Cantonese tone production performance of mainstream school children with hearing-impairment

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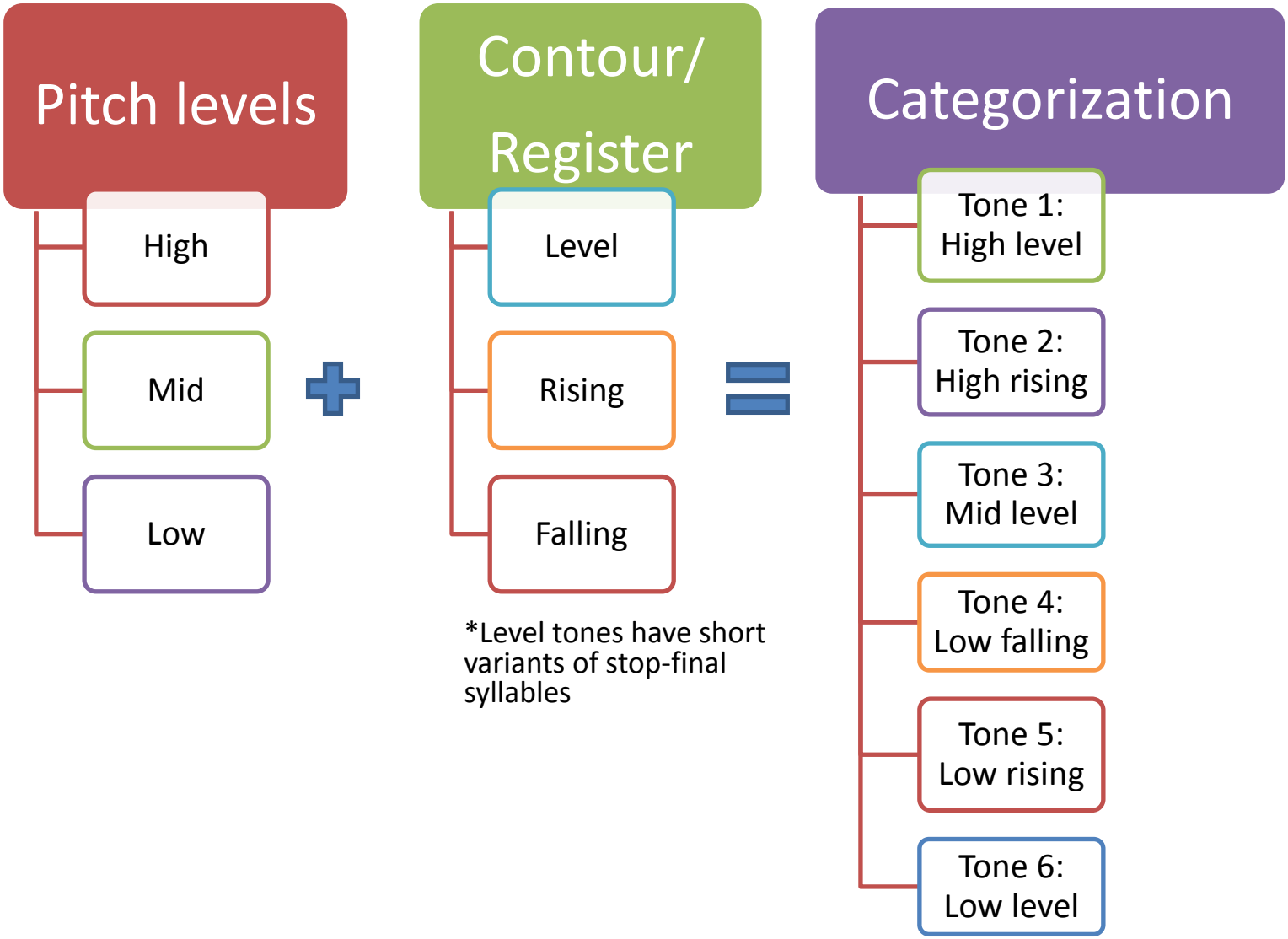
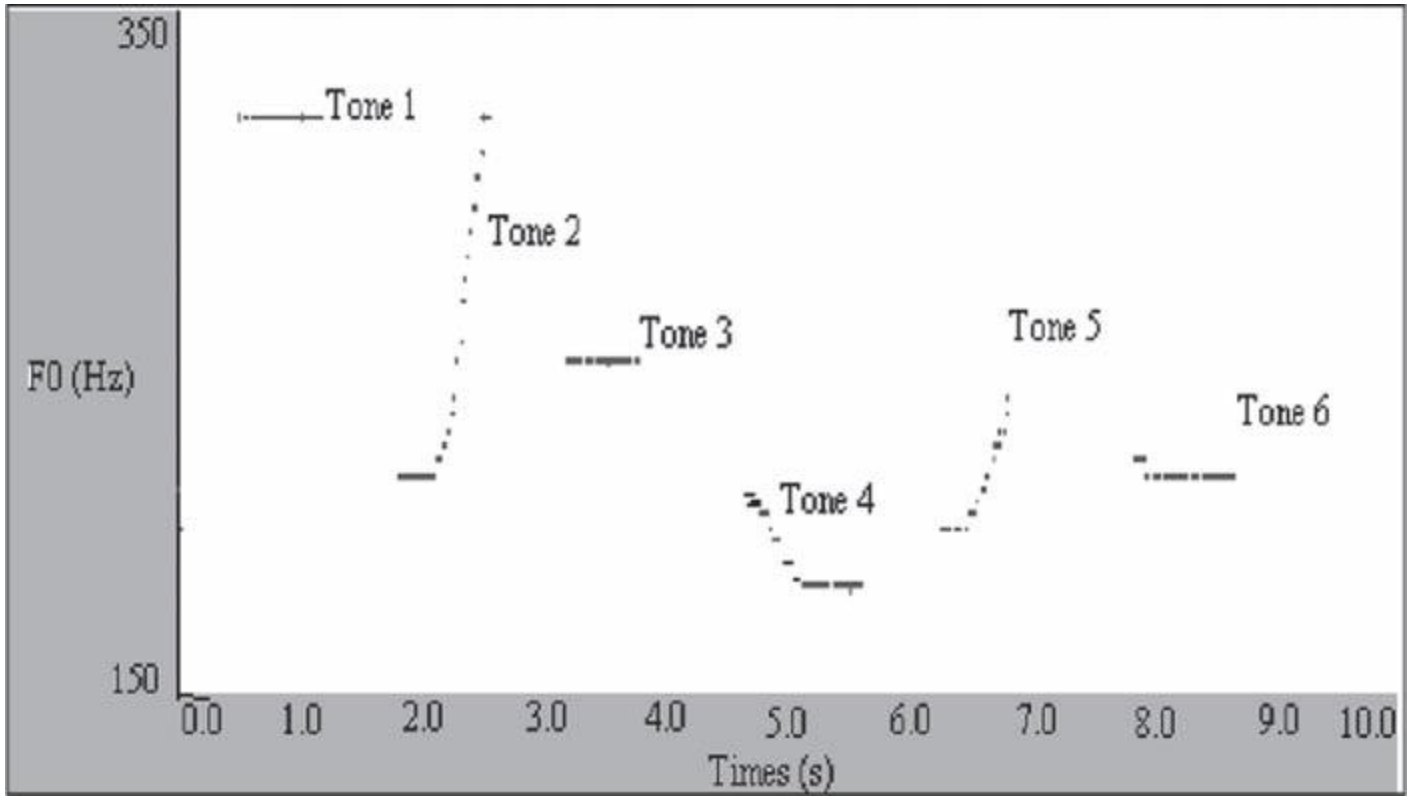
Cantonese tone

(Matthews & Yip, 1994; Yip, 2002; Yue-Hashimoto, 1972)



Different fundamental frequency (F0) of the six Cantonese tones on the vowel [a]

(Lee et al., 2002)



- Tone signals lexical information
  - Same syllable, different tones → different meanings

Tone perception

Normal hearing population

- Tone **1** contrasts → Most successfully perceived
  (Barry et al., 2002; Ciocca & Lui,2003; Lee, Chiu, & van Hasselt, 2002a; Lee et al., 2002b)
  - Distinctively high average F0
- Small F0 differences → tone discrimination difficulty
  (Barry et al., 2002; Ciocca & Lui, 2003; Lee et al., 2002a, b)
  - Close proximity of F0 at onset
    - Tone 2/4; Tone 2/5; Tone 4/5; Tone 5/6
  - Same contour but with small F0 difference
    - Tone 3/6

Tone perception

Hearing impaired population

- In general conformed to that of normal hearing population
  - Close proximity of F0 at onset → tone discrimination difficulty (Barry et al., 2002; Ciocca, Francis, Aisha, & Wong, 2002; Lee, van Hasselt, & Tong, 2010b; Tse & So, 2012; Wong & Wong, 2004)
  - Tone 1 → fewest errors
- Tone 6 → most difficult to identify (Ching, 1988; Wong & Wong, 2004)
- Tone 5 contrasts → most difficult for children and adults with cochlear implants (CI) (Barry et al., 2002; Lee, Cheung, Chan, & van Hasselt, 1997)
- Confusion between contour and level tones (Lee et al., 2002b; Wong & Wong, 2004; Tse & So, 2012)
  - Tone 1/2; Tone 1/5; Tone 2/6 ; Tone 3/5

Tone production

Normal hearing population

(Cheung & Abberton, 2000; Tse, 1978; Tse, 1992)

- Tone 1 emerges the earliest
- Tone 4/5/6 → differentiated in later stage of acquisition
- Rising tones → difficult for some children

Tone production

Hearing impaired population

- Tone 4 & 5 → most difficult for children with CI (Lee, Tong, & van Hasselt, 2007; Lee, van Hasselt, & Tong, 2010a)
- Normal hearing children → able to master all tones correctly at 2;0 (Lee, et al., 2010a)
  - HI children with CI continue to make errors
- They produce tones matching the F0 features of Tone 1 (Khouw & Ciocca, 2006)
- Little acoustic differences
- Smaller range of average F0

Tone perception ←→ production

- Tone perception and production → RELATED
  - Similarities in the findings between tone perception studies and tone production studies
  - HI population → tend to perceive and produce some of the tones better

Mainstreaming

- *"The process of educating the deaf not within the artificial confines of an institution but within the more natural structure of the public school system"*
  (Wamae & Kang'ethe-Kamau, 2004, p.33)

- Higher speech production scores for HI children (English speaking) with CI studying in mainstream classroom (Tobey et al., 2003; Most, 2007)

- Hong Kong?
  - No investigation on speech production ability of Mandarin- or Cantonese-speaking HI children
  - Unknown → Effect of mainstreaming on Cantonese tone production

Research questions

- Limited studies on tone production

√	X
NH children	Children with milder degree of hearing loss
Profound HI children	
CI users	HA users
Overall tone production accuracy	Tone error pattern

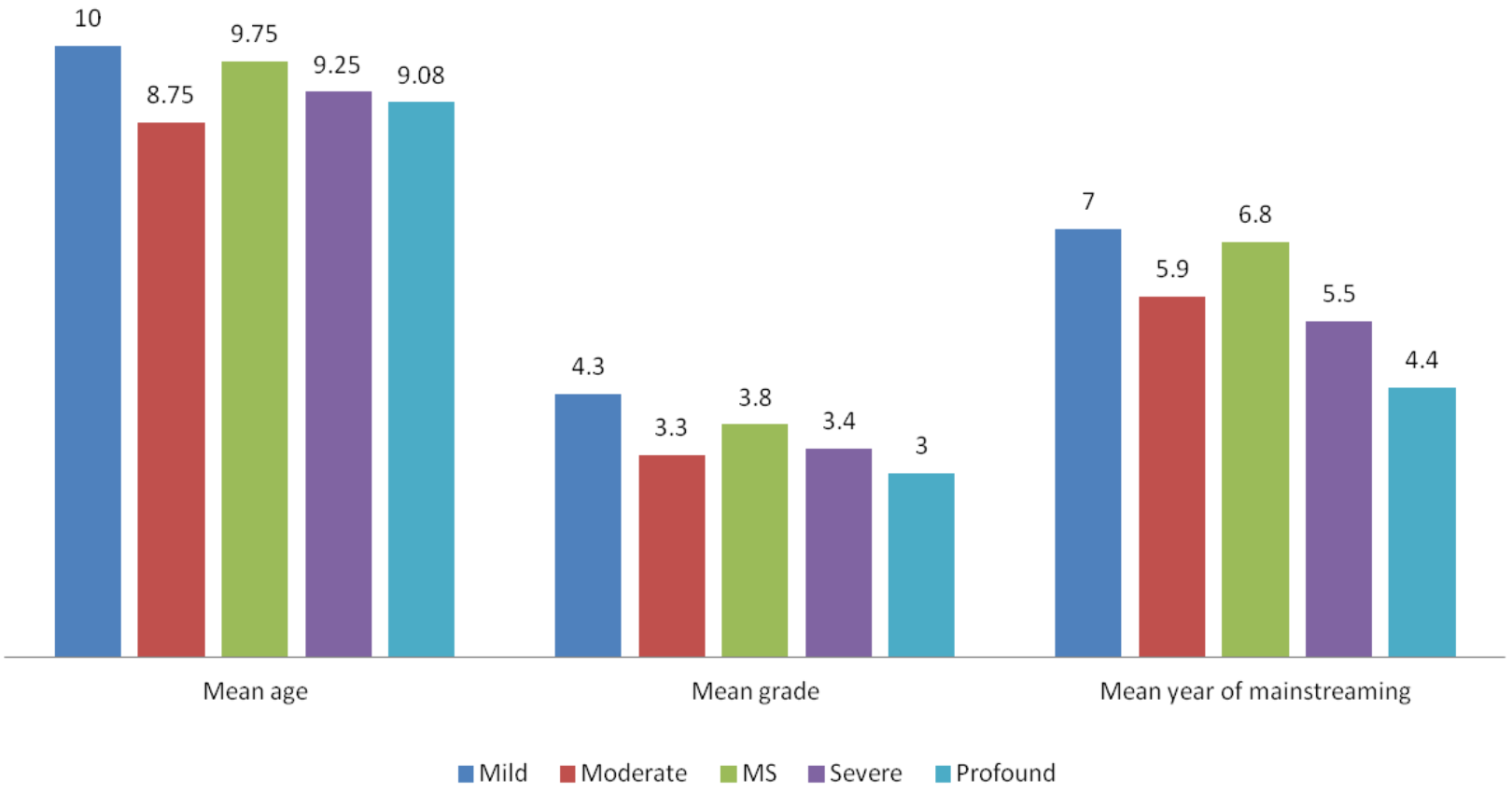
- Effect of mainstreaming still remains unknown for HI children's tone production

Research questions

- Intrinsic differences of the 6 tones?
  - Tone 1 → better performance than → Tone 4/5/6
- Effect of degree of hearing loss?
  - Milder degree of hearing loss → better tone production due to better tone perception
- Role of mainstreaming?
  - Longer exposure → better performance
- Tone error pattern?
  - By HI children with various degrees of hearing loss

Participants

HL level	Mild	Moderate	MS	Severe	Profound	TOTAL
No. of students	18	18	15	14	22	**87**



Material & Procedure

- The Hong Kong Cantonese Articulation Test (HKCAT) (Cheung, Ng & To, 2006)
  - Picture naming task
- Administrators: 2 speech therapists
- Soundproof/segregated room in a school setting
- Recorded with microphone placed 30 – 40 cm away from the participant's mouth
- Recordings rated by 3 native Cantonese raters in a quiet office (rated 2 times in a 3-month interval)
  - 1 ST who had administered HKCAT to the HI children
  - 2 researchers with 3 years of experience on HI children and had phonetic training
  - 0 = incorrect; 1 = correct (Total = 0 - 3; combine all 3 raters)

Result - Descriptive

- Rater reliability
  - Inter-rater Agreement = 92.9% (ICC = .984)
  - Intra-rater Agreement = 95.5% - 98.1% (ICC = .95 - .99)

- Tone production accuracy by hearing loss group

	Word level (Level 1) ($n = 6003$)		Subject level (Level 2) ($n = 87$)	
Hearing loss group	Mean (SD)	n	Mean (SD)	n
Mild	2.99 (.15)	1242	2.99 (.02)	18
Moderate	2.94 (.35)	1242	2.94 (.11)	18
Moderate–severe	2.92 (.36)	1035	2.92 (.08)	15
Severe	2.95 (.26)	966	2.95 (.04)	14
Profound	2.62 (.83)	1518	2.62 (.44)	22

Note: Tone production accuracy score ranged from .0–3.0.

Cheung et al. (2014)

Result – Multi-level analysis

- Multi-level analysis with three predictors:
  - Tone (word level) (n=6003)
  - Year of mainstreaming (subject level) (n=87)
  - Hearing loss level (subject level) (n=87)

Result - Multi-level analysis

A random intercepts and slopes model for predicting tone production accuracy of participants with hearing impairment

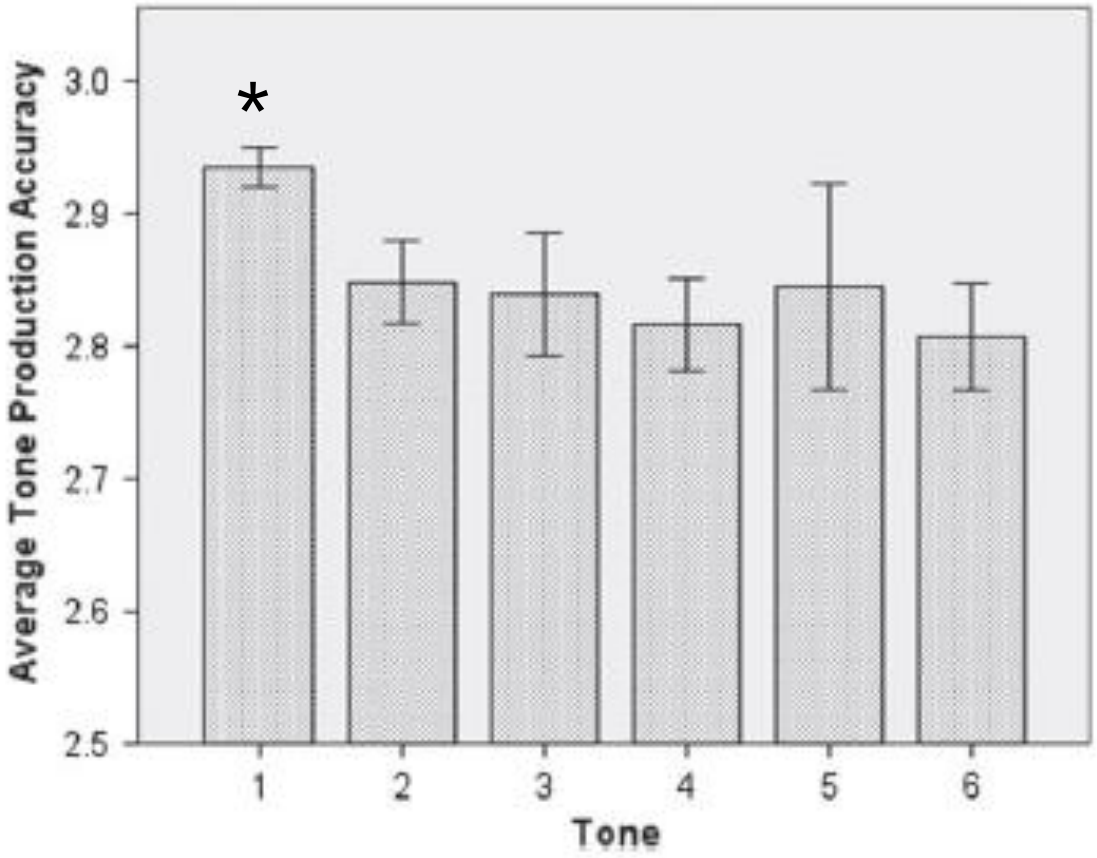
Predictors (Level)	F-value	Numerator df	Denominator df	p-value
Tone (L1)	5.928	5	421.467	<.001
HL group (L2)	14.463	4	92.635	<.001
Year of MainS (L2)	.448	1	92.635	.505
Tone (L1) * HL group (L2)	2.784	20	421.467	<.001
Tone (L1) * Yr of MainS (L2)	.274	5	421.467	.927
Yr of MainS (L2) * HL group (L2)	1.825	4	92.635	.131
Tone (L1) * Yr of MainS (L2) * HL group (L2)	1.377	20	421.467	.128

Note: L1 and L2 denote word level and subject level predictors, respectively.

Cheung et al. (2014)

Result –
Post-hoc on significant main effects

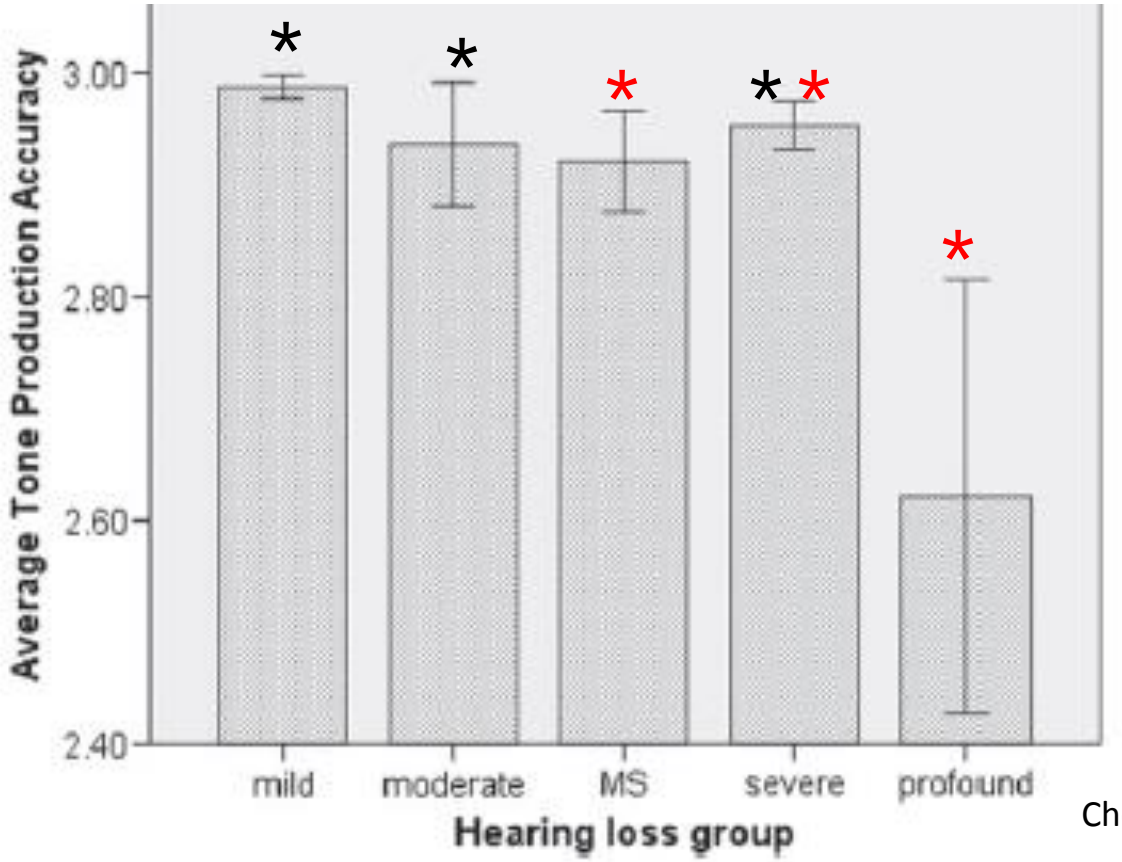
Tone production accuracy on word level by tone



Cheung et al. (2014)

Result –
Post-hoc on significant main effects

Tone production accuracy on subject level by hearing loss level



Cheung et al. (2014)

Result – Tone*HL interaction

Post-hoc multiple comparisons on the Tone*Hearing Loss group interaction effect at word level

Hearing loss group	Tone pairs showing statistically significant difference
Mild ($n = 1242$)	–
Moderate ($n = 1242$)	–
Moderate–Severe ($n = 1035$)	Tone 1 > Tone 6 ($p < .0006$)
Severe ($n = 966$)	Tone 1 > Tone 6 ($p < .0006$)
Profound ($n = 1518$)	Tone 1 > Tone 2 ($p < .0006$); Tone 1 > Tone 3 ($p < .0006$); Tone 1 > Tone 4 ($p < .0006$); Tone 1 > Tone 5 ($p < .0006$); Tone 1 > Tone 6 ($p < .0006$)

Note: With Bonferroni correction, $p < .05/(5^*15) = .000,667$ is considered as statistical significance.

n denotes the total number of words produced by children in the hearing loss group. > denotes statistically significantly more accurate than.

Cheung et al. (2014)

Tone error pattern

Summary of tone production errors of children with various degrees of hearing loss (n=87)

	Produced tones								
Target tones	T1	T2	T3	T4	T5	T6	χ^2	df	p
Tone 1 ($n = 2175$)		22	42	5	9	24	41.627	4	.000**
Tone 2 ($n = 1131$)	16		13	46	18	36	32.279	4	.000**
Tone 3 ($n = 522$)	30	11		11	3	5	38.000	4	.000**
Tone 4 ($n = 1218$)	30	64	47		28	18	35.273	4	.000**
Tone 5 ($n = 174$)	2	10	4	2		7	9.600	4	.048*
Tone 6 ($n = 783$)	55	7	40	16	9		70.283	4	.000**

Note: Chi-square test significant level: * $p < .05$. ** $p < .01$.

Cheung et al. (2014)

Hearing loss effect – Relationship between HL & Tone accuracy

Mild > MS, severe, profound

- Produce more consistent F0 information and distinguish the 6 tones better (Khouw & Ciocca, 2006) because of better tone perception (Xu et al., 2011)
- Older?
- Receive longer mainstream education?

Profound < Mild, moderate, severe

- CI & HA provide limited assistance in tone production (Wong & Wong, 2004; Tse & So, 2012)
- Children with profound hearing loss benefits little from HA (Lee et al., 2008) or CI (Lee et al., 2010; Tse & So, 2012) on tone perception
- Relationship between tone perception & tone production??

Mainstreaming effect – Duration of mainstreaming and tone accuracy

- NO main / interaction effect of mainstreaming
  - Tone production ability was not found to increase with the number of years studying in a mainstream environment
  - Inconsistent to previous studies examining speech production in terms of segmental features (Tobey, Geers, Brenner, Altuna & Gabbert, 2003; Most, 2007)

⌦ Mainstreaming does not have an effect on suprasegmental features (i.e. tone)

⌦ Teaching strategy may be a less important factor than other factors (e.g., age of implantation, amplification mode etc.) (Connor, 2000)

Tone effect – intrinsic characteristics of Cantonese tones

- Tone 1 was produced significantly better
  - Level tone; pitch remains constant and no varying of tension of laryngeal muscle (Yip, 2002)
  - Frequency effect of level tone (Lee, 2012)
  - Tonal Sonority Hierarchy (Jiang-King, 1999): high tone more prominent; easier to perceive (Barry et al., 2002) → easier to produce
  - Children's shorter vocal tract & larynx height → exhibit higher pitch than adults

Tone effect – intrinsic characteristics of Cantonese tones

- Tone 6 is the least accurate
  - Small average F0 separation with other low tones (tone 3, 4, 5) (Ciocca et al., 2002; Lee et al., 2010)
  - Mis-categorization of tone production due to unreliable subtle F0 change and average F0 produced by children with hearing impairment (Khouw & Ciocca, 2006)
  - Difficult to perceive (Wong & Wong, 2004)
  - Difficulty in contrasting individual level tones by differentiating average F0 ranges

Tone error pattern

- Confusions were made for similar F0 onset but not offset
  - Tone 2 & Tone 4: 1.36 Hz (Lee et al., 2010)
    (TD: Lee et al., 2002; HI: Lee et al., 2010)
  - Tone 2 & Tone 5: 7.46 Hz (Lee et al., 2010)
    (Both TD & HI: Barry et al., 2002; Ciocca & Lui, 2003; Ciocca et al., 2002)

Tone error pattern

- Majority of tone errors were from Profound HI children
  - Confusion patterns matched past perception studies:
  - Tone 2/4 (Lee, van Hasselt, Chiu & Cheung, 2002; Tse & So, 2012)
  - Tone 2/5 (Barry et al., 2002; Ciocca & Lui, 2003; Wong & Wong, 2004; Tse & So, 2012)
  - Tone 1/3/6 (Tse & So, 2012)

- Children can discriminate between level and contour tones
  - But lack fine control of muscles to produce different contrastive F0 patterns within the group of level/contour tones (Lee et al., 2002)

    Tone 1 vs. Tone 3 → Level tones

    Tone 2 vs. Tone 5 → Contour tones

Conclusion

- Intrinsic difference of tones affect children's tone production accuracy
  - Similar F0 of tone pairs during onset caused confusion
  - Tone confusion patterns in perception studies coincide with the production error patterns

- Satisfactory tone production for children with mild to severe hearing loss but not profound hearing loss
  - Children with mild and moderate hearing loss significantly outperformed the children with higher degree of hearing loss
  - Tone remains a challenging aspect for children with profound hearing loss
  - HA or CI did not help much in tone production accuracy

Conclusion

- Mainstreaming the HI children in normal schools does not help much in the production of tone
  - Increase in number of years in normal schools does not boost tone production
  - More intensive training on tone production is needed

References

- Barry, J. G., Blamey, P. J., Martin, L. F. A., Lee, K. Y. S., Tang, T., Yuen, Y. M., et al. (2002). Tone discrimination in Cantonese-speaking children using a cochlear implant. *Clinical Linguistics and Phonetics, 16*, 79–99.
- Cheung, P., & Abberton, E. (2000). Patterns of phonological disability in Cantonese-speaking children in Hong Kong. *International Journal of Language and Communication Disorders, 35*(4), 451-473.
- Cheung, P., Ng, K. H., & To, C. (2006). *Hong Kong Cantonese Articulation Test.* Hong Kong: Language Information Sciences Research Centre and City University of Hong Kong.
- Ciocca, V., & Lui, J.Y.K. (2003). The development of the perception of Cantonese lexical tones. *Journal of Multilingual Communication Disorders, 1*(2), 141-147.
- Jiang-King, P. (1999). *Tone-vowel interaction in optimality theory*. Muenchen: LINCOM Europa.
- Lee, K.Y.S., van Hasselt, C.A., Chiu, S.N., & Cheung, D.M.C. (2002). Cantonese tone perception ability of cochlear implant children in comparison with normal-hearing children. *International Journal of Pediatric Otolaryngology, 63*, 137–147.
- Lee, K.Y.S., Tong, M.C.F., & van Hasselt, C.A. (2007). The tone production performance of children receiving cochlear implants at different ages. *Ear & Hearing, 28*, 34S-37S.
- Lee, K.Y.S., van Hasselt, C.A., & Tong, M.C.F. (2010). Age sensitivity in the acquisition of lexical tone production: an evidence from children with profound congenital hearing impairment after cochlear implantation. *Annals of Otology, Rhinology & Laryngology, 119*(4), 258-265
- Lee, K.Y.S., van Hasselt, C.A., & Tong, M.C.F. (2011). Tone perception development in the Cantonese-speaking children. Proceedings from PLRT 2011: *Psycholinguistic Representation of Tone Conference*. Hong Kong: The Chinese University of Hong Kong.
- Matthews, S., & Yip, V. (1994). *Cantonese: a Comprehensive Grammar.* London: Routledge.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.
- Most, T. (2007). Speech intelligibility, loneliness, and sense of coherence among deaf and hard-of-hearing children in individual inclusion and group inclusion. *Journal of Deaf Studies and Deaf Education, 12*(4), 495-503.
- Tobey, E.A., Geers, A.E., Brenner, C., Altuna, D., & Gabbert, G. (2003). Factors associated with development of speech production skills in children implanted by age five. *Ear & Hearing, 24*, 36S-45S.
- Tse, A. (1992). *The Acquisition Process of Cantonese Phonology: A Case Study*. (Mphil thesis). The University of Hong Kong, Hong Kong.
- Tse, J.K.P. (1978). Tone acquisition in Cantonese: a longitudinal study. *Journal of Child Language, 5*, 191-204.
- Tse, W.T., & So, L.K.H. (2012). Phonological awareness of Cantonese-speaking pre-school children with cochlear implants. *International Journal of Speech-Language Pathology, 14*(1), 73-83.
- Wamae, G.M.I., & Kang'ethe-Kamau, R.W. (2004). The concept of inclusive education: teacher training and acquisition of English language in the hearing impaired. *British Journal of Special Education, 31*(1), 33-40.
- Wong A.O.C., & Wong, L.L.N. (2004). Tone perception of Cantonese-speaking prelingually hearing-impaired children with cochlear implants. *Otolaryngology-Head and Neck Surgery, 130*(6), 751-758.
- Yip, M. (2002). *Tone.* Cambridge, U.K.; New York: Cambridge University Press.

THANK YOU!