

Categorical Perception of Vowels in Older Listeners of Cantonese

Hao Huang¹, Kwan Ho Lam², Jing Shao*

Academy of Language and Culture, Faculty of Arts and Social Sciences, Hong Kong Baptist University

*indicates corresponding author: jingshao@hkbu.edu.hk

Ageing and age-related hearing loss may negatively influence speech perception [1][2]. However, how such factors affect the categorical perception of vowels still remain insufficiently characterized, especially regarding Cantonese vowel contrasts that heavily rely on formant-based spectral cues and long-term phonological category representations. The present study aims to reveal the categorical perception pattern of Cantonese vowels among older cohorts, those with hearing impairment in particular.

Three groups of native Cantonese listeners living in Hong Kong were recruited to join the experiment: young adults with normal hearing (YNH, $n = 10$) between 18 and 23 years old ($M = 20.9$ years, $SD = 1.97$), older adults with normal hearing (ONH, $n = 9$) and their counterpart with hearing loss (OHL, $n = 10$), aged above 60 (ONH: $M = 68.1$ years, $SD = 4.19$; OHL: $M = 71.9$ years, $SD = 6.43$). Using a 7-step /fu/-/fɔ/ continuum, all groups completed both an identification task (ID, two-alternative forced choice) and a same-different discrimination task (DIS, two sequential token judgement). For the ID task, categorical responses and reaction time (RT) were analysed: subject-level probit fits yielded boundary position (50% crossover) and boundary width. For the DIS task, within-/between-category pairs were defined relative to each listener's ID boundary: pairs were within-category if both tokens fell on the same side of the boundary (both /fu/ or both /fɔ/), and between-category if the two tokens fell on opposite sides (one /fu/, one /fɔ/); discrimination sensitivity was quantified as d' . RTs were analysed with linear mixed-effects models after standard trimming ($\pm 3SD$).

The results showed that **in the identification task**, boundary position showed no significant group effect ($F(2,26)=2.40$, $p=.111$), although ONH trended toward a lower boundary than YNH ($\beta = -0.62$, $p=.099$) (YNH: Mean = 4.06, $SD = 1.75$; ONH: Mean = 3.59, $SD = 2.64$; OHL: Mean = 4.25, $SD = 1.93$) (see **Figure.1**). The group differences on boundary width were not significant as well ($F(2,26)=2.56$, $p=.096$). Regarding identification RTs (**Figure.2**), the LME showed a significant main effect of group ($p = .018$), and emmeans indicated slower responses for OHL than YNH (within-category tokens: Tukey- $p = .023$; boundary-adjacent tokens: Tukey- $p = .060$).

In the discrimination task, for d' (**Figure.4**), there was a significant main effect of group ($F(2,29)=3.58$, $p=.0409$), a marginal effect of pair category ($p=.0737$), and no group $\times$ category interaction ($p=.422$). With YNH-within as the reference level, OHL showed reduced sensitivity ($\beta=-1.12$, $p=.0159$). Discrimination RTs (**Figure.3**) showed no reliable effects of group, category, or interaction (all $ps \geq .55$), suggesting that group differences were better captured by sensitivity than by response speed.

Taken together, our findings suggested that age-related hearing loss resulted in degraded performance in categorical perception of Cantonese vowels: older adults with hearing loss tended to use more time in categorizing the vowels in the identification task, suggesting they need to employ more cognitive effort in the process [3][4]. More importantly, they showed reduced discrimination sensitivity (lower d') than younger listeners, implying their overall perceptual sensitivity to vowel categories is significantly impaired. Collectively, these findings refine our comprehension of the extent to which age-related hearing loss influences speech perception, particularly in the domain of vowel processing, which remains comparatively underexplored in the literature.

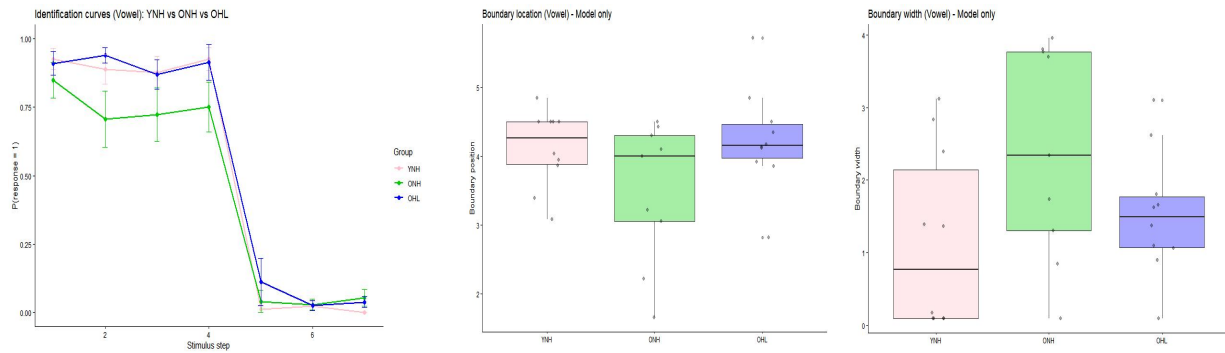


Figure.1 Identification curves, boundary location, and boundary width for YNH, ONH, and OHL groups. (YNH: young adults with normal hearing; ONH=older adults with normal hearing; OHL: older adults with hearing loss)

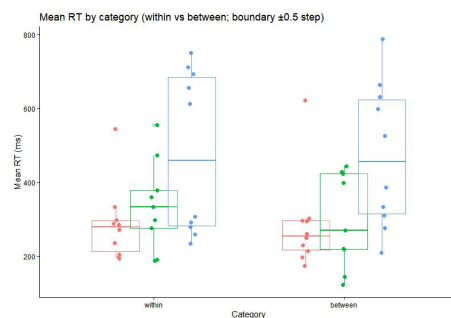


Figure.2 Comparisons of reaction time (RT) across YNH, ONH and OHL groups in the identification task (ID).

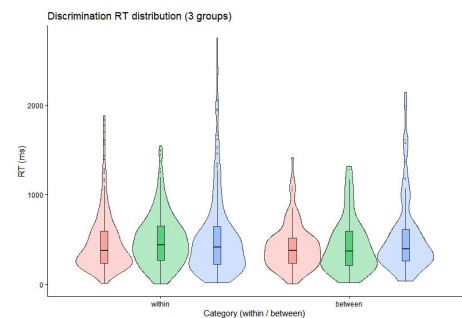


Figure.3 Comparisons of reaction time (RT) distribution across YNH, ONH and OHL groups in the discrimination task (DIS).

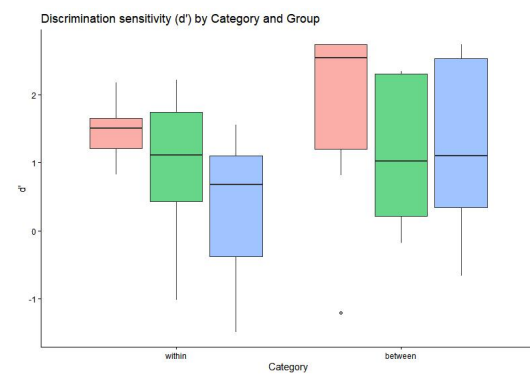
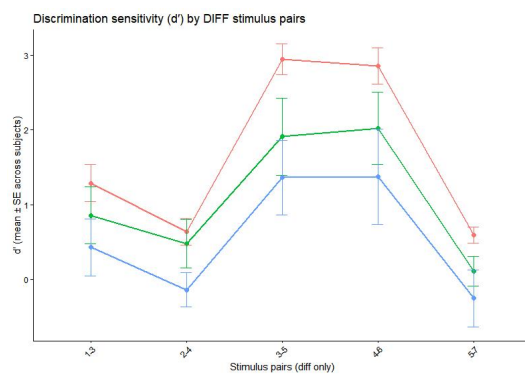


Figure.4 The d' scores of each stimulus continuum in the discrimination task for the YNH, ONH, and OHL groups (left); and the interaction plot of the average d' scores of between- and within-category pairs for these groups (right).

Acknowledgement

This study was supported by the General Research Fund (GRF:12613224) from Research Grants Council of Hong Kong, and the Initiation Grant for Faculty Niche Research Area (RC-FNRA-IG/23-24/ARTS/01) from Hong Kong Baptist University.

References

- [1] Ananthakrishna Chintanpalli, Jayne B. Ahlstrom, Judy R. Dubno. (2016) *Effects of age and hearing loss on concurrent vowel identification*. J. Acoust. Soc. Am. 140 (6): 4142–4153.
- [2] Gordon-Salant S. (2005) *Hearing loss and aging: new research findings and clinical implications*. J Rehabil Res Dev. Jul-Aug;42(4 Suppl 2):9-24.
- [3] Salthouse T. A. (1996) *The processing-speed theory of adult age differences in cognition*. Psychological Review 103: 403–428.
- [4] Ching T., Dillon H., Byrne D. (1997) *Prediction of speech recognition from audibility and psychoacoustic abilities of hearing-impaired listeners*. In: Jesteadt W. (ed.) Modeling sensorineural hearing loss, Mahwah, NJ: Lawrence Erlbaum, pp. 433–445.