

Talker- and listener-conditioned use of height-dependent vowel duration cue under sound change in progress: /o/ to /u/ raising in Daejeon Korean

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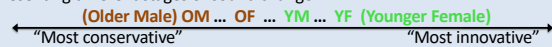
Introduction

- Intrinsic height-dependent vowel duration:** All else being equal, higher vowels tend to be shorter than lower vowels and Production studies have investigated whether this intrinsic duration is solely a mechanical by-product of vowel height implementation or a phonologized target controlled by speakers [7,8].
- /O/ raising in Korean:** /o/ is undergoing raising, resulting in a height merger between /o/ and /u/ in numerous Korean dialects [2,4,5], including Daejeon Korean, where younger listeners rely more on F2 than F1 for distinguishing between the two vowels [9].
- Research questions:**
 - Is the duration cue utilized in perceiving subtle height contrasts?
 - Does its use vary by the talkers' and listeners' age and gender, mirroring the loss of height distinction led by the speech of younger female speakers?
- Predictions:** The duration cue will be more robust for older and male talkers and listeners than for younger and female talkers and listeners, in line with the direction of height merger.

Methods

Stimuli talkers' production

- Stimuli talkers:** four Daejeon Korean speakers varying in age and gender and representing different stages of sound change



- Speech materials:** 8 monophthongs (i, ɪ, u, e, ɛ, o, ɐ, ɔ, a) embedded in a carrier; randomized within a larger list; 10 repetitions
 “문장 맨 마지막 말은 ___다.”
 [mundʒaŋ mən madʒimaj maɾin ___da]
 ‘The last word of the sentence is ___.’

Manipulation

- A baseline was created for each speaker by splicing together a token of carrier ('s' + 'pause') and a token of [o + da] from a different production.
- Carrier sentence:** manipulated to vary in speech rate
 - Fast vs. Slow: 20% shorter and longer from the average for all speakers ('s') and 50ms ('p').
- Target vowel:**
 - Duration: 20% shorter and longer to match the speech rate.
 - Formants: varied to cover all /o/ and /u/ tokens by all talkers in the normalized F1 and F2 space.

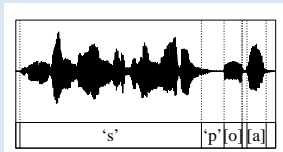


Figure 1: Spliced baseline for YF (carrier + [oda])

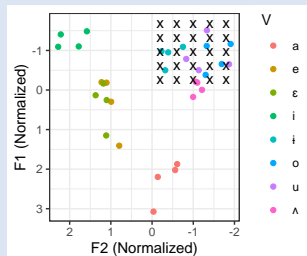


Figure 2: Perception stimuli (x) and by-talker F1 and F2 means of the eight monophthongs (circles)

Participants

- 81 speakers of Daejeon Korean born between 1932 and 2003, balanced for age and gender (OM, OF, YM, YF)

	Older (50s +)	Younger (20s)
Male	20 (OM)	21 (YM)
Female	20 (OF)	20 (YF)

Experiment

- Implemented in *Psychopy* (Peirce et al. 2019) on a touch-screen tablet PC.
- Forced choice identification task (o < ɔ, u < ʊ, i < ɪ, ɛ < ɛ̃).
- 200 trials = 5 F1 steps * 5 F2 steps * 2 duration steps * 4 talkers

Statistical analyses

- In R [6], generalized mixed-effects regression by *lme4* [1] and post-hoc tests by *phia* [3].
- Response variable:** 'o' vs. 'u' response (excluding 'ɛ' and 'i' responses)
- Predictors:**
 - Acoustic:** F1 (5 steps), F2 (5 steps), duration (slow, fast)
 - Listener age and gender:** OM, OF, YM, YF
 - Talker age and gender:** OM, OF, YM, YF
 - Interactions:** (F1, F2, duration) * listener * talker
- Random effects:**
 - By-listener intercept & random slopes for F1, F2, & duration.

References

[1] Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., Dai, B., Grothendieck, G. 2017. lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-13. [Computer software] <https://CRAN.R-project.org/package=lme4>. [2] Byun, H. (2018). Acoustic parameters that differentiate /o/ from /u/ in Seoul Korean. *Phonetics and Speech Sciences*, 10(2), 15-24. [3] De Rosario-Martinez, H., 2015. phia: Post-Hoc interaction analysis. R package version 0.2-1. [Computer Software] <https://CRAN.R-project.org/package=phia>. [4] Igeta, T., Sonu, M., Arai, T. 2014. Sound change of /o/ in modern Seoul Korean: Focused on relations with acoustic characteristics and perception. *Phonetics and Speech Sciences*, 6(3), 109-119. [5] Kang, E. J., Kong, E. 2016. Static and dynamic spectral properties of the monophthong vowels in Seoul Korean: Implication on sound change. *Phonetics and Speech Sciences*, 8(4), 39-47. [6] R Core Team. 2023. R: A Language and Environment for Statistical Computing. Vienna: R Foundation for Statistical Computing. [7] Solé, M. J. and Ohala, J. J., 2010. What is and what is not under the control of the speaker: Intrinsic vowel duration. *Papers in laboratory phonology*, 10, pp.607-655. [8] Yu, A.C., 2021. Toward an individual-difference perspective on phonologization. *Glossa: a journal of general linguistics*, 6(1), [9] Yun, J., Seong, Cheoljae, 2013. Effects of F1/F2 Manipulation on the Perception of Korean Vowels /o/ and /u/. *Phonetics and Speech Sciences*, 5(3), pp.39-46.

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Results

Figure 3: Response by F1 * F2, duration, talker, and listener group (ellipses: 95% confidence interval)

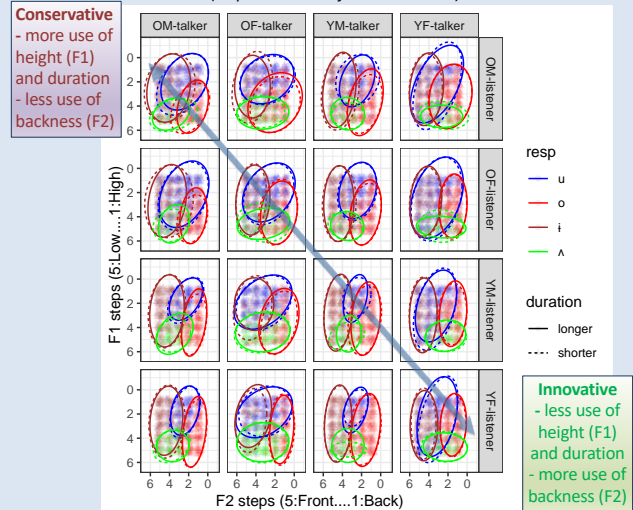
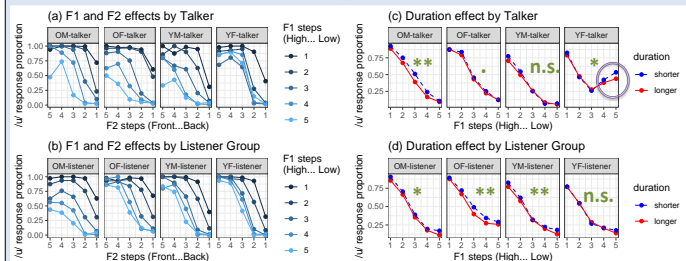


Figure 4: Average /u/ (vs. /o/) response proportion

- (a) by F1, F2 & Talker; (b) by F1, F2 & Listener;
- (c) by F1, Duration & Talker; (d) by F1, Duration & Listener



F1 & F2:

- Listeners use both F1 and F2 cues to distinguish /u/ & /o/: lower F1 and higher F2 favor /u/.
- The effects were significant in all talker and listener group conditions but differed in strength, in ways consistent with the direction of change.
- F1 effect (separation of lines) was stronger in older than younger talker and listener conditions.
 - F1 * Talker: OM >> (OF > YM) >> YF
 - F1 * Listener: ((OF > OM) >> YM) > YF
- F2 effect (steepness of lines) was stronger in younger than older talker and listener conditions.
 - F2 * Talker: OF << (YF < YM) << OM
 - F2 * Listener: (OM < OF) << (YM < YF)
- The unexpected F2 effect in OM is likely driven by high F1 conditions, where /o/ is competing with /ɪ/, not /u/.

Duration:

- Shorter (—) duration causes more high vowel /u/ responses than longer (—) duration.
- The effect was significant only for a subset of the talker and listener group conditions and also differed in strength, consistent with the direction of change.
- Duration * Talker:
 - OM** > OF > YM > YF
 - The unexpected duration effect in YF is driven by high F1 conditions, where /u/ is competing with /ɪ/, not /o/.
- Duration * Listener:
 - OM* > OF** >> (YM** > YF)

">>": significant difference
 ">": non-significant difference

Conclusions

Sound change in progress and F1 and F2 cue

- The study found that the talker and listener age (and to a lesser degree, gender) modulates the use of F1 and F2 cues in /o/ and /u/ perception.
- F1 is used more and F2 is used less in more conservative conditions (older talkers/listeners), while F2 is used more and F1 is used less in more innovative conditions (younger talkers/listeners).

Intrinsic duration cue in vowel height perception

- Listeners attend to the intrinsic duration cue, which originates from vowel height difference, even when the cue is varied independently of F1 (and F2).
- We also observed a trend of reduced importance in the duration cue when listeners or talkers are presumed to be more advanced in the change (loss of F1 contrast).
- This suggests that an intrinsic duration cue may be socially indexed and selectively attended to, but it is still tied to the availability/strength of F1 contrast, falling short of developing into a cue fully independent of F1.