Production and perception of the coda nasals in Shanghai Mandarin

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Overview. Speakers of regional dialects of Standard Mandarin (i.e., Taiwan Mandarin, Shanghai Mandarin) have been thought to merge the coda nasals /n/ and /ŋ/ after non-low vowels such as /ə/ and /i/. Studies vary in describing the resulting codas as [n] or [ŋ], depending on the methods used (Yang 2010, Guan 2019, Chiu et al. 2019). To resolve this contradiction, we carried out production and perception experiments to determine the contexts which condition neutralization and the place of articulation of the resulting nasal in Shanghai Mandarin.

Production study. Ultrasound imaging was used to examine the articulation of nasal codas by 5 monolingual Standard-Mandarin speaking controls (M) and 15 Shanghai Mandarin speakers (S), who all also speak Shanghainese, the local Wu Chinese variety. The dimensionality of the ultrasound signal was reduced using principal components analysis. The resulting data were submitted to a linear discriminant (LD) analysis, with *canonical* nasal coda tokens defined as those having a strongly [n]-like (less than 0.4) or [ŋ]-like (less than 0.6) LD value.

While the coda nasal contrast was always maintained after /a/, and in all contexts for M speakers, S speakers neutralize after /ə/ and /i/. Nasals produced after /ə/ were mostly canonical: S speakers varied non-contrastively between [ən] and [əŋ]. After /i/, S speakers' nasals are mostly *non-canonical* (Fig. 1). Inspection of ultrasound data indicates that non-canonical nasals are fronted velar or palatal (Fig. 2).

Perception study. In a follow-up focused on the /i/ context, we used an AXB discrimination task to test whether Shanghainese (S) listeners and Mandarin (M) control listeners could discriminate canonical and non-canonical [in] and [iŋ] tokens from the production study. M listeners (n=15) performed better than S listeners (n=14), who performed at chance, although discriminability was surprisingly low overall for both listener groups (Fig. 3). Instead of the bias towards /in/ observed in previous research (Zee 1981), a logistic regression model showed that all listeners had a bias towards /iŋ/ responses for tokens other than Mandarin /in/ (Fig. 4).

Discussion. Neutralization in Shanghai Mandarin has different outcomes after /i/ and /ə/: after /i/, fronted dorsal [iŋ̟] or [iɲ], as a consequence of coarticulation with [i]; but after /ə/, non-contrastive variation between [ən] ~ [əŋ]. This finding suggests that vowels with a relatively high degree of articulatory constraint, such as /i/ (Recasens & Rodríguez 2016), condition less structure-preserving outcomes in neutralization than those vowels with a lower degree of articulatory constraint such as /ə/.

M speakers produce distinct [in] and [iŋ], but even they failed to discriminate [in] and [iŋ] at the high level expected for a native phonemic contrast. Both listener groups' poor discrimination performance are consistent with findings of previous perception studies (Mou 2006) and may indicate a near-merger for the M speaker group.

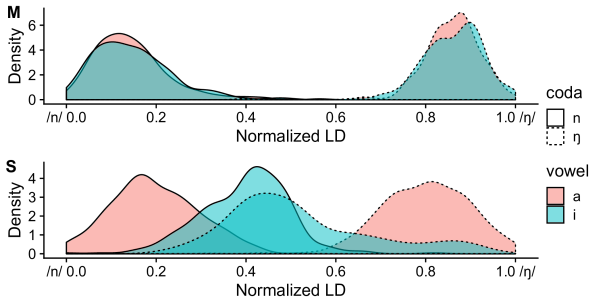

Figure 1: Typical M and S speakers' production data (0 = [n]-like, 1 = [ŋ]-like). Note tail for S speakers' /iŋ/ where LD > 0.6, the source of canonical [iŋ] for the perception study.

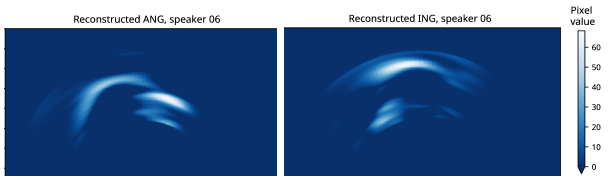

Figure 2: Reconstruction from principal components of canonical [ŋ] (left) and non-canonical [n̪] (right) for a Shanghai Mandarin speaker. Bright contour is tongue surface; right is anterior.

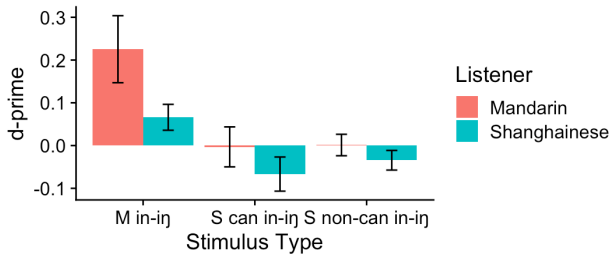

Figure 3: d-prime for AXB discrimination task by talker and coda type.

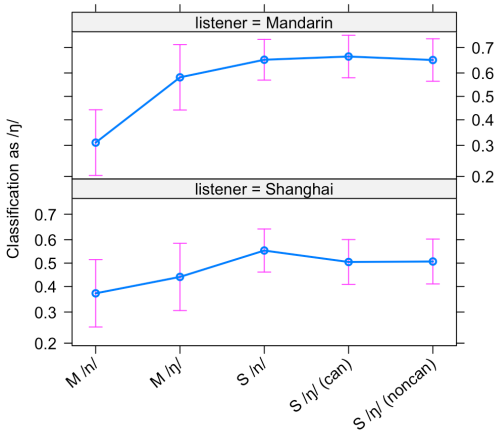

Figure 4: Effects plot for mixed-effects logistic regression (fixed effects of stimulus type, listener group, interactions; random intercepts for listener and speaker).

References: Chiu, C. et al (2019). Uncovering syllable-final nasal merging in Taiwan Mandarin: ultrasonographic investigation of tongue postures and degrees of nasalization. ICPhS 19. **Guan, Y.** (2019). Nasal coda realization in speech production of Shanghai Mandarin. ICPhS 19. **Mou, X.** (2006). Nasal codas in Standard Chinese: a study in the framework of the distinctive feature theory (PhD dissertation, MIT). **Recasens, D. & Rodríguez, C. (2016).** A study on coarticulatory resistance and aggressiveness for front lingual consonants and vowels using ultrasound. JPhon 59. **Zee, E.** (1981). Effect of vowel quality on perception of post-vocalic nasal consonants in noise. JPhon 9(1).