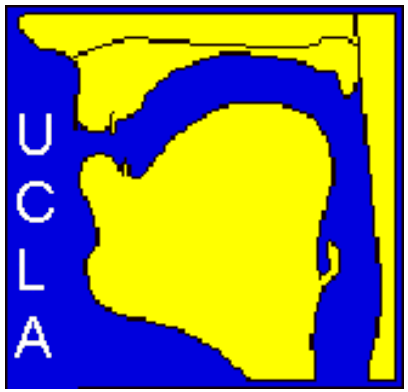
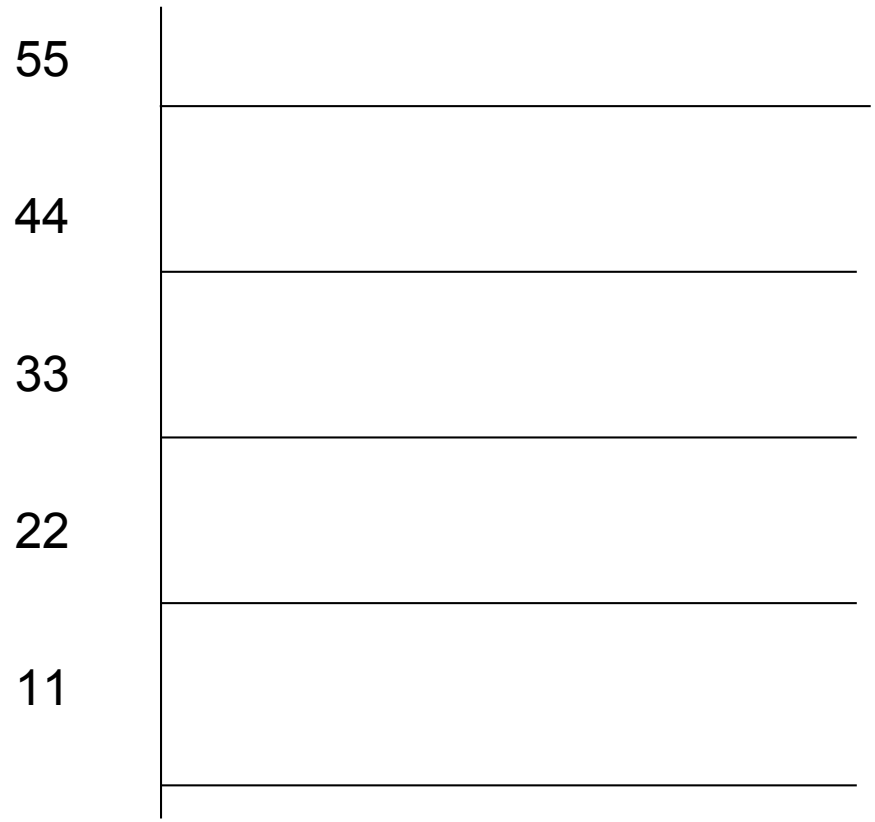
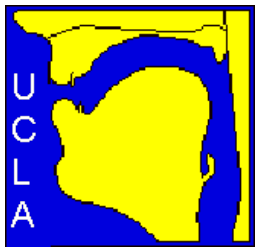


How is a five-level-tone contrast possible?

Jianjing Kuang
UCLA Linguistics Department

Five contrasting pitch levels



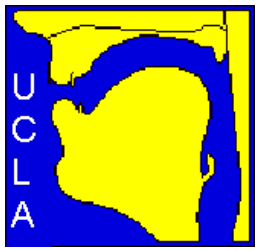


- It's easy to produce more than ten different pitch levels, even for poor singers

- How many contrasting pitch levels can tonal languages have?

Language facts

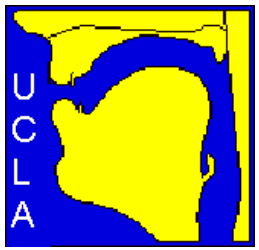
- Usually 1 – 2 level tones
- Less often 3
- Rare 4
- Extremely rare 5



Phonological contrasts should be subject to two principles:

Speakers: easy to produce → the smaller the better

Listeners: easy to hear → the bigger the better

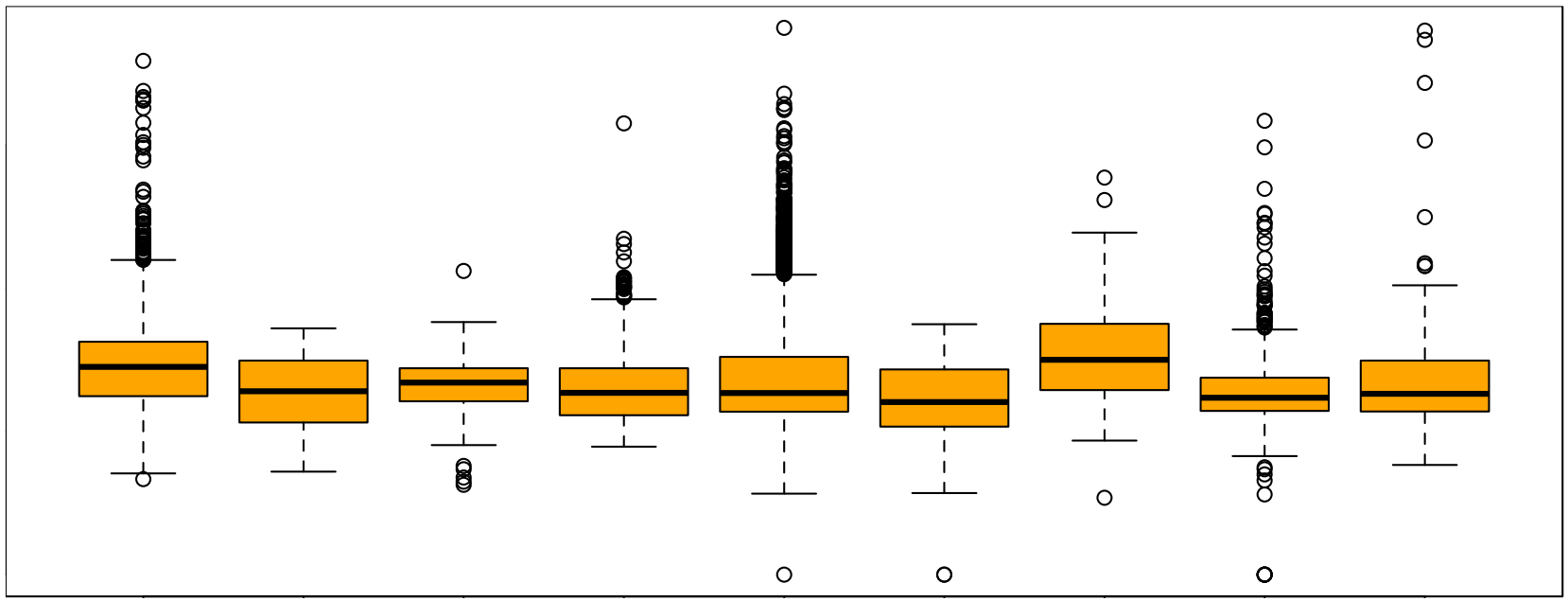


Five-level-tone contrast is very hard to maintain, because…

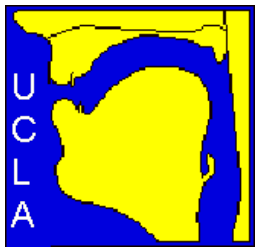
Limitation in production:

- pitch range of normal speech is around 100Hz (Baken and Orlikoff 2000)
- Also see next slide, our data

Pitch range across languages (male speakers)

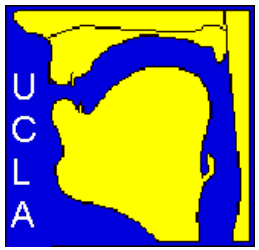


UCLA languages corpus

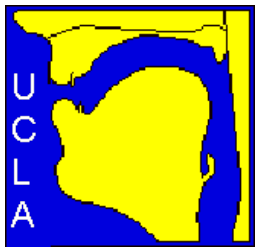


Limitation in perception:

- JND of pitch in lexical tones is about 9Hz (Silverman 2003), but a phonological contrast requires much greater difference
- 20-30Hz difference for a tonal contrast is a small number, e.g. Cantonese 22 and 33 are very confusable and merging (Mok and Wong 2011)

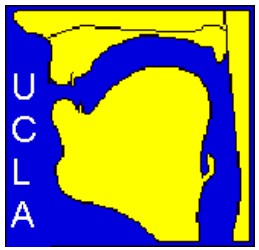


Even a three-level contrast is very hard to maintain in a 100 Hz range, not to mention a fourth or fifth level.



This talk

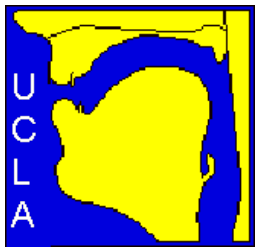
Given normal hearing and speaking ability, how can native speakers produce and hear multiple contrasting level tones?



This talk

Given normal hearing and speaking ability, how can native speakers produce and hear multiple contrasting level tones?

àThe tonal production and perception of a language with five-level-tone contrasts.



This talk

Given normal hearing and speaking ability, how can native speakers produce and hear multiple contrasting level tones?

àThe tonal production and perception of a language with five-level-tone contrasts.

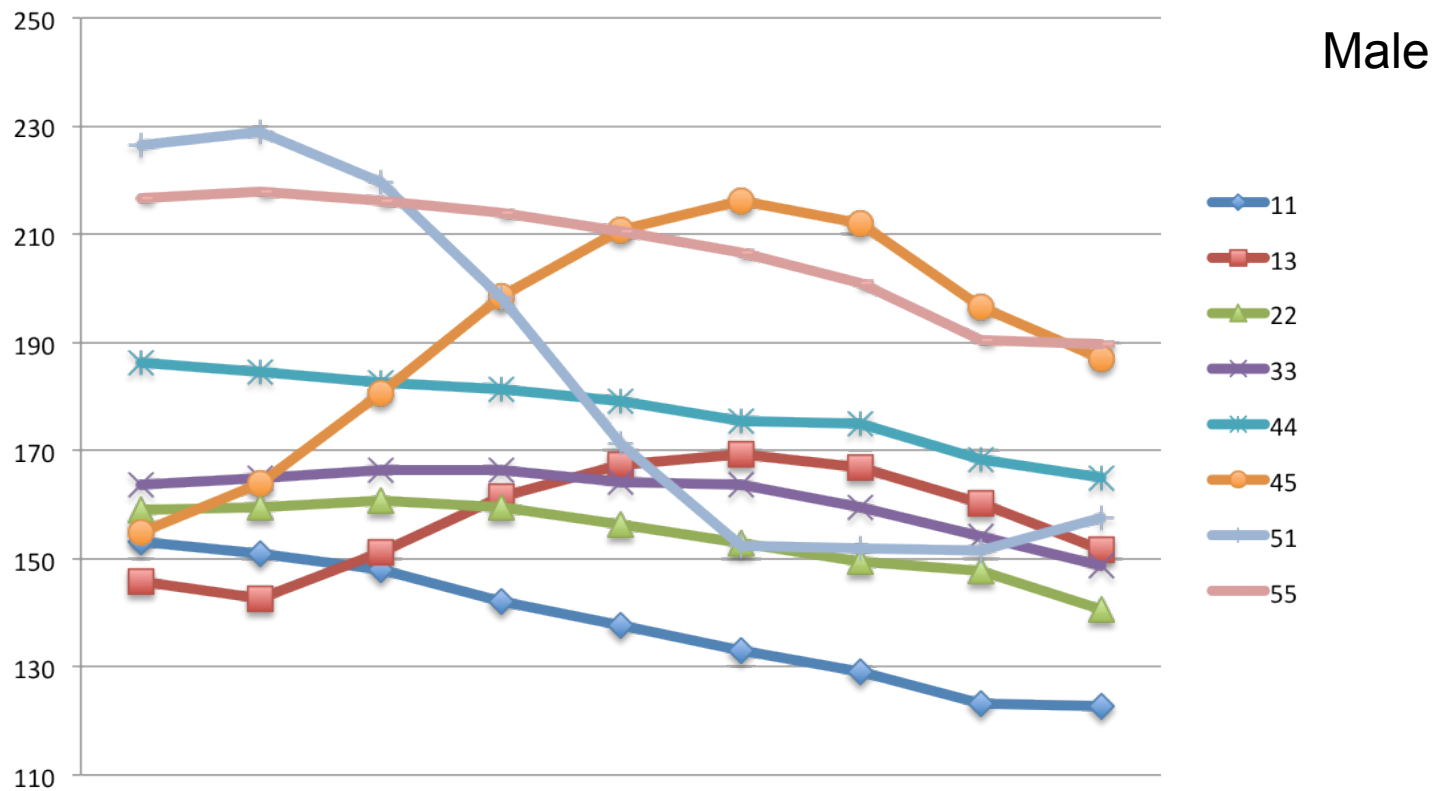
àTonal contrasts are so much more than pitch contrasts. When pitch contrasts get crowded, other cues will be involved to enhance the contrasts.

Black Miao

- Black Miao dialect, called Qingjiang Miao (Ch'ing Chiang Miao). This dialect is spoken at Shidong Kou (Shih-Tung-K'ou), Taijiang (T'ai-Kung) county of Guizhou (Kweichow) province in China.
- Miao languages are unrelated to Sino-Tibetan languages like Chinese.

Tonal system

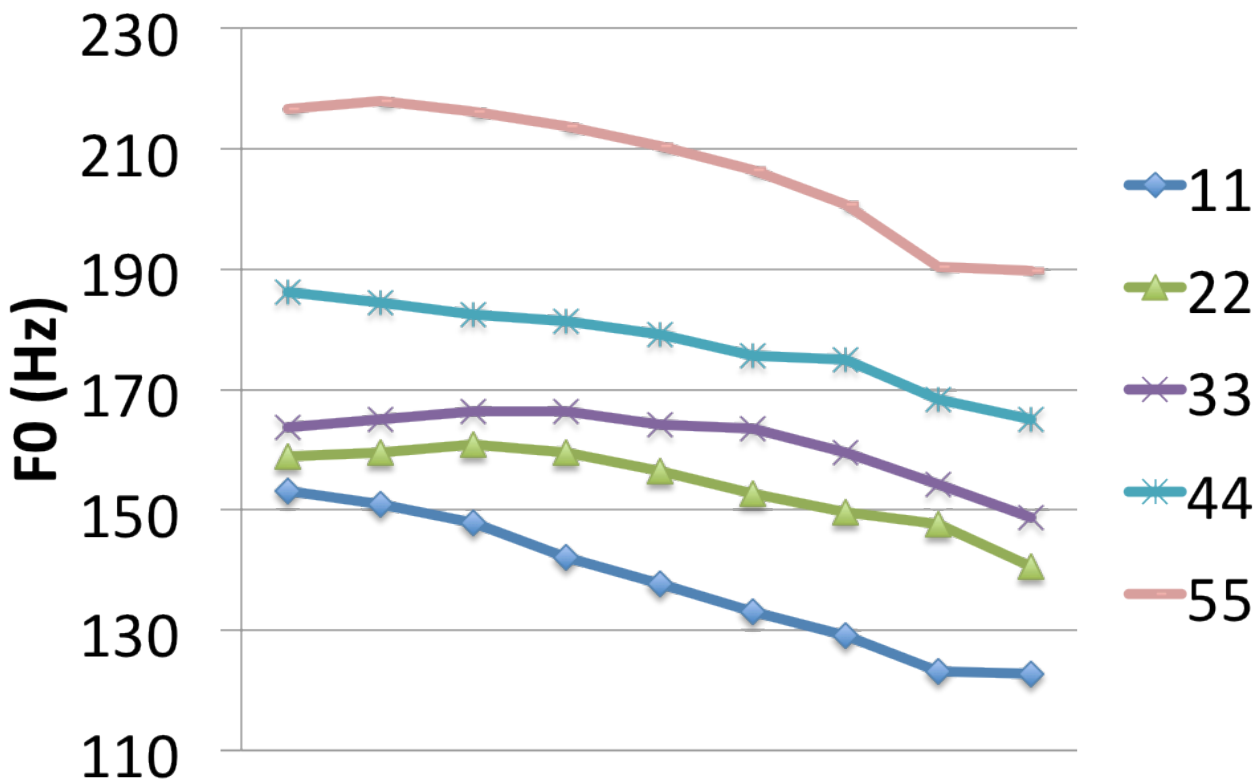
I	II	III	IV	V	VI	VII	VIII
44	51	55	22	45	33	13	11



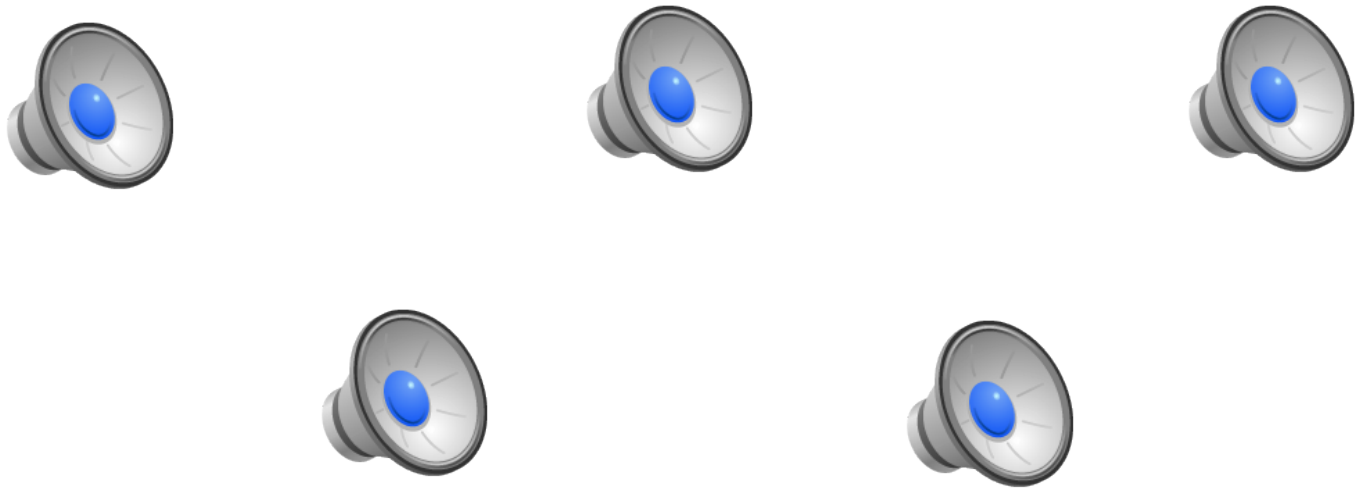
Tonal system

I	II	III	IV	V	VI	VII	VIII
44	51	55	22	45	33	13	11

Male



Five levels



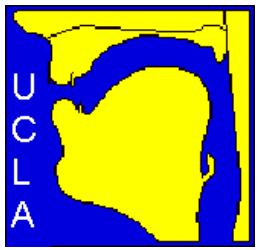
Perception experiment

Stimuli:

- A minimal set of eight real monosyllabic words with [pa]. Produced by a male native speaker.
- /pa55/ "(water) full” 
- /pa44/ "send” 
- /pa33/ "fail” 
- /pa22/ "net” 
- /pa11/ ”pull” 

Procedure

- Familiarity phase: testing words were instructed in proper contexts
- Identification: single audio target; preceded by an audio introduction
- AX discrimination: two audio stimuli (possible pairs among eight tones); measuring RT and accuracy.

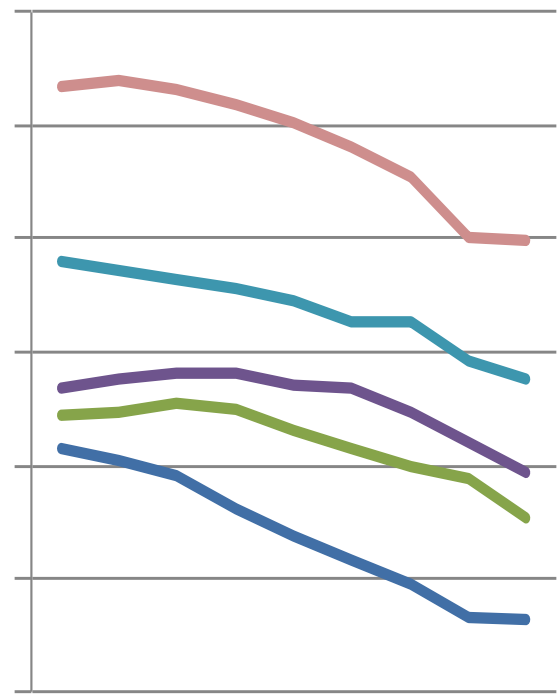


Subjects

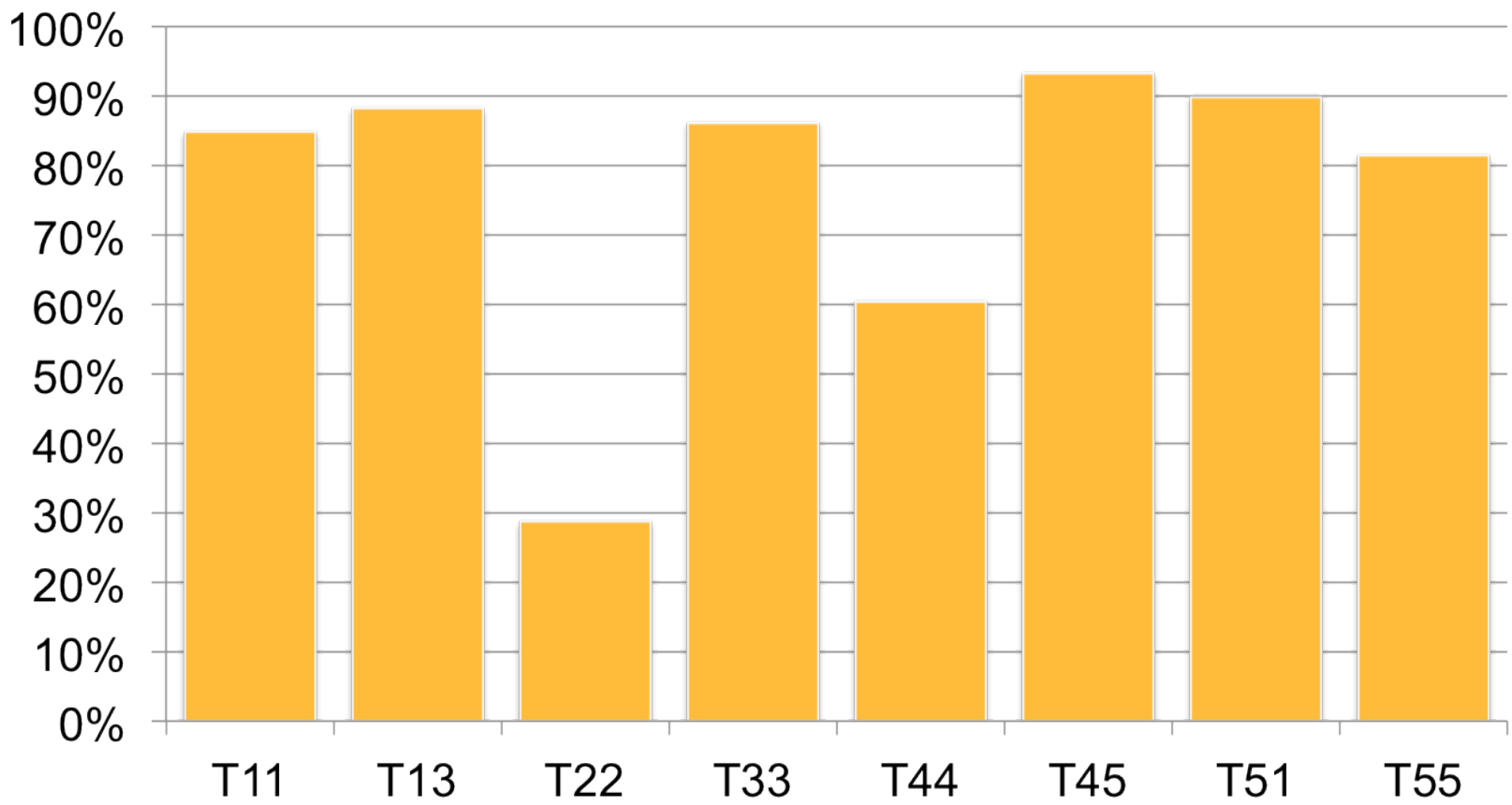
¢A total of 18 subjects, eight males and ten females, participated in this experiment. Four females, who were not native speakers of this particular Black Miao dialect, were excluded from the current analysis, leaving 14 subjects.

Hypotheses

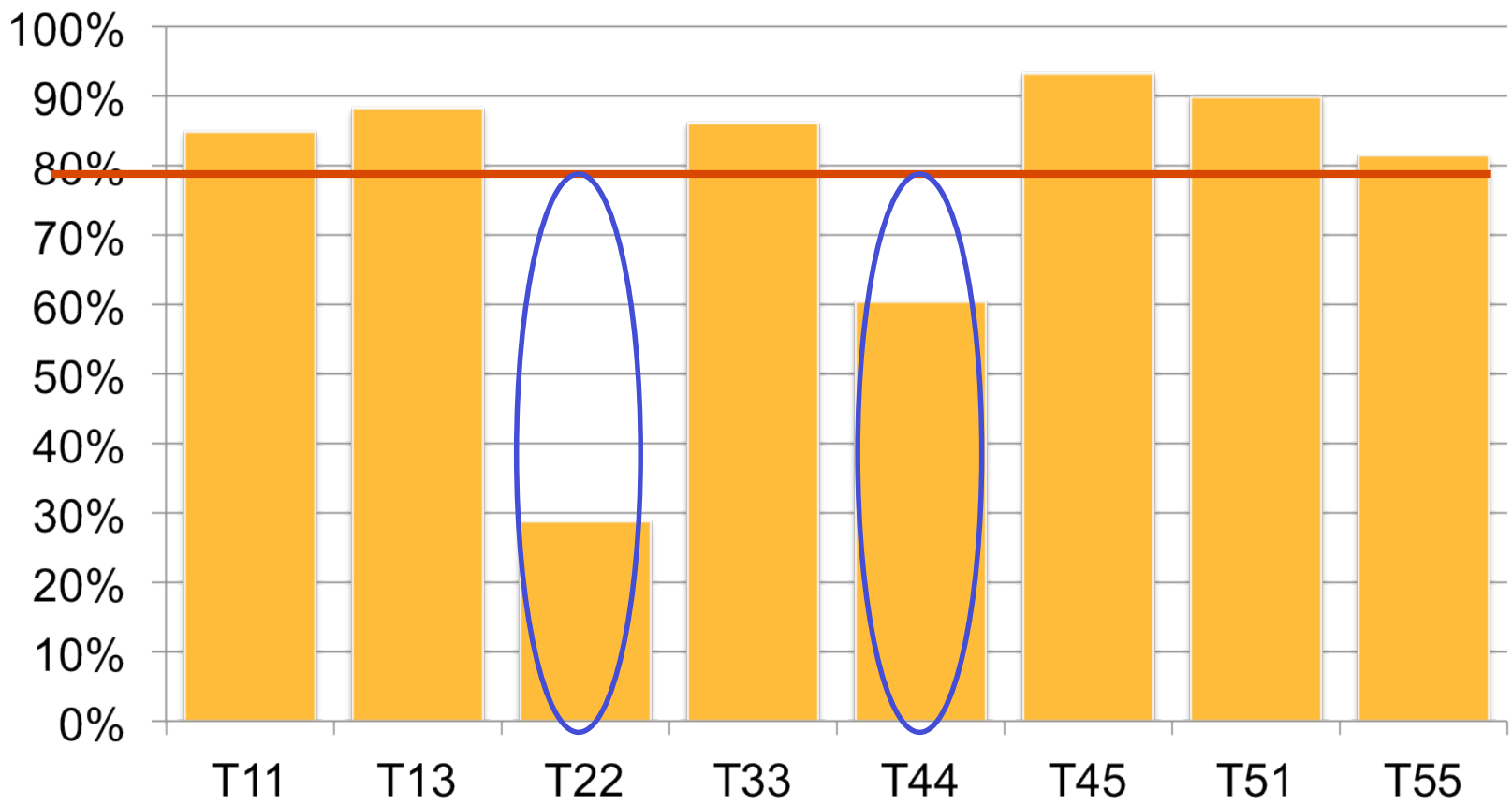
- Tones with adjacent pitch values are in trouble
- If F0 is the only cue, accuracy for 33 should be the worst.



ID Accuracy



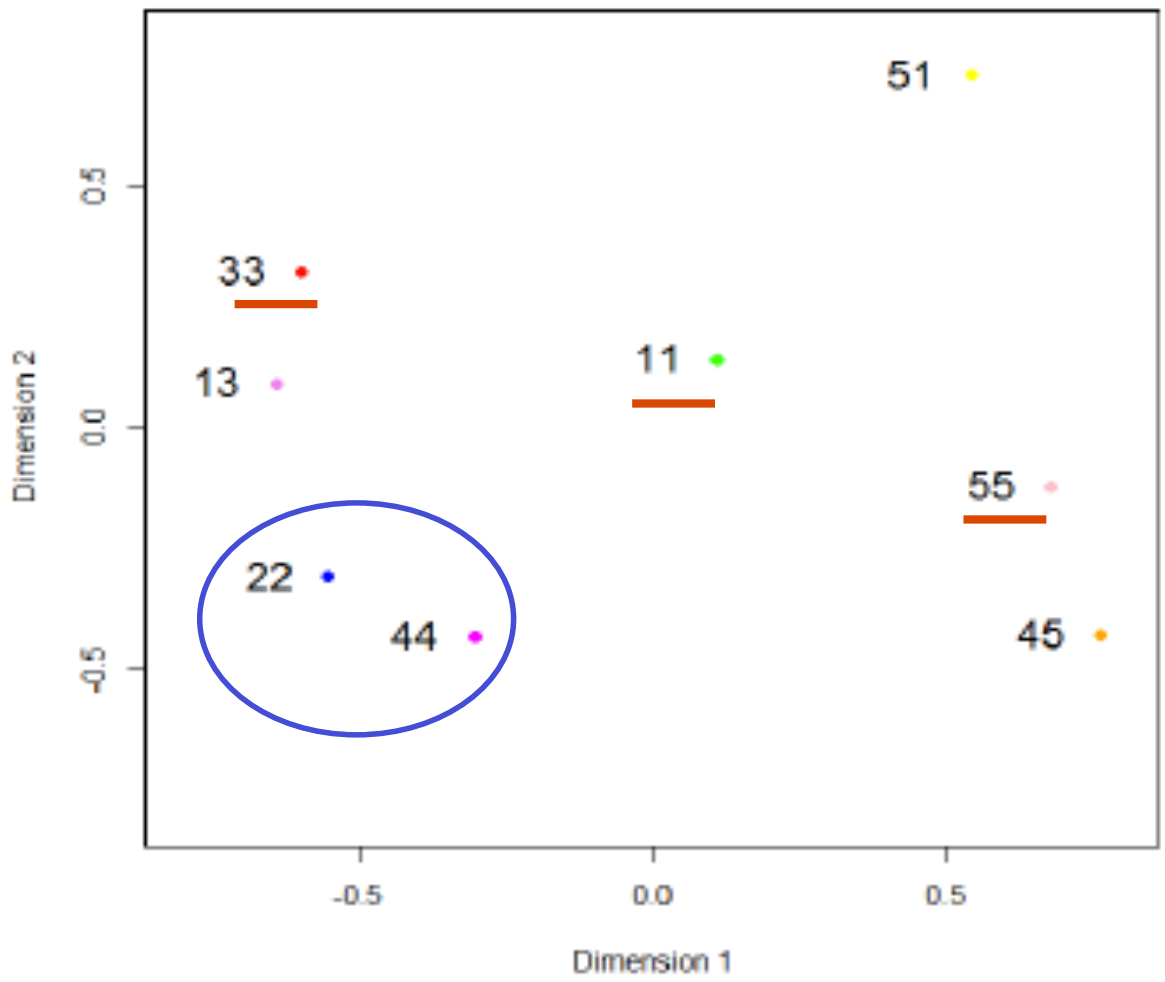
ID Accuracy

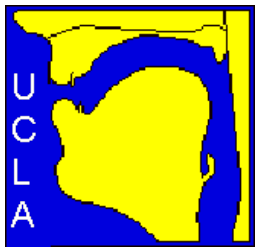


Dissimilarity matrix for all listeners.

	T11	T13	T22	T33	T44	T45	T51	T55
T11	0.05							
T13	0.94	0.00						
T22	0.93	0.88	0.03					
T33	0.97	0.78	0.95	0.05				
T44	0.98	1.00	0.70	0.98	0.03			
T45	0.94	1.00	1.00	1.00	1.00	0.00		
T51	0.94	1.00	1.00	1.00	1.00	1.00	0.00	
T55	0.95	1.00	1.00	1.00	0.92	0.88	0.88	0.00

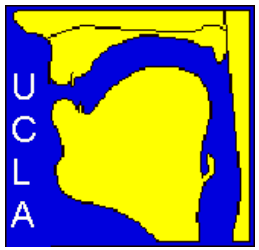
MDS perceptual space





Production experiment

- A wordlist of minimal monosyllabic sets for the eight tones was created based on Li's transcriptions (Kwan1966). 23 minimal or near-minimal sets were confirmed by the speakers.
- Simultaneous EGG and audio recordings were then collected from 15 native speakers (ten males and five females).



Measures

- ¢ Pitch related:

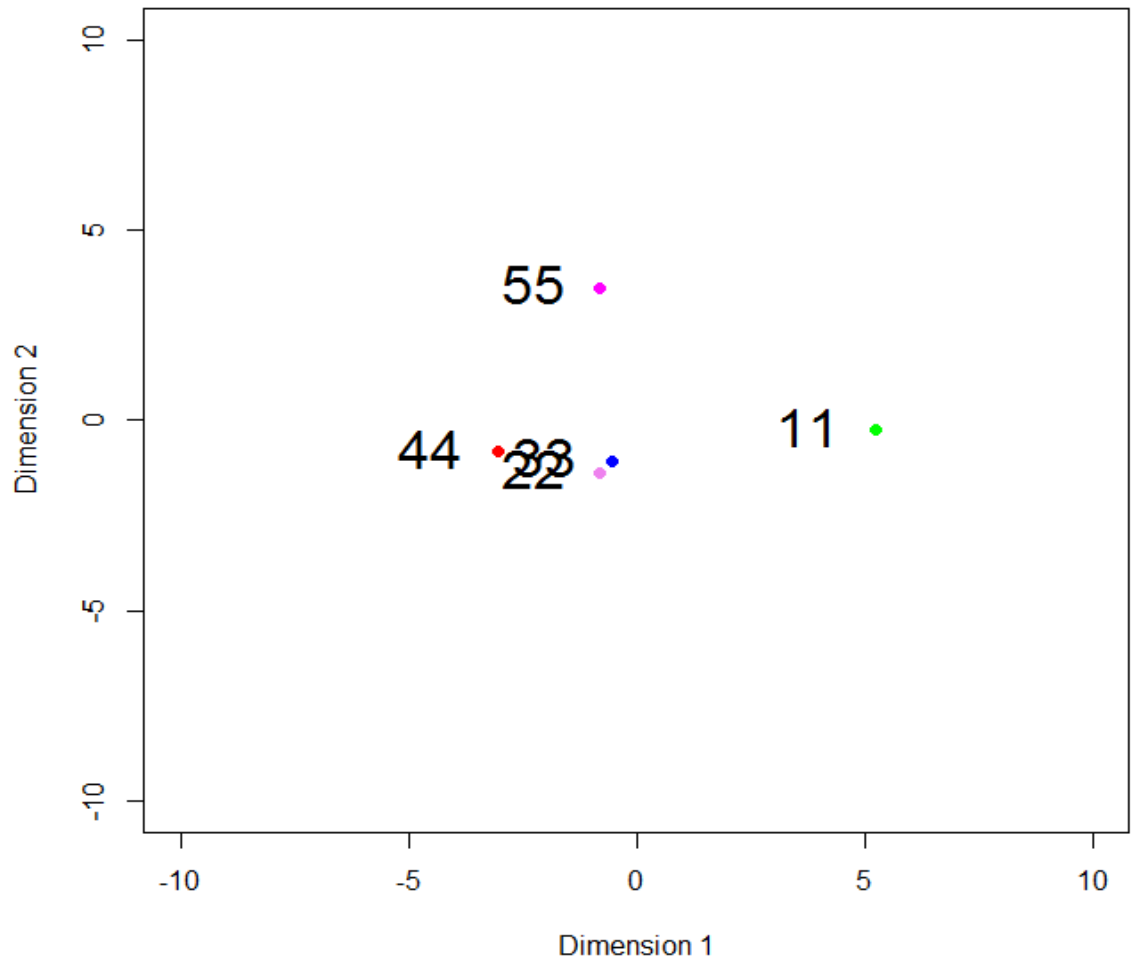
mean F0, F0 change, offset, onset

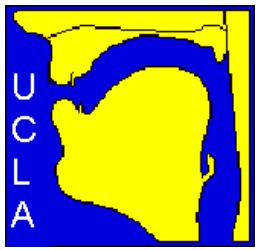
- ¢ Duration
- ¢ Voice quality related (* corrected, Iseli et al 2007):
- Spectral: H1*, H2*, H4*, A1*, A2*, A3*; H1*-H2*/A1*/A2*/A3*;H2*-H4*
- EGG: CQ (contact quotient), SQ (skew quotient), PIC, PDC

MDS Production space

Pitch measures only

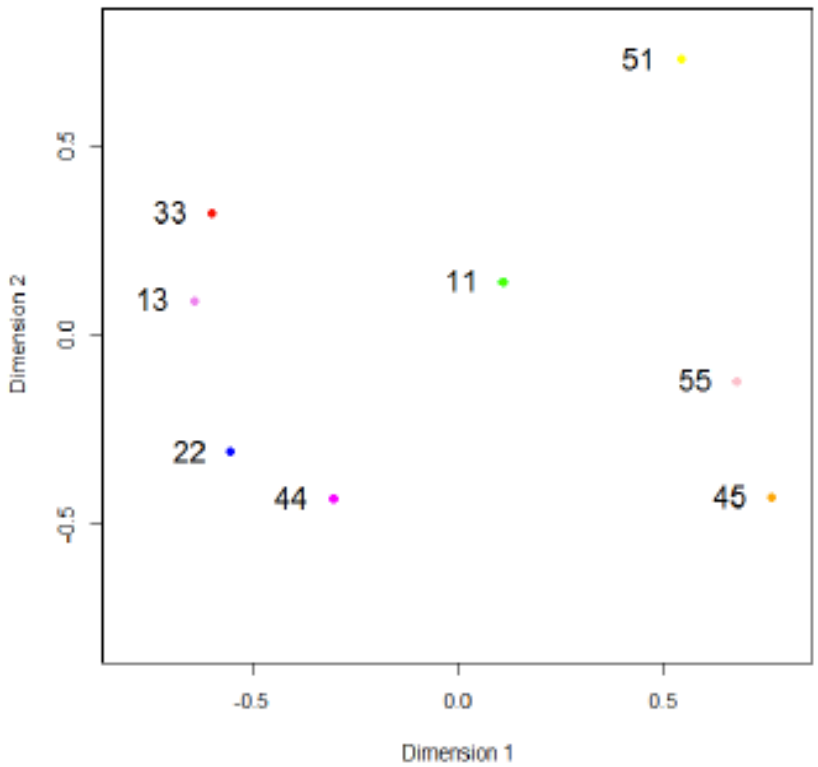
- Mean F0,
- F0 change
- onset
- offset
- duration



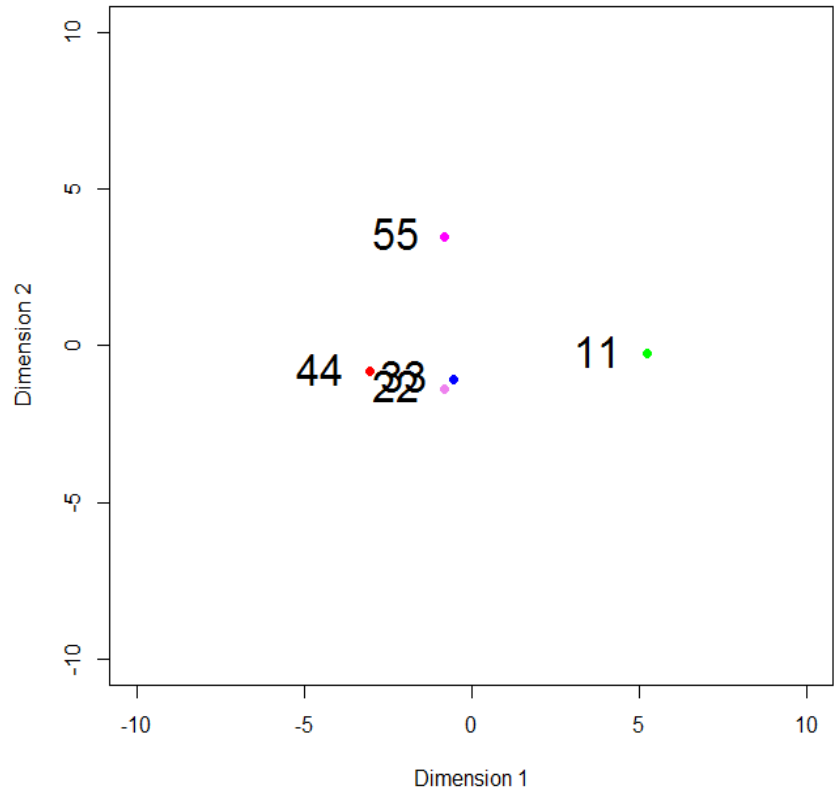


R=0.17

Perceptual space



Production space



MDS Production space

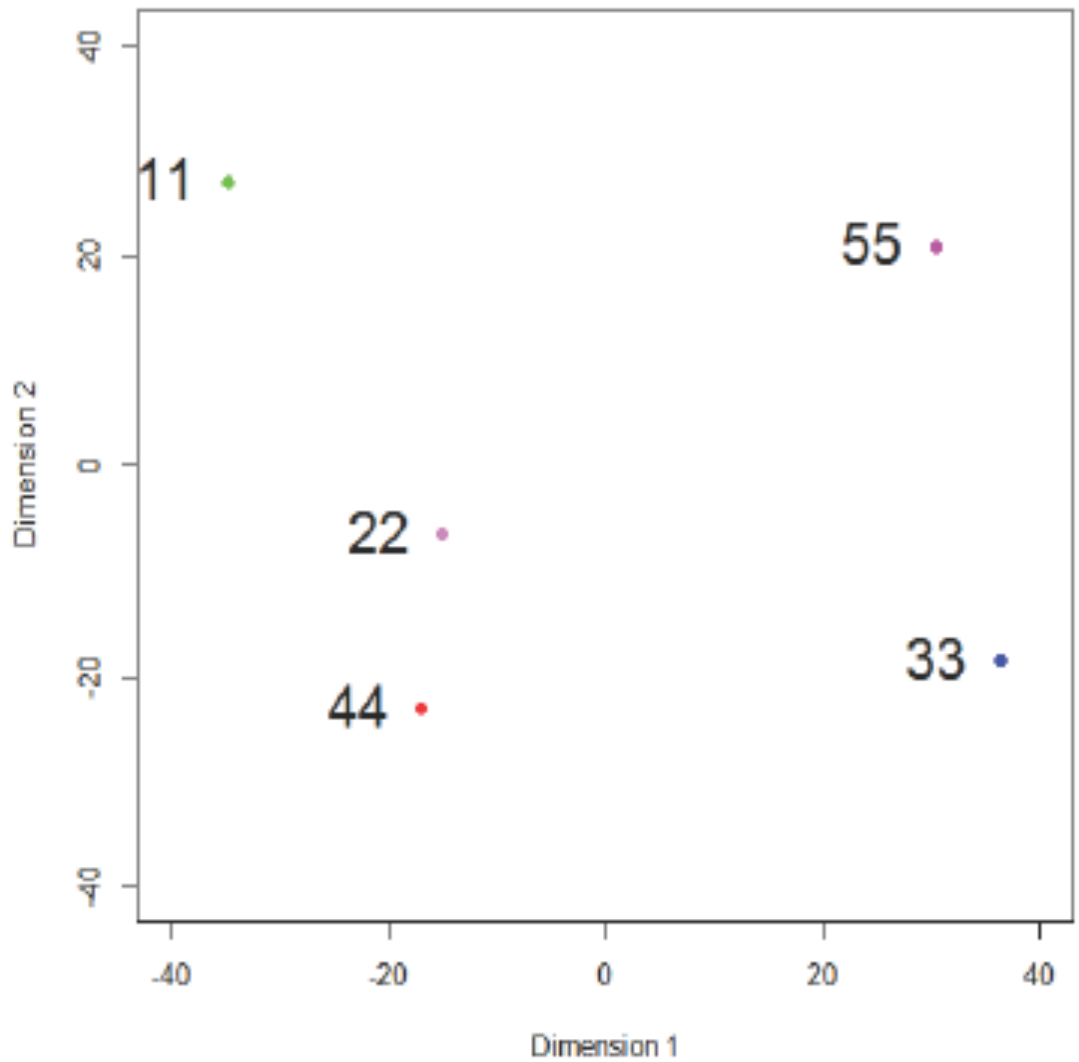
Pitch + voice quality

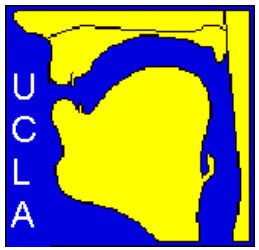
H1*,H2*,H4*

H1*-H2*

H1*-A1*/A2*/A3*

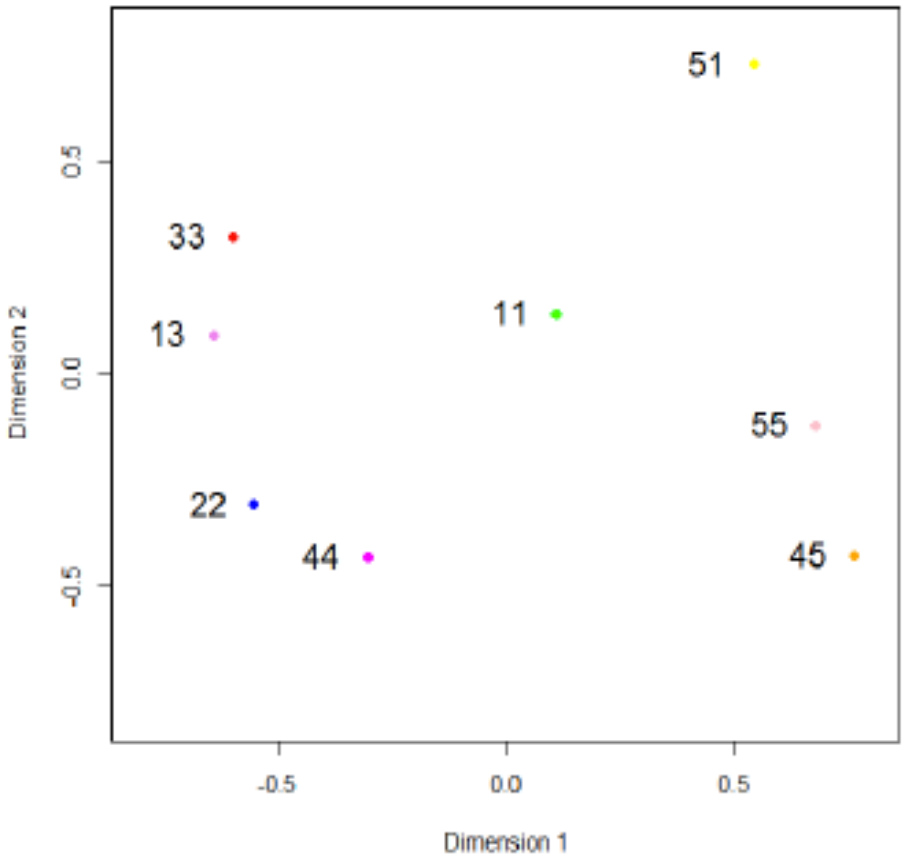
H2*-H4*



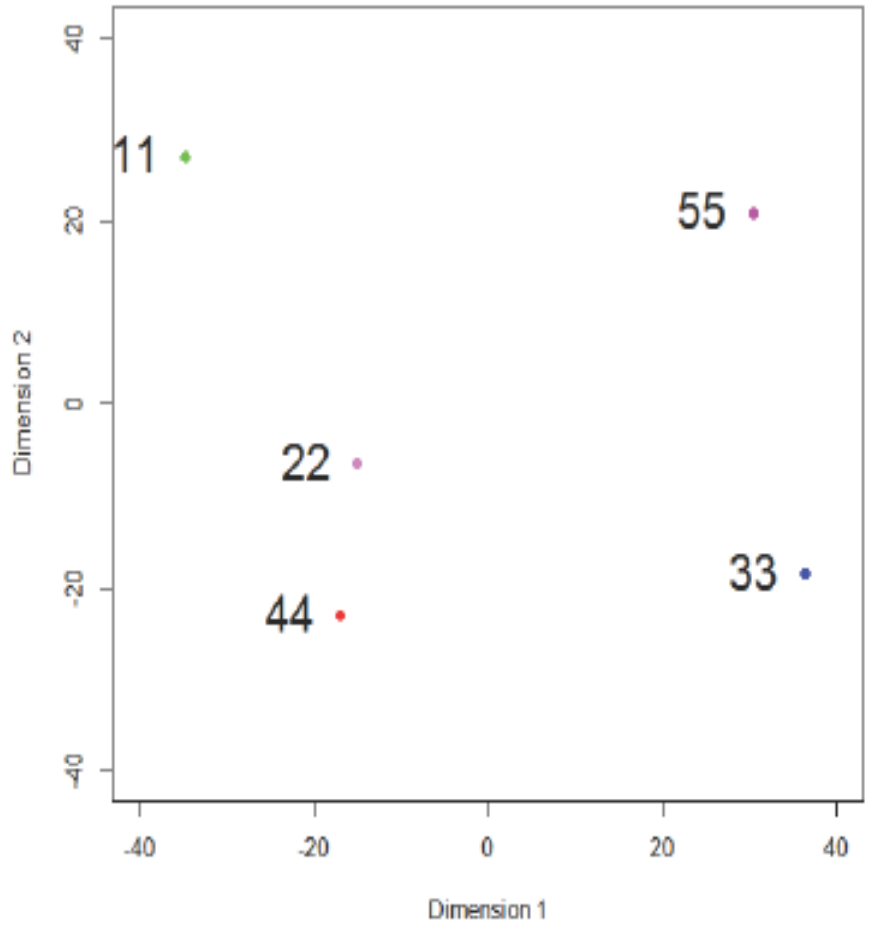


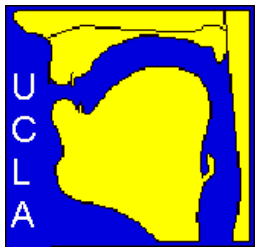
R=0.76

Perceptual space



Production space





Summary

- Tones with similar adjacent pitch values have no trouble:

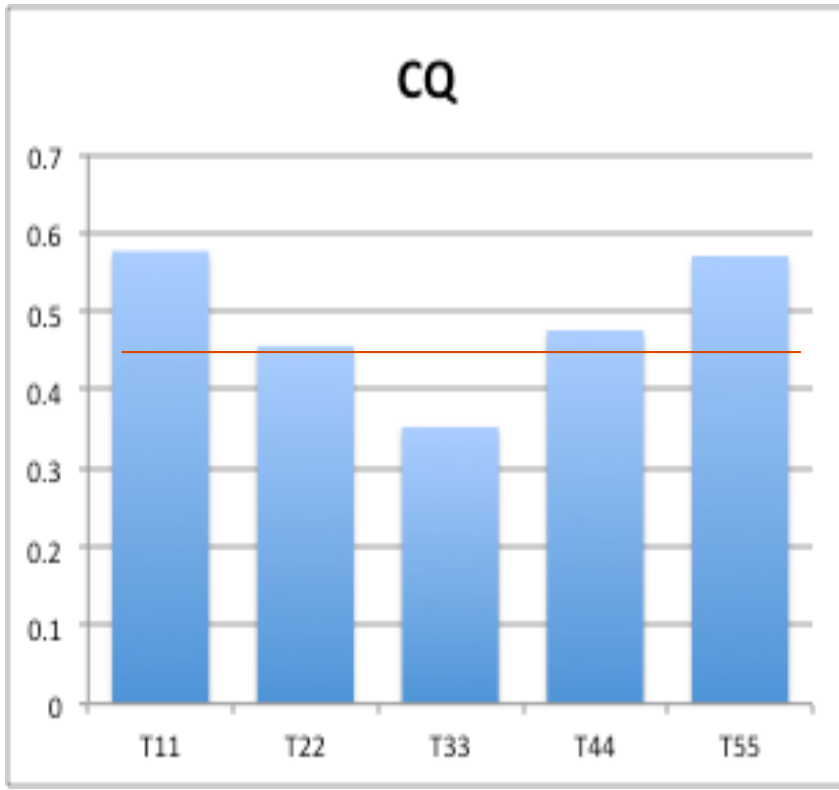
  11 ~ 22 ☺ 22 ~ 33 ☺

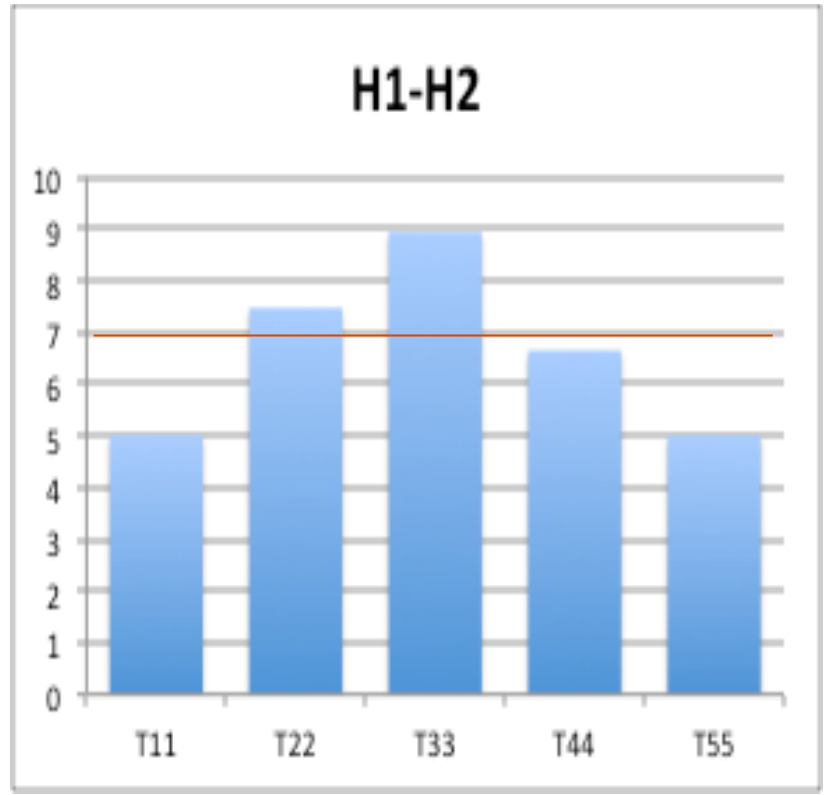
  33 ~ 44 ☺ 44 ~ 55 ☺

- 33 is very distinguishable

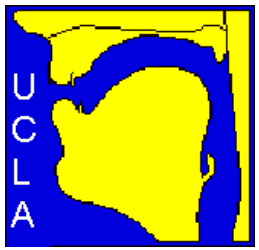
But 22 ~ 44 ☹ (with 20-30Hz difference)

Voice qualities in tones



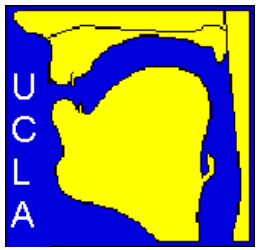


11, 33 and 55 benefit from phonation cues



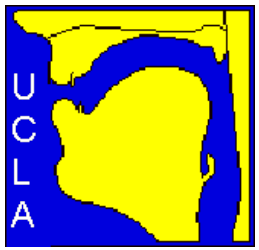
Discussions

- 55 and 11 can benefit from both pitch cues and phonation cues
- For the mid-range tones that have very similar pitch cues, 33 is distinctive from 22 and 44 primarily by the phonation cue.
- 22 vs. 44, the tonal contrast with only a pitch difference is the most confusable



Conclusions

- Tone is more than pitch
- Complicated tonal contrasts rely on other cues, e.g. duration, contour and voice quality
- Voice quality can play important roles in tonal production and perception – especially here, in a language with a crowded tone space



Thank you! ☺

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