The effect of sound change in the perception of checked versus unchecked tone contrast in Taiwanese Southern Min

Taiwanese Southern Min (TSM) has seven lexical tones: five unchecked tones and two checked tones. The checked tones (high-checked T5 and mid-checked T3) occur with closed CVC syllables, ending in voiceless obstruents [p, t, k, ʔ]. In contrast, the five unchecked tones (high-level T55, low-rising T13, high-falling T51, low-falling T31, and mid-level T33) are associated with open syllables or nasal-closed syllables (Pan, 2017). Besides segmental differences, the short duration and the glottalization in the final portion of the checked vowels are crucial properties for distinguishing checked tones from unchecked tones (Pan, 2017). Pan (2017) reported that TSM checked tones are currently undergoing a sound change where the final coda of the checked syllables is gradually dropped. The rate of coda deletion ranks as /ʔ/ > /k/ > /t/ > /p/. Due to this ongoing sound change, listeners may rely on the preceding vowel of the final coda to distinguish between checked and unchecked tones. Zhang and Lu (2023) examined the role of duration in distinguishing checked and unchecked tones for the coda type /ʔ/. The findings indicated that duration served as a reliable cue in the mid tonal register (i.e., T3 and T33). Building upon their research, the current study expands the investigation to include three additional coda types, /p/, /t/, and /k/. It not only examines the role of duration and glottalization in the checked vs. unchecked contrast but also explores how listeners rely on these two cues in relation to the varying deletion rates of the three coda types in production.

To examine the perception of the checked vs. unchecked contrast, a two-alternative forced choice identification task was conducted with 20 TSM listeners (10 males, 10 females; mean age = 22.4, range = 20-27). Stimuli for the experiment consisted of three types of eight-step continua: Mid/High Checked, Mid/High Unchecked, and All-cue. The duration of the target syllable was manipulating using PSOLA in Praat (Boersma, 2020) for the Mid/High Checked and Mid/High Unchecked continua. Glottalization cues were only present in the Mid/High Checked continua. The All-cue continua utilized Tandem-Straight (Kawahara, 2006) and manipulated both duration and final glottalization by combining endpoints from the Mid/High Checked and the Mid/High Unchecked continua. It is important to note that all the selected target syllables have the same nucleus, a high front vowel /i/. In the stimuli for the coda type /k/, there was a transitional [ə] sound preceding the coda consonant /k/ due to coarticulation of /ik/. Consequently, we anticipate the result for the coda type /k/ may not exhibit a strong duration effect, as the prominent vowel transition cue is likely to provide sufficient coda information to the listeners.

The results (Fig. 1) indicate the absence of categorical perception in the Mid/High Checked and Mid/High Unchecked continua. This suggests that final glottalization plays a more significant role than duration in the perception of checkedness in TSM. Dispite the possibility of coda consonant deletion in the production of TSM checked tones (Pan and Lyu, 2021), glottalization still strongly influences the perception of TSM checked tones at present. One

possible explanation is that the perception input of these young TSM listeners mainly comes from the older generation, who preserve the coda consonant in their production of checked tones. Consequently, the perception of the young TSM listeners does not align with their own production. However, a duration effect can still be observed in these two types of continua. In our result, the Mid register exhibits a stronger duration effect compared to the High register. We consider two possible explanations for this asymmetry. First, the perception of vowel duration can be influenced by F0 height (Gussenhoven and Zhou, 2013; Lu and Lee-Kim, 2021). In our case, stimuli in the High register may be perceived as longer than stimuli in the Mid register, which, in turn, may encourage unchecked tone perception in the High register. Second, glottalization can simultaneously indicate low pitch sounds and checked tones, causing a lower reliability in cuing checkedness in the Mid register than in the High register. As a result, a trading relationship may emerge, where the importance of the duration cue increases as the reliability of the glottalization cue decreases. Except for coda type /k/, the patterns observed in the Mid register showed a convincing duration effect, which aligned with the ranking of coda deletion rates in production: (/k/ >) /t/ > /p/. In Figure 1, we can see that in the Mid register, the coda type /t/ exhibited a greater duration effect compared to coda types /p/ and /k/ in both Mid/High Checked and Mid/High Unchecked continua. The consistent weak duration effect for coda type /k/ can be attributed to the high saliency of the vowel transition cue in its stimuli. Although the participants generally relied more on the glottalization cue than the duration cue in perceiving checkedness in TSM, the stronger role of vowel duration in coda type /t/ compared to coda type /p/ suggests an increasing role of duration in the checked vs. unchecked contrast in TSM after coda deletion.

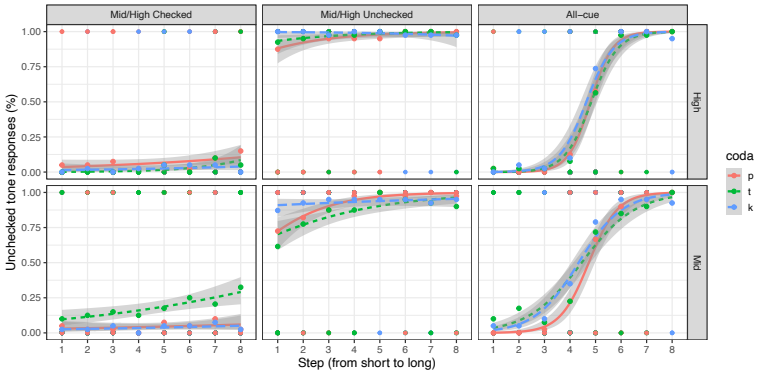

Figure 1: Tonal categorization results: Red = /p/, Green = /t/, Blue = /k/. Rows: High register (top), Mid register (bottom). Columns: Mid/High Checked (left), Mid/High Unchecked (middle), All-cue (right).

Selected references

Pan, Ho-hsien. (2017). "Glottalization of Taiwan Min checked tones." *Journal of the International Phonetic Association* 47.1: 37-63.

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