone vs. Sandhi tone**
  - **Juncture tone vs. Sandhi tone ; Sandhi tone vs. Juncture tone**
  - **Citation tone vs. Citation tone**
  - **Hummed tone vs. Hummed one**

- **2646 tonal pairs = (7 tones × 3 repetitions) * (7 tones × 3 repetitions) × 6 tonal pairs**

- **InterStimuli Intervals: 400 ms**

- **Randomized tone pair orders and tone sessions**

Method: Procedure

- **Listen to AX stimuli pair**
- **Click on “same” or “different” buttons**
- **Response time displayed for 1000 ms**
- **If listeners failed to click, then maximal 4000 ms response time displayed.**

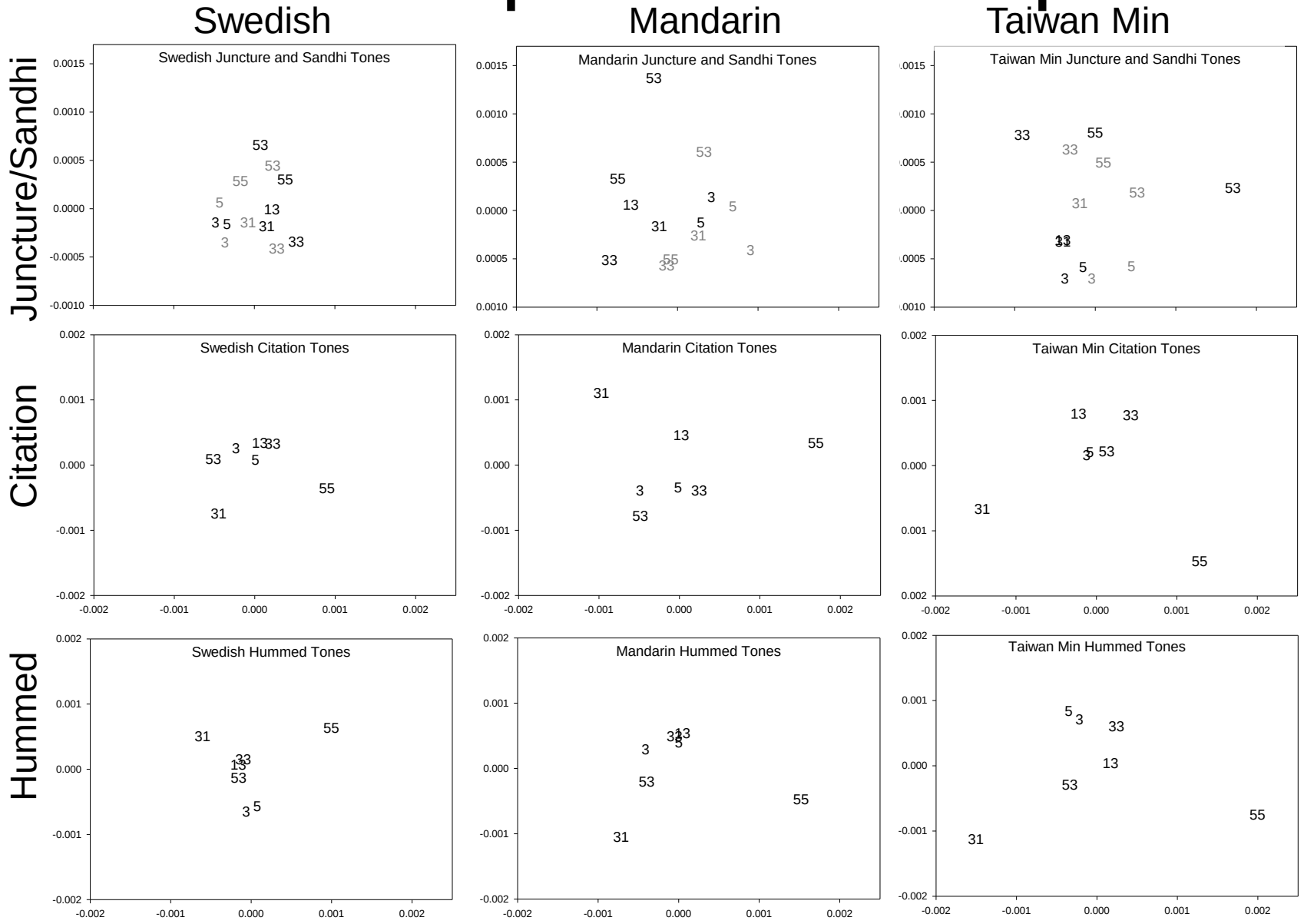
Method: Data Analysis

- **True responses:**
  - **“same” to same surface tones**
  - **“different” to different surface tones**
- **Reciprocal of response times -> perceptual distances between tonal pairs**
  - **Multidimensional scaling analysis (MDS)**
    - **Perceptual tonal distribution**

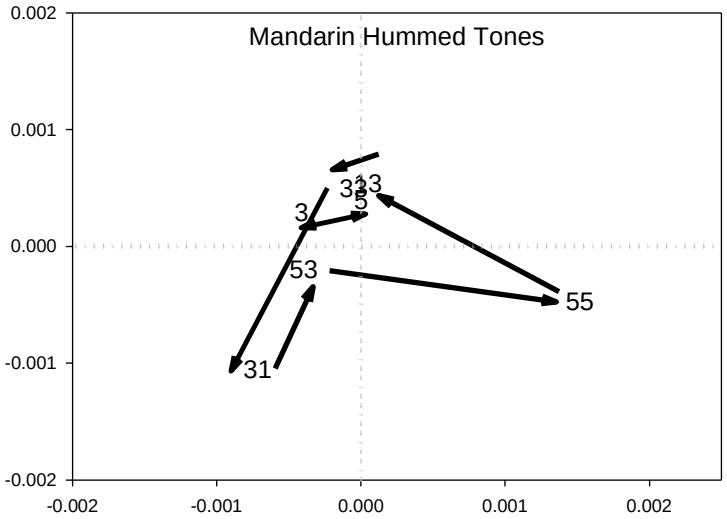
Results: Error Rates 1

- **Language groups****
  - **Swedish > Mandarin > Min**
- **Tonal sessions ****
  - **juncture vs. sandhi > juncture, citation, sandhi, hummed**
- **Language × tonal sessions****
  - **Swedish: hummed, juncture ≤ citation, juncture vs. sandhi, sandhi**
  - **Mandarin: juncture, sandhi, citation < hummed < juncture vs. sandhi**
  - **Min: sandhi, juncture vs. sandhi ≤ juncture, hummed .**

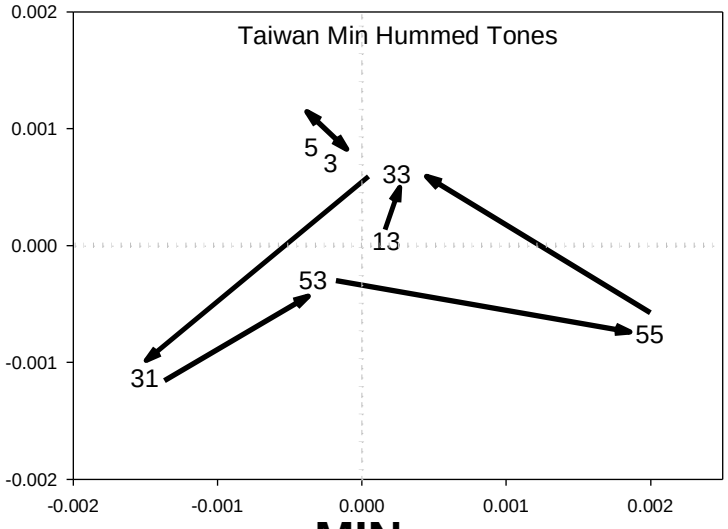
MDS: Perceptual Tonal Space



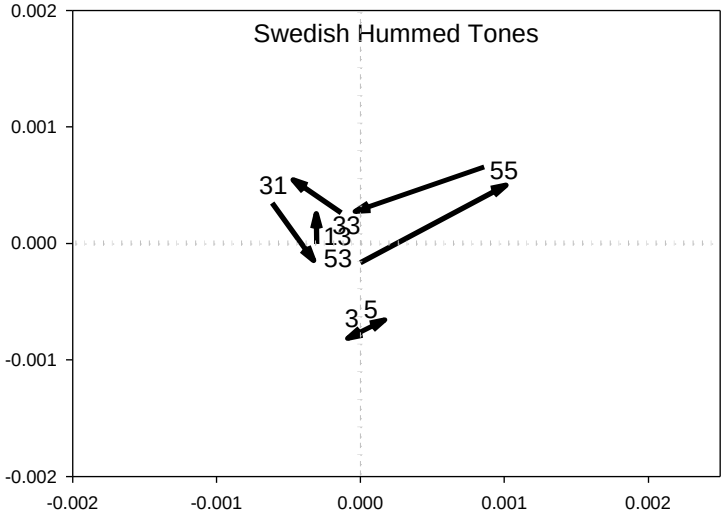
Non-speech Hummed Tones



MANDARIN

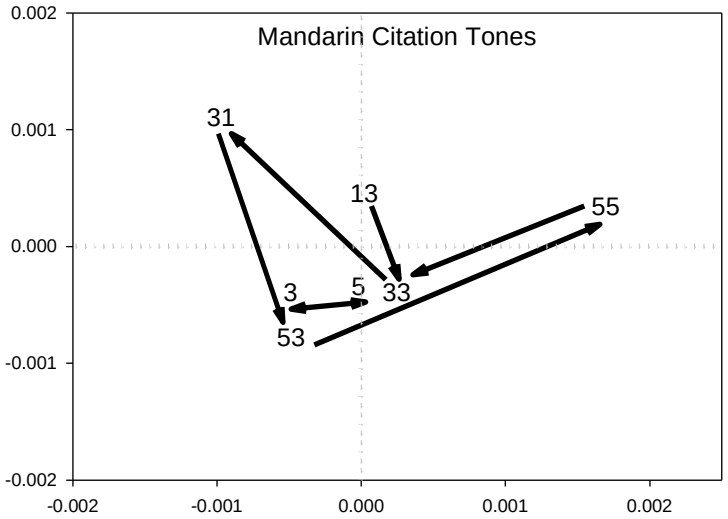


MIN

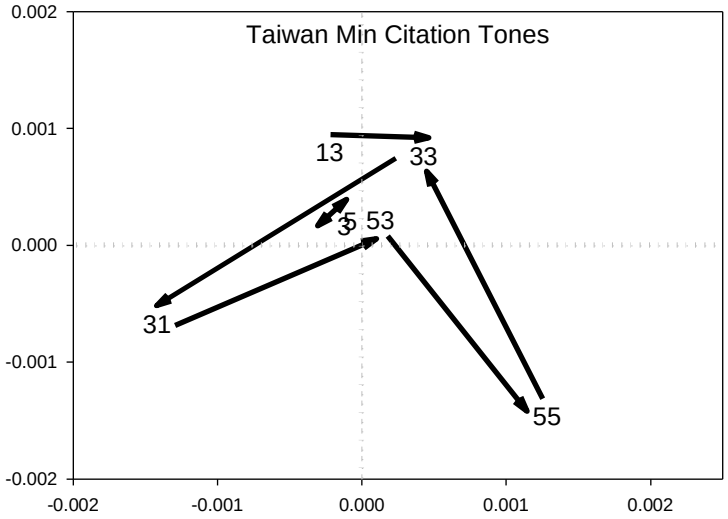


SWEDISH

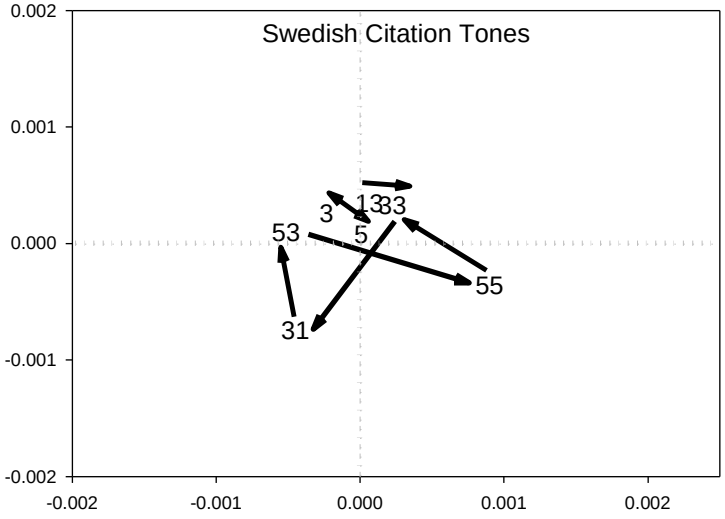
Citation Tones



MANDARIN

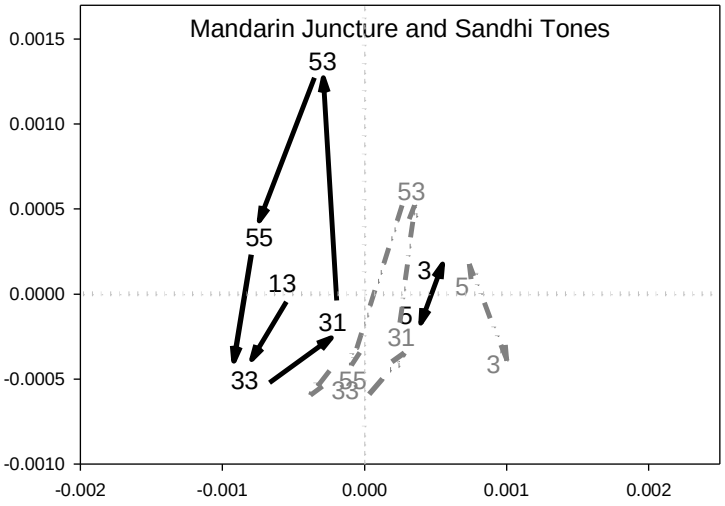


MIN

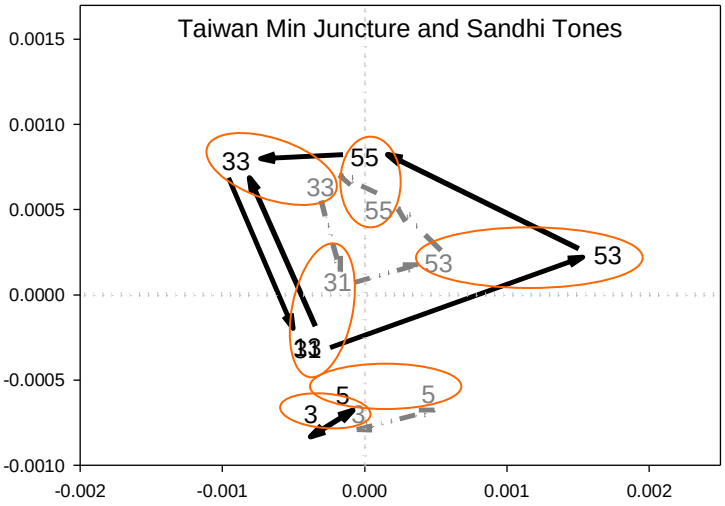


SWEDISH

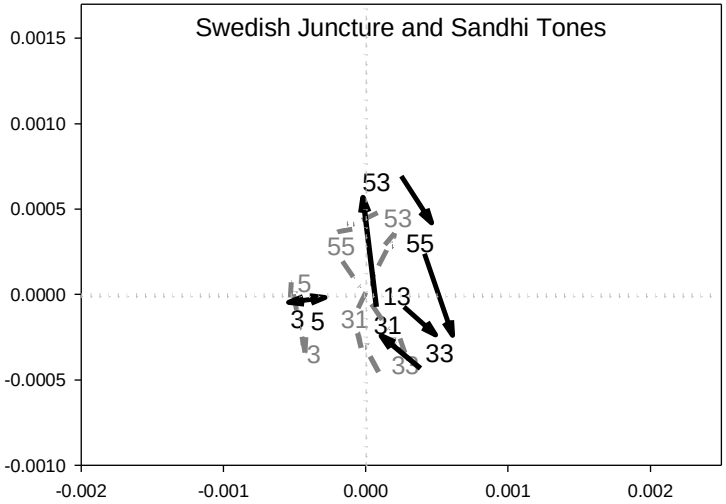
Juncture and Sandhi Tones



MANDARIN



MIN

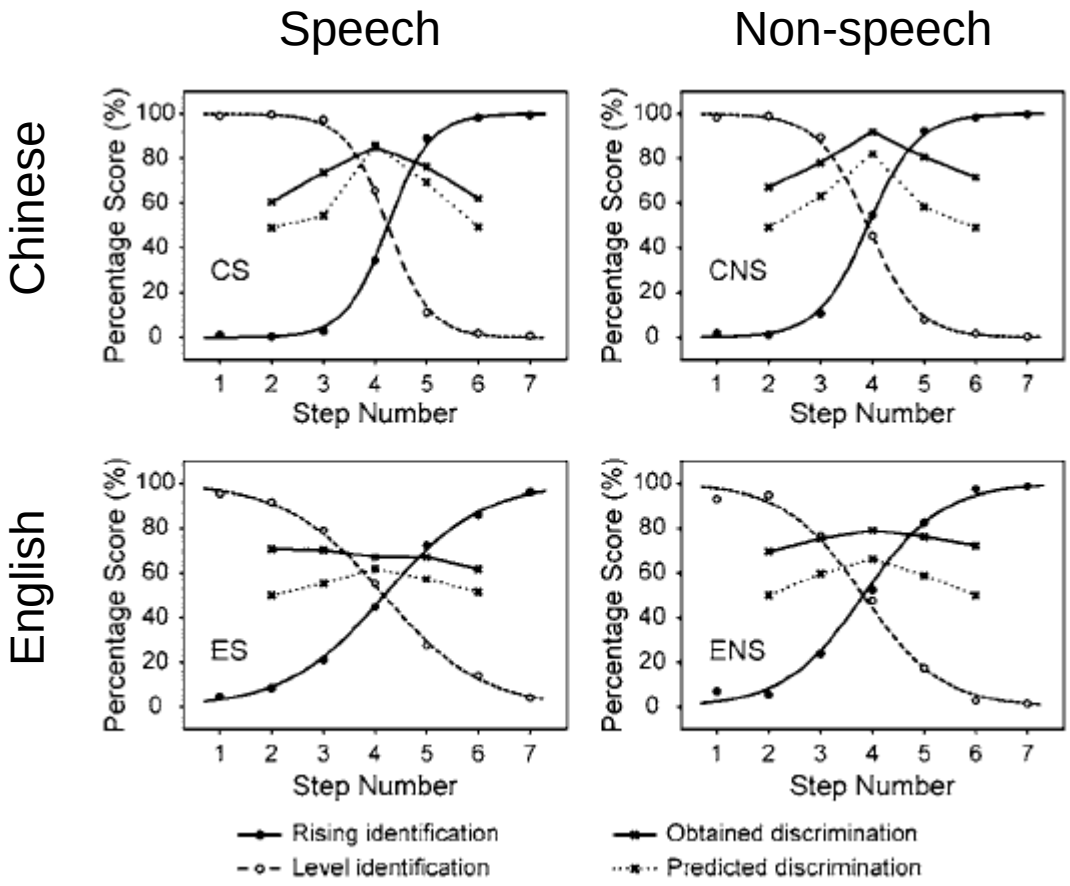


SWEDISH

Discussions: Swedish listeners 1

- **Lowest error rates in hummed tone session**
- **Hummed tones formed a loop that resembles Min sandhi chain.**
- **Swedish listeners' performance in non-speech stimuli was similar to tone language listeners.**
- **However, their performance differs in speech stimuli.**

Discussions: Swedish listeners 2



XU, Y, GANDOUR, J. T., and FRANCIS, A. L. (2006).

Discussions: Taiwan Mandarin

- **Juncture tones formed one loop, sandhi tones formed a different loop.**

- **NO clustering of base tone and sandhi tones**
  - **Unable to undo the phonetic differences between juncture and sandhi tones**
  - **Tones with sandhi relationship not neutralized.**

Discussions: Taiwan Min

- **Two loops for juncture and sandhi tones that resemble Min sandhi chain.**
- **Neutralization of juncture and sandhi tones with same f0 contours.**
- **Taiwan Min sandhi chain is psychologically real.**

Future Study

Investigate resemblance between production and perceptual tone spaces.

- **THANK YOU**
- 多謝

References

-Chen, S.-c. (2009) 台灣閩南元音系統及陰陽入聲調的變化： 台灣各地閩南的字表調查分析[Change in the vowel system and in the Entering Tone of Taiwan Southern Min: A character list analysis of multiple geographical locations]. *Journal of Taiwanese Languages and Literature*, 3, 157 – 178

- Clopper, C. G. and Pierrehumbert, J. B. (2008). Effects of semantic predictability and regional dialect on vowel space reduction. *Journal of Acoustic Society of America*, 124(3), 1682-1688.
- Gandour, J., & Harshman, R. (1978). Cross language differences in tone perception: a multidimensional scaling investigation. *Language and Speech*, 21, 1-33.
- Gandour, J. (1983). Tone perception in Far Eastern languages. *Journal of Phonetics*, 11, 149-175.
- Huang, T. (2004). Language Specificity in Auditory Perception of Chinese Tones. Unpublished Ph.D. dissertation, The Ohio State University.
- Johnson, K., Babel, M. (2010). On the perceptual basis of distinctive features: Evidence from the perception of fricatives by Dutch and English speakers, *Journal of Phonetics*, 38, 127-136.
- Wang, Y., Jongman, A., & Sereno, J.A. (2001). Dichotic perception of Mandarin tones by Chinese and American listeners, *Brain and Language*, 78, 332-348.
- Wang, Y., Behne, D.M., Jongman, A., Sereno, J.A. (2004). The role of linguistic experience in the hemispheric processing of lexical tone. *Applied Psycholinguistics*, 25, 449-466.
- Xu, Y, Gandour, J. T., and Francis, A. L. (2006). Effect of language experience and stimulus complexity on categorical perception of pitch direction, *Journal of Acoustical Society of America*, 120 (2), 1063-1074.