10 months in 10 minutes

INVESTIGATION OF THE RELATIONSHIPS BETWEEN HEARING LEVEL AND MEASURE OF MUSICAL PITCH, LEXICAL TONE AND SPEECH-IN-NOISE PERCEPTION IN MANDARIN SPEAKING ADULTS

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BACKGROUND

Pitch perception is important in music, speech and speech-in-noise.

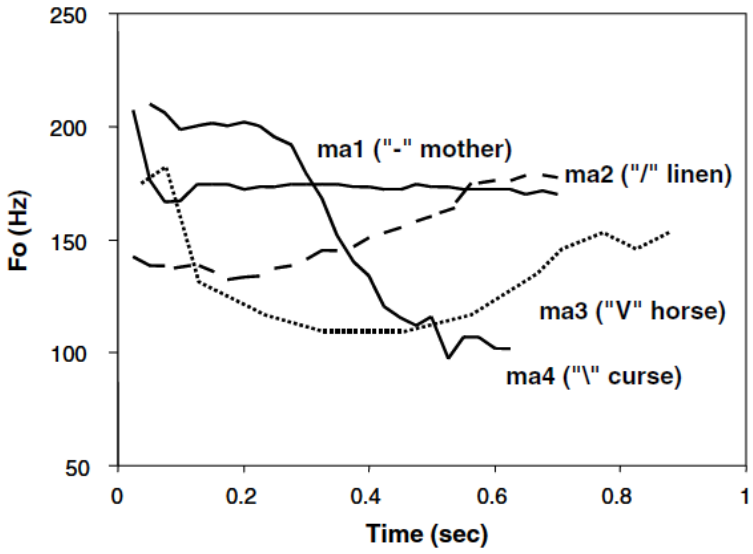
- In music, pitch allows the ordering of sounds on a frequency-related scale.
- Pitch is used to distinguish lexical or grammatical meaning in speech for tonal and non-tonal languages.
- Pitch segregation is also one of the important features in understanding speech in noisy environment.

Musical perception in CI users has been studied, especially in the pitch discrimination aspect, and has been shown to be much **poorer** compared to NH [1,2]

BACKGROUND: MANDARIN

Mandarin is a tonal language

- F0's height, contour and duration



(Wei et al., 2004)

Tone Pattern	Characteristics: contour of the F0	Example
1	Flat high	妈 (mother)
2	Rising	麻 (linen)
3	Falling and then rising	马 (horse)
4	Falling	骂 (scold)

PREVIOUS STUDIES

Several studies showed that CI users performed poorer in tonal languages such as Cantonese and Mandarin, compared to their acoustic hearing counterparts [3-6].

A couple of studies suggested that there might be a similar mechanism between musical pitch perception and lexical tone perception in CI users [6,7]

AIMS:

- Examine the relationship between musical pitch perception, lexical tone perception and Mandarin speech perception in noise in Mandarin-speaking normal hearing (NDU), cochlear implant (CI) and hearing aid (HA) users in Singapore
- Investigate the correlation between these three aspects

METHODS

- 44 subjects from NUH and NUS
- Three subjects groups : NDU, CI and HA users
- Subjects were proficient in English and Mandarin

NDU (n=33)	**CI (n=8)**	**HA (n=3)**
Age: 18-60y (M 34.7y) Thresholds ≤ 40dBHL bilaterally at each of 250, 500, 1000, 2000 & 4000 Hz	Age: 13-38y (M 23.5y); Time with CI: 10-86mths (M 38m). 3 used contralateral HA, but tested CI-only	Age: 26-59y (M 38.33y); Time with HA: 4-103mths (M 43.33m)

METHODS

- Questionnaires: daily use of English and Mandarin and music experience scores
- Test battery: pitch-ranking, lexical tone identification and Mandarin speech perception in Noise test

Test	Summary
Pitch-ranking	2AFC, ½, ¼ & semitone intervals. Male and Female-Sung /a/ vowel.
Lexical Tone identification	4AFC, 200 Mandarin tone tokens (100 male talker; 100 female). Natural tone duration maintained
Mandarin speech perception in Noise	Mandarin HINT test (M-HINT). Two lists with 10 sentences each. Male speaker. Fixed +10dB SNR

RESULTS: PITCH-RANKING TEST

- Paired-samples *t* tests showed no significant difference between Male and Female-Sung stimuli of each subtest for each subject group.
- ANOVA+Post hoc tests using Bonferroni correction showed that the NDU group performed significantly better at the pitch-ranking test compared to the CI group, $p < .001$.
- ANOVA+Post hoc tests using Bonferroni correction indicated scores of half-octave subtest was significantly higher compared to quarter-octave, $p = .001$, and semitone subtests, $p = .005$.

Mean (SD)	**Half-Octave**		**Quarter-Octave**		**Semitone**	
	Male	Female	Male	Female	Male	Female
NDU	90 (10.4)	92 (11.5)	84 (14.3)	85 (14.9)	84 (15.6)	83 (17.1)
CI	76 (15.0)	72 (15.4)	59 (9.1)	59 (22.4)	61 (9.1)	60 (14.2)
HA	83 (19.1)	78 (25.5)	79 (21.9)	69 (32.9)	76 (21.1)	73 (23.6)

RESULTS: LEXICAL TONE CONFUSION MATRICE

ANOVA+Post hoc tests using the Bonferroni correction

- Male: Tone 3 is significantly poorer compared to Tone 1 ($p = .001$) and Tone 4 ($p = .002$)
- Female: Tone 3 is significantly poorer compared to the other tonal patterns ($p < .001$), Tone 2 significantly poorer compared to Tone 1

Stimuli presented: NDU group

Response given

	Male-voiced stimuli					Female-voiced stimuli			
Tone	1	2	3	4	Tone	1	2	3	4
1	97.3	2.1	0.8	0.8	1	97.3	1.2	0.6	0.8
2	1.1	90.1	12.2	1.7	2	1.3	90.1	24.2	1.5
3	1.0	6.9	86.6	1.0	3	1.1	7.9	74.8	1.3
4	0.6	1.0	0.4	96.5	4	0.3	0.8	0.4	96.4

RESULTS: LEXICAL TONE CONFUSION MATRICE

ANOVA+Post hoc tests using the Tamhane's T2

- Male: No significant difference between tonal patterns
- Female: Tone 2 score was significantly poorer compared to Tone 1

Stimuli presented: CI group

Response given

	Male-voiced stimuli					Female-voiced stimuli			
Tone	1	2	3	4	Tone	1	2	3	4
1	81	19	4	5.5	1	82	15	7.5	9.5
2	7.5	54.5	42	4.5	2	5	46.5	36	6
3	6.5	20	51	3	3	7.5	34.5	52.5	8.5
4	5	6.5	3	87	4	5.5	4	4	76

RESULTS: LEXICAL TONE CONFUSION MATRICE

- ANOVA+Post hoc analysis using the Wilcoxon signed-rank
  - No significant difference between tonal patterns for Male and Female stimuli

Stimuli presented: HA group

Response given

	Male-voiced stimuli					Female-voiced stimuli			
Tone	1	2	3	4	Tone	1	2	3	4
1	93.33	0	0	0	1	93.33	2.67	0	2.67
2	2.67	78.67	25.33	2.67	2	1.33	82.67	36	4
3	4	21.33	73.33	0	3	0	14.67	64	0
4	0	0	1.33	97.33	4	5.33	0	0	93.33

RESULTS: LEXICAL TONE

ANOVA+Post hoc test using the Bonferroni correction

- Male: NDU group performed significantly better than CI group, $p < .001$
- Female: NDU group performed significantly better compared to the CI group, $p < .001$. HA group performed significantly better compared to the CI group, $p = .01$.

ANOVA+Post hoc tests using the Tamhane's T2

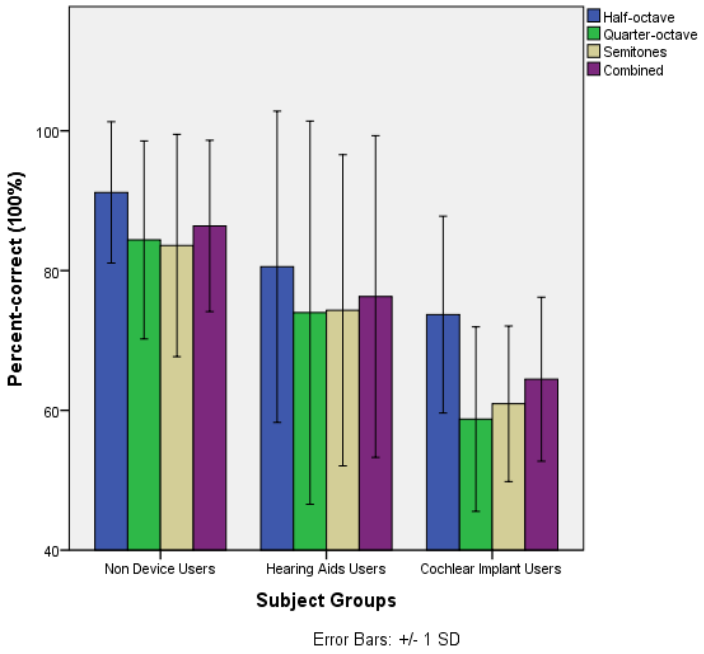
- NDU group performed significantly better compared to CI group, $p = .024$.

RESULTS: SPEECH IN NOISE

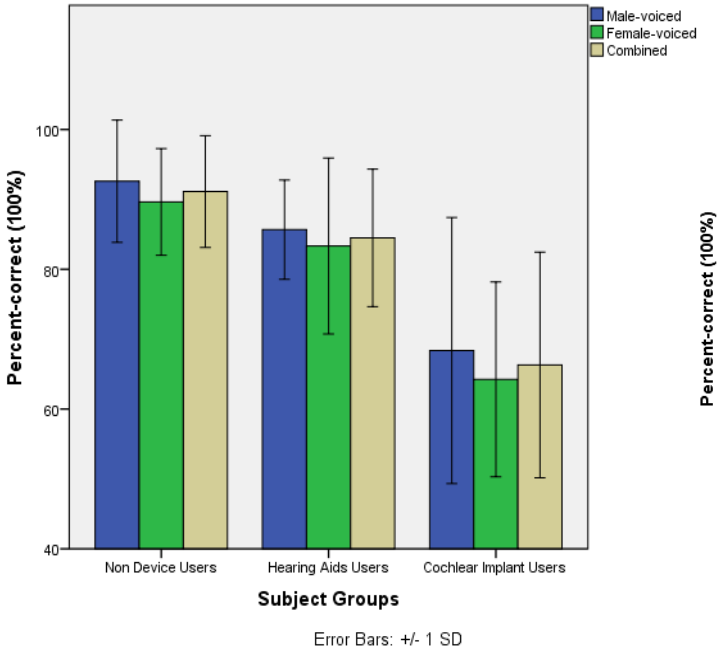
ANOVA+Post hoc tests using the Tamhane's T2

- NDU group performed significantly better than CI group, $p = .001$
- HA group performed significantly better than the CI group $p = 0.03$.

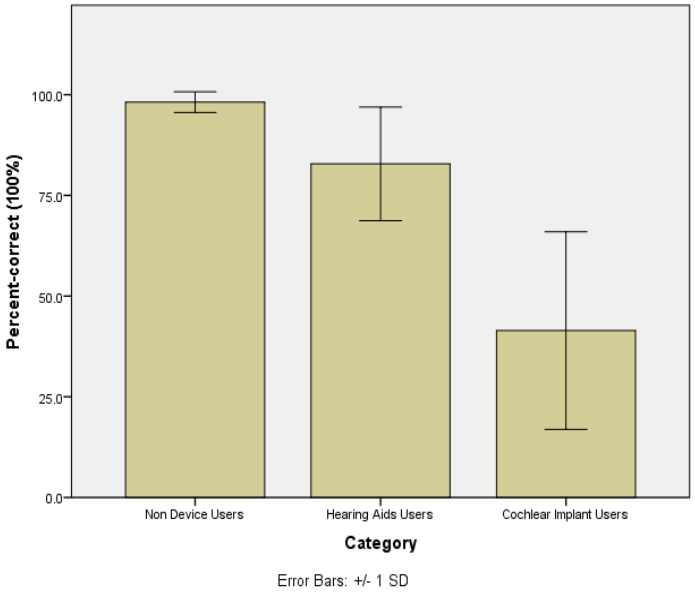
RESULTS: GRAPHICAL SUMMARY



Pitch-ranking test



Lexical tone identification test



Pitch-ranking test

RESULTS: CORRELATION BETWEEN TESTS

- Significant strong positive correlations
- Pitch-ranking and lexical tone identification ($r = 0.67$)
- Lexical tone identification and M-HINT ($r = 0.61$)
- Pitch-ranking and M-HINT ($r = 0.57$).

PREDICTIVE FACTORS:

- Backward regression models identify predictive factors (subject group and music experience score as fixed factors and age, daily hours of Mandarin use, and combined scores from other two tests as covariates)

Pitch	**Lexical Tone**	**M-HINT**
Final Model: **Music experience score**, Lexical tone identification test, daily hours of Mandarin use	Final Model: **Subject group**, Pitch-ranking test, daily hours of Mandarin use	Final Model: **Subject group**, daily hours of Mandarin use
$R^2 = 0.60$ ($adjR^2 = 0.57$) – ~60% of the variance in Pitch-ranking scores.	$R^2 = 0.84$ ($adjR^2 = 0.81$) – ~84% of the variance in Lexical tone identification scores.	$R^2 = 0.83$ ($adjR^2 = 0.82$) – ~83% of the variance in Lexical tone identification scores.
Music experience: $\beta = 4.46$; $p = 0.02$ Lexical Tone: $\beta = 0.69$; $p < 0.01$ Mandarin use: $\beta = -1.41$; $p = 0.02$	HA group: $\beta = -2.02$; $p = 0.70$ CI group: $\beta = -18.21$; $p < 0.01$ Pitch-ranking: $\beta = 0.43$; $p < 0.01$ Mandarin use: $\beta = 1.07$; $p = 0.04$	HA group: $\beta = -14.93$; $p = 0.02$ CI group: $\beta = -60.19$; $p < 0.01$ Mandarin use: $\beta = 1.37$; $p = 0.03$

DISCUSSION

- CI subjects scored significantly poorer compared to the NDU subjects in musical pitch perception, lexical tone perception and Mandarin speech perception in noise.
- Average scores of HA group was higher than CI group but was still lower compared to NDU group. Results were consistent with existing research.
  - SNHL listeners are known to have degraded spectral and temporal resolution ability as a result of cochlear damage
  - Degradation in frequency selectivity because of the broadened auditory filter bands resulting from the hearing impairment (Moore, 1996).
- Significant correlations with all the three tests suggested similar mechanism among all three aspects, more research?

INTERESTING DISCUSSION

Tone 3 was observed to be statistically poorer compared to the other tonal patterns in NDU users

- Lexical tone identification test material from Beijing.
- Duration cues might not have an impact on the subjects
  - Tone 1, 2 and 3 in the Singaporean Mandarin does not differ much in duration, resulting in the lack of temporal cues [10]
- Tone 1 and 4 showed cross dialectal consistency with both the Beijing Mandarin and Taiwan Mandarin, however, Tone 2 and Tone 3 are different and distinct [10]

LIMITATION

- More subjects have to be recruited especially from the Device user groups.
  - Small samples might have implications on the statistical significance of results, care when interpreting results.
  - More standardization for subjects.
- There is a need to create a Lexical tone identification test and M-HINT for the local population
  - Difference in accent, words used and sentence structure
  - An adaptive M-HINT test should also be used in future studies when involving normal-hearing group

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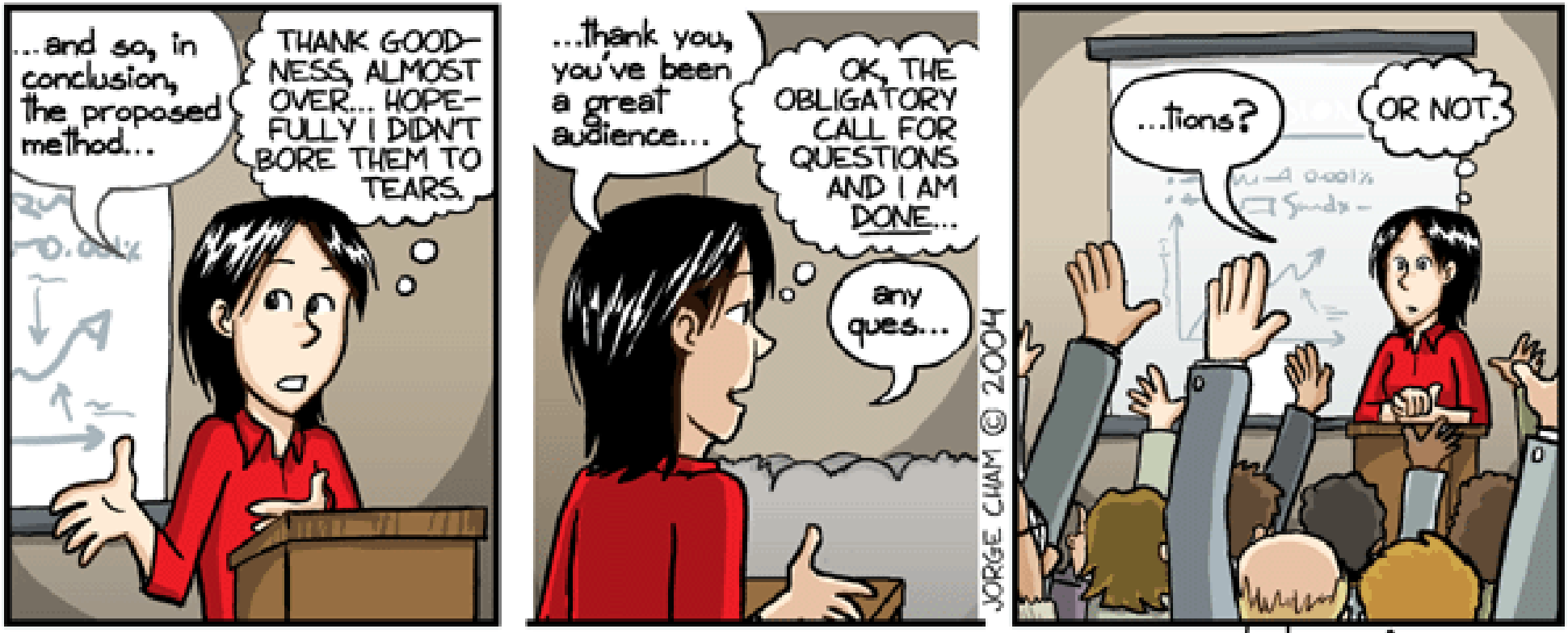
...and so, in conclusion, the proposed method...
THANK GOODNESS, ALMOST OVER... HOPEFULLY I DIDN'T BORE THEM TO TEARS.
...thank you, you've been a great audience...
OK, THE OBLIGATORY CALL FOR QUESTIONS AND I AM DONE...
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