Testing the production-perception link in a sibilant fricative contrast

Caihong Weng[1], Alexander Martin[2], and Ioana Chitoran[1]

[1] *Université Paris Cité (France)* [2] *University of Groningen (Netherlands)*

BACKGROUND. The merger of the Mandarin /s/~/ʂ/ contrast, known as "deretroflexion", frequently occurs in Mandarin spoken by bilingual Southern Min speakers, whose L1 lacks the retroflex category [4]. Recent studies of the /s/~/ʂ/ contrast in this population have highlighted high levels of individual variation [2, 3, 5]. The present study aims to explore a key question related to this variation: are individual speakers who produce a stronger contrast also those who can better perceive the contrast? To address this, we examine how a single group of bilingual speakers of L1 Quanzhou Southern Min (QSM) and L2 Mandarin both produce and perceive the sounds [s] and [ʂ], allowing us to explore the relation between perception and production in the same speaker.

METHOD. 54 QSM-Mandarin bilinguals (28 women, 26 men) from Quanzhou, China completed both a sentence reading and an ABX discrimination task. In sentence reading, all materials were CVCV Mandarin real words. Lexical frequency was controlled to be within a log frequency range of 3–5. For the ABX task, we compared perception of a control contrast [m]~[p] (present in both the L1 and L2 and taken as baseline performance in the task) to the target contrast [s]~[ʂ] in two vowel contexts ([a] and [u]). Stimuli were CVCV nonsense words, with a high-level tone.

RESULTS. *Production*: Four spectral moments were extracted at the mid-point of the fricative, though we focus here on Center of Gravity (CoG). We computed a difference score for each participant by subtracting the mean CoG of the retroflex fricative from that of the alveolar fricative (ΔM = (M (alveolar) − M (retroflex)). As is clear in fig. 1, a large number of participants had a difference score close to zero, indicating no production of a contrast. L1 Mandarin speakers have been shown to produce a difference between these fricatives in the range of 2,000–5,000 Hz [1]. *Perception*: We used a logistic mixed-effect model to compare the target contrast in each vowel context to the control contrast. Our full model included a fixed effect for Contrast (control, target-[a], target-[u]) and both random intercepts for participants including random slopes for Contrast. We found significant effects for Contrast ([ma]~[pa] vs. [sa]~[ʂa]: $z = -12$, $p < 0.001$; [ma]~[pa] vs. [su]~[ʂu]: $z = -14$, $p < 0.001$), indicating that participants had a significantly harder time discriminating the target fricatives than the control contrast (see fig. 2). *Production-perception link:* Following [6], we ran two linear regressions, using performance in the ABX task on the target contrast in the context of [a] and in the context of [u] to predict performance on the control contrast. From these regressions, we extracted the residuals, with lower values indicating worse discrimination of the target [s]~[ʂ] contrast relative to the control contrast. For each vowel context, participants' CoG difference score in production was then predicted using these residuals (see fig. 3). In the context [a], the relationship between ABX residuals and CoG contrast difference was not statistically significant ($R^2 = 0.07$, $p = 0.057$). In contrast, in the context [u], the residuals did significantly predict CoG differences ($R^2 = 0.13$, $p < 0.01$).

DISCUSSION. This study on bilingual QSM-Mandarin speakers found, in line with previous work, much individual variability in the production of the Mandarin sibilant fricative contrast. We found significantly worse perception of the target contrast relative to a control contrast, in both tested vowel contexts. A significant relationship between perception and production was noted in the context of the vowel [u], indicating that participants who could better perceive the target contrast in this context were also those who produced a larger difference between the target fricatives in sentence reading. We did not observe a similar significant relation in the context of the vowel [a]. Given the large number of speakers who made no difference between the target fricatives in production, it will be interesting in future work to see if these relations hold only for a specific subset of the population (e.g., speakers who make some reliable contrast in production), or if our results were affected by our comparison across processing levels: non-words for perception and real words in production.

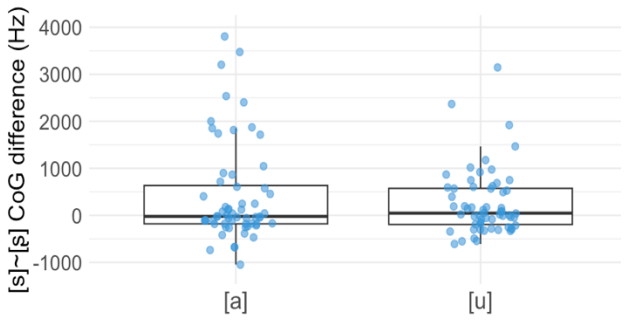

Figure 1: [s]~[ʂ] production in vowel contexts

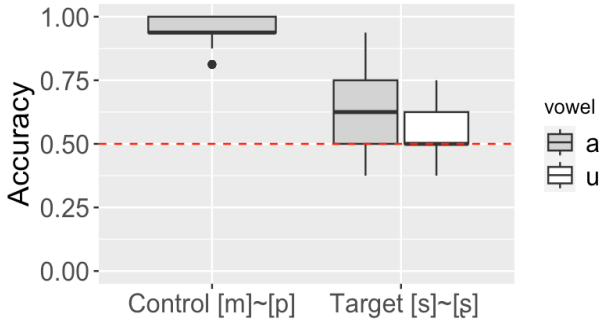

Figure 2: ABX discrimination accuracy for control and target contrast

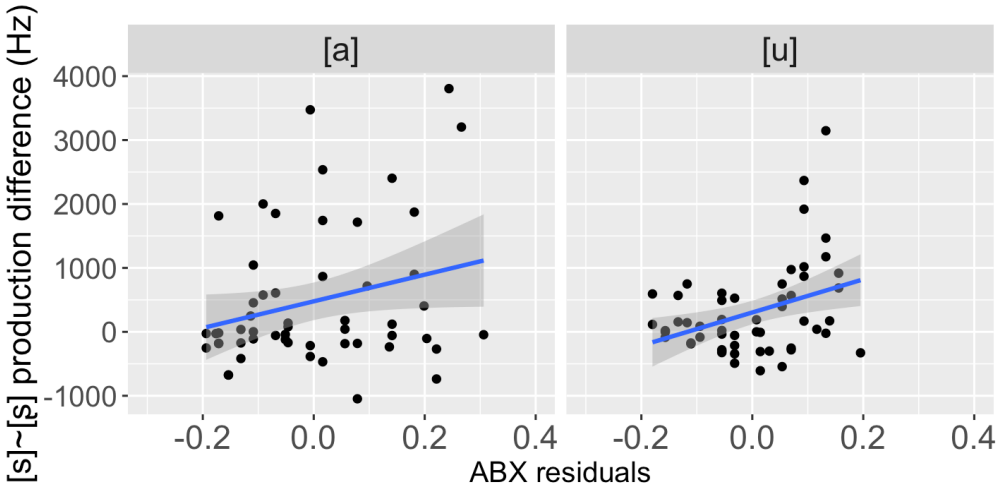

Figure 3: Regression of contrast production difference by participant as a function of the residuals extracted from the ABX task.

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