Preliminary ultrasound investigation on the production of Mandarin /r/ sounds by Japanese learners

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INTRODUCTION

- The acquisition of English /r/ by Japanese learners is a very thoroughly researched topic in speech acquisition [1].

  ➤ Japanese learners typically tend to assimilate both English /r/ and /l/ to a single sound category, the Japanese /r/.
  ➤ Asymmetric assimilation: more likely to assimilate the English /l/ to the Japanese /r/ than to the English /r/.
  ➤ Few studies on rhotic sounds for Japanese learners in other languages, e.g., the Mandarin Chinese /r/.

- Mandarin /r/ and English /r/

  ➤ Both can be prevocalic, syllabic and postvocalic.
  ➤ Differ in articulatory gestures, bunched and retroflex gestures are used in all syllable positions in English, while only bunched gesture is used for Mandarin prevocalic /r/ [2].
  ➤ How about the production of Mandarin /r/ by Japanese learners?

- Early and late bilinguals

  ➤ Past studies have shown that early language experience can provide a significant boost to speakers' production and perception of that language later in life in comparison to L2 learners with no prior experience [3].
  ➤ Theoretically interesting to compare the production between early learners and late learners.

- **The present study**: this study investigated the production of Mandarin /r/ sounds by Japanese-Mandarin simultaneous bilinguals (early bilinguals) and advanced Japanese learners of Mandarin (late bilinguals) to test relevant speech acquisition theories [4] [5].
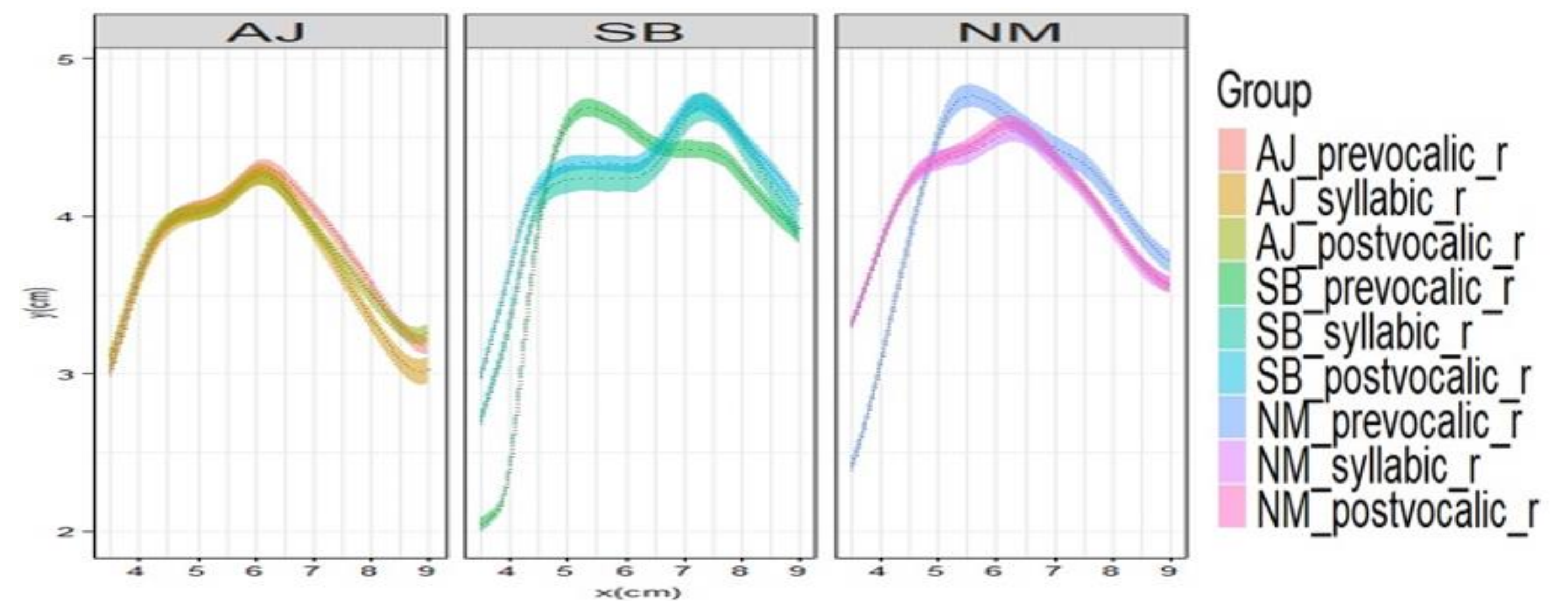
METHOD

- **Participants**
- Two target groups

  ➤ Advanced Japanese learners of Mandarin (AJ group): 6 participants, who learned Mandarin as L2, with over 1-year immersion in Beijing and HSK-6 level.
  ➤ Japanese-Mandarin simultaneous bilinguals (SB group): 6 participants, who acquired both Mandarin and Japanese from an early age with their mothers being native Mandarin speakers.

- One baseline group

  ➤ Native Beijing Mandarin speakers (NM group): 6 participants, born and grow up in Beijing, have not learned Japanese.

- **Stimuli:** allophones of the Mandarin /r/

  ➤ Prevocalic /r/: 14 tokens, e.g., 如 [ɻu]
  ➤ Syllabic /r/: 3 tokens, e.g., 儿 [ɚ]
  ➤ Postvocalic /r/: 32 tokens, e.g., 皮儿 [bʰiɻ]
  ➤ Carrier phrase: 他答__吧 ([tʰaˈtaˌ/__baˈ])

- **Procedure**

  ➤ Ultrasound data collected with the Telemed Echo B 128 ultrasound system at a frame rate of 36Hz.
  ➤ The participants' heads were unconstrained by the helmet, they were seated on a chair with their jaw rested on the ultrasound probe, as shown in the picture above.
  ➤ The target words embedded into the carrier phrase were shown in the PPT slides on a laptop screen in front of the participants.

- **Data analysis**

  ➤ The tongue splines: drawn manually with Articulate Assistant Advanced (AAA) software, with sixty equally spaced data points on each spline.
  ➤ Smoothing spline ANOVA (SS-ANOVA): used to compare tongue curves.
 ➤ tongue contours: generated using the "gss" and "lme4" packages in R [6].
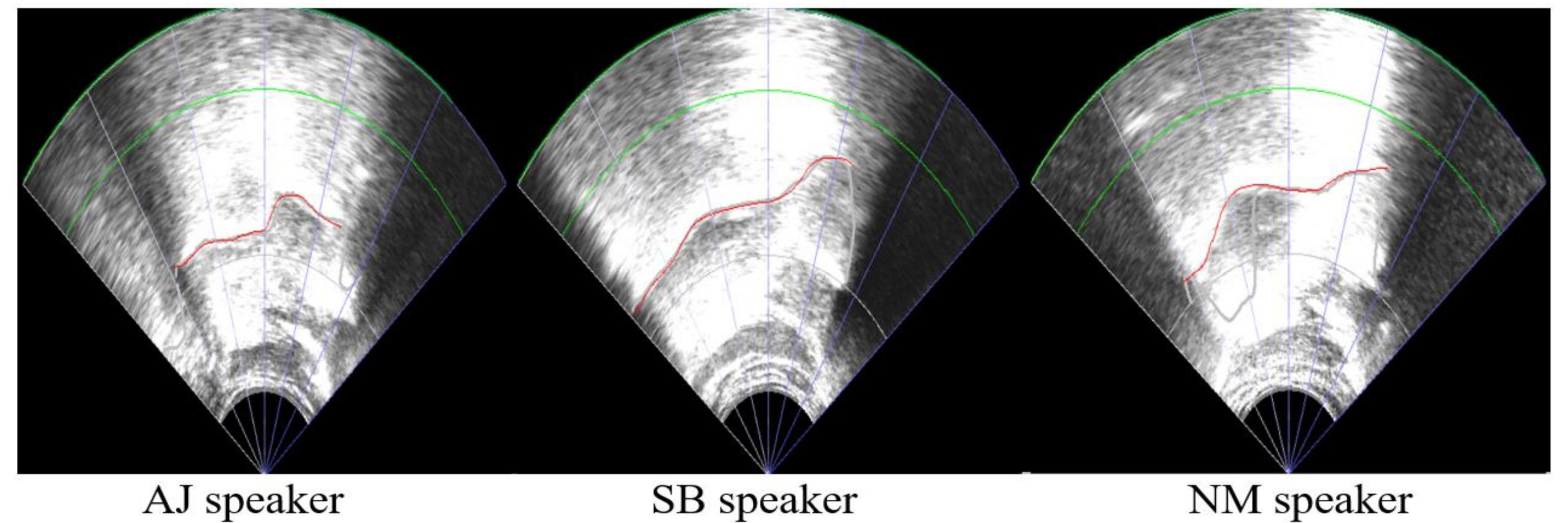
RESULTS

- Figure 1. tongue contours of the Mandarin /r/ sounds produced by NM, SB and AJ speakers
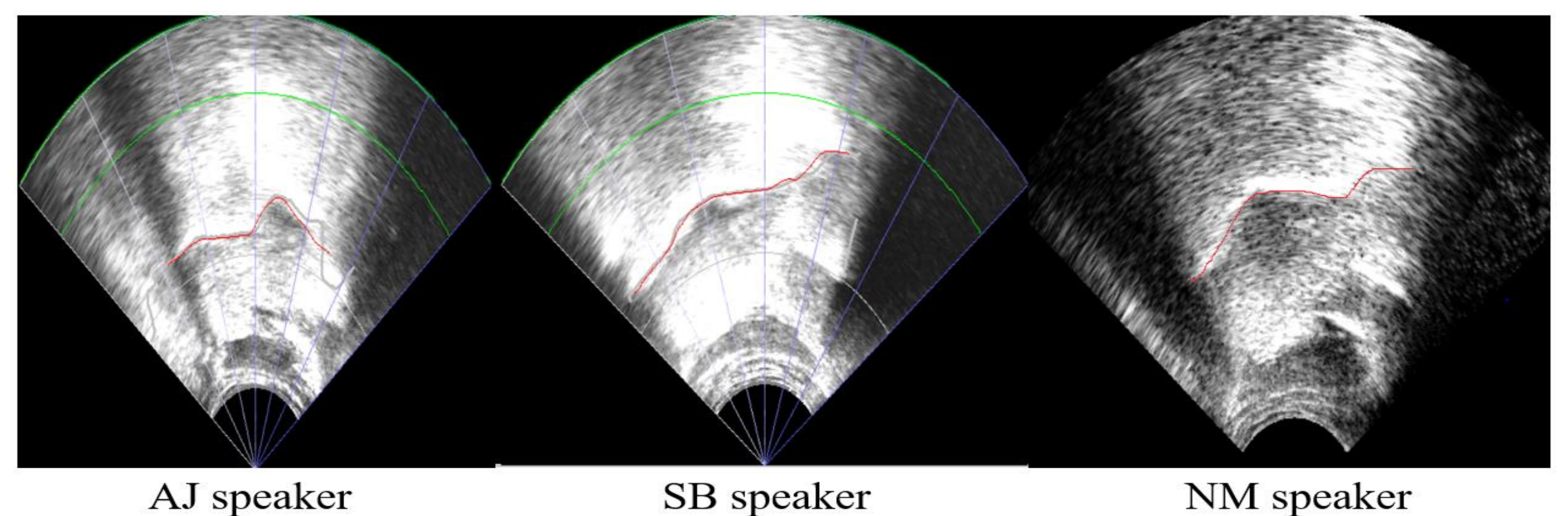

Group
AJ_prevocalic_r
AJ_syllabic_r
AJ_postvocalic_r
SB_prevocalic_r
SB_syllabic_r
SB_postvocalic_r
NM_prevocalic_r
NM_syllabic_r
NM_postvocalic_r

- Ultrasound images produced by one speaker from each group.
  ➤ Figure 2. ultrasound images of the stimuli "入" [ɻu] (prevocalic /r/).

AJ speaker   SB speaker   NM speaker
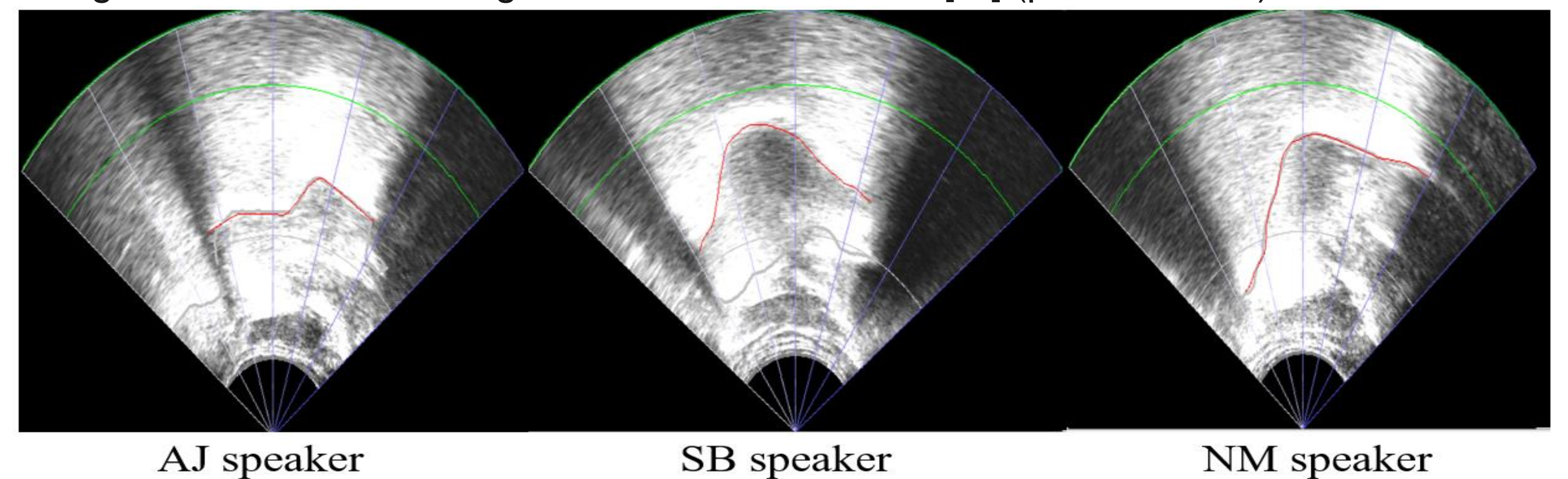
  ➤ Figure 3. ultrasound images of the stimuli "耳" [ɚ] (syllabic /r/).

AJ speaker   SB speaker   NM speaker

  ➤ Figure 4. ultrasound images of the stimuli "事儿" [ʂɻ] (postvocalic /r/).

AJ speaker   SB speaker   NM speaker

- Summary of articulatory patterns
  ➤ SB & NM groups: adopted similar tongue gestures for syllabic /r/ and postvocalic /r/, which were different from that of prevocalic /r/.
  ➤ AJ group: used a similar tongue gesture for all the three Mandarin /r/ sounds.

DISCUSSION

- SB speakers had an advantage over the AJ speakers in producing Mandarin /r/ sounds.

  ➤ The AJ speakers failed to produce allophones of the Mandarin /r/ with different articulatory gestures as the NM and SB speakers did.
  ➤ Consistent with the previous studies that early language learners have advantages over late language learners [3].

- Possible reason: AJ speakers were not aware of the subtle difference between the allophones of Mandarin /r/.

  ➤ Provided with explicit instruction and more inputs, the AJ speakers might acquire the different articulatory gestures for the Mandarin /r/ sounds.

- Further work will analyze the ultrasound data of more participants and test the perceptual relationship between Mandarin /r/ and Japanese /r/.

Reference: [1] Goto, H. (1971). Auditory perception by normal Japanese adults of the sounds "L" and "R". Neuropsychologia, 9(3), 317-323 [2] Chen, S. & Mok, P. (2021) Articulatory and acoustic features of Mandarin /ɻ/: A preliminary study. In Proceedings of the 12th International Symposium on Chinese Spoken Language Processing (ISCSLP 2021). Hong Kong (online). [3] Montrul, S. A. (2008). Incomplete Acquisition in Bilingualism: Re-examining the Age Factor (John Benjamins Publishing, Amsterdam), pp. 1–312. [4] Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. In W. Strange (Ed.), Speech perception and linguistic experience: Issues in cross-language research (pp. 233–277). [5] Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception. Language Experience in Second Language Speech Learning, 13- 34. [6] Davidson, L. (2006). Comparing tongue shapes from ultrasound imaging using smoothing spline analysis of variance. The Journal of the Acoustical Society of America, 120(1), 407–415.