Spatial Co-variation of Lip and Tongue at Strong and Weak Syllables

Ju Zhang [1], Kiyoshi Honda [1], Jianguo Wei [2, *], Jianrong Wang [1], Jianwu Dang [1, 3]

[1] School of Computer Science and Technology, Tianjin University

[2] School of Computer Software, Tianjin University

[3] School of Information Science, Japan Advanced Institute of Science and Technology

Introduction

➢ The purpose of this present study is to explore evidence of articulatory co-variation during speech production through the analysis of orofacial visual data:

    ➢ To observe opening, spreading, narrowing and protrusion of the lips, and

    ➢ To examine the relationship between those components and tongue surface deformation.

➢ The hypothesis is proposed that the lip and tongue will exhibit certain extent of synergistic co-variation between vowels at different levels of syllable strength in sentences.
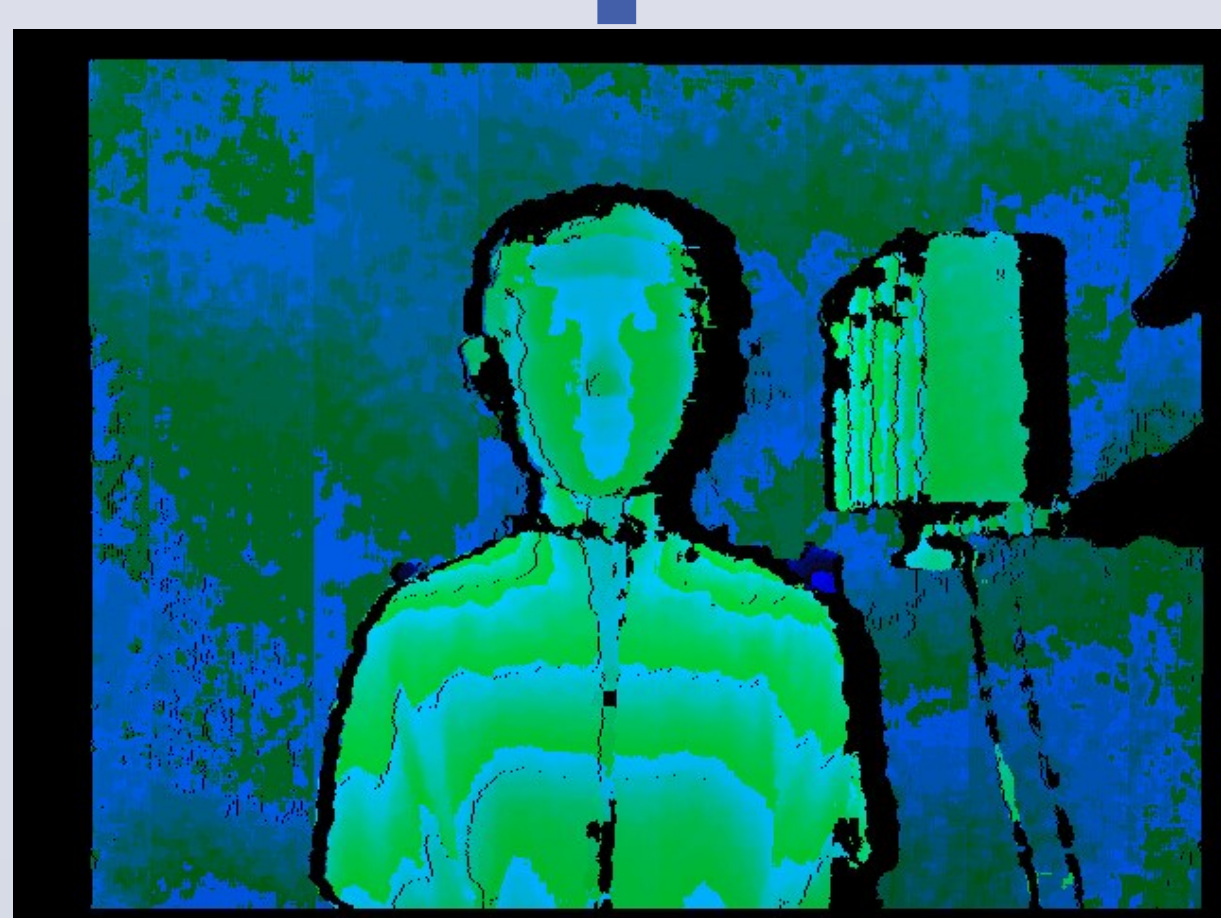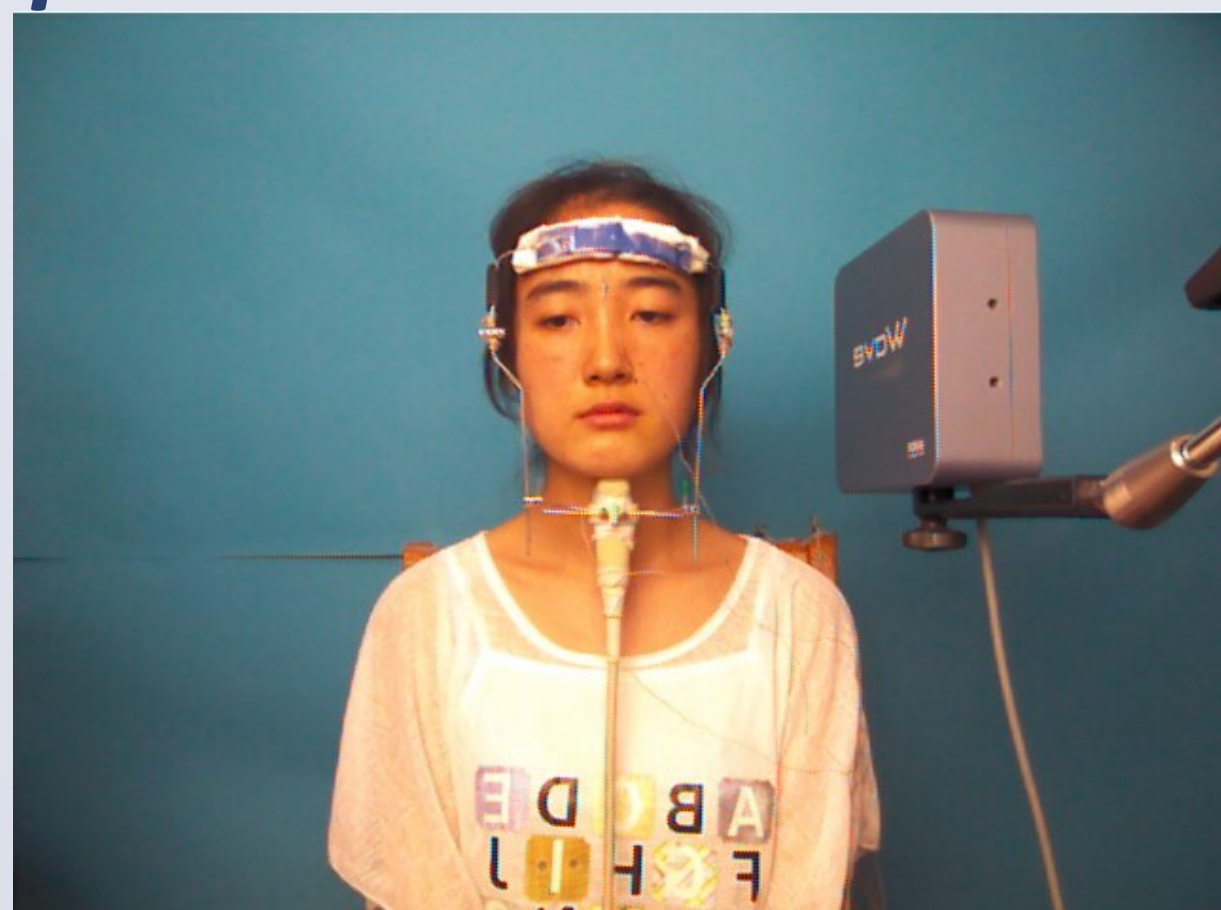
Method

Participants

➢ Two females (JL and YXQ)

➢ Native speakers of Chinese

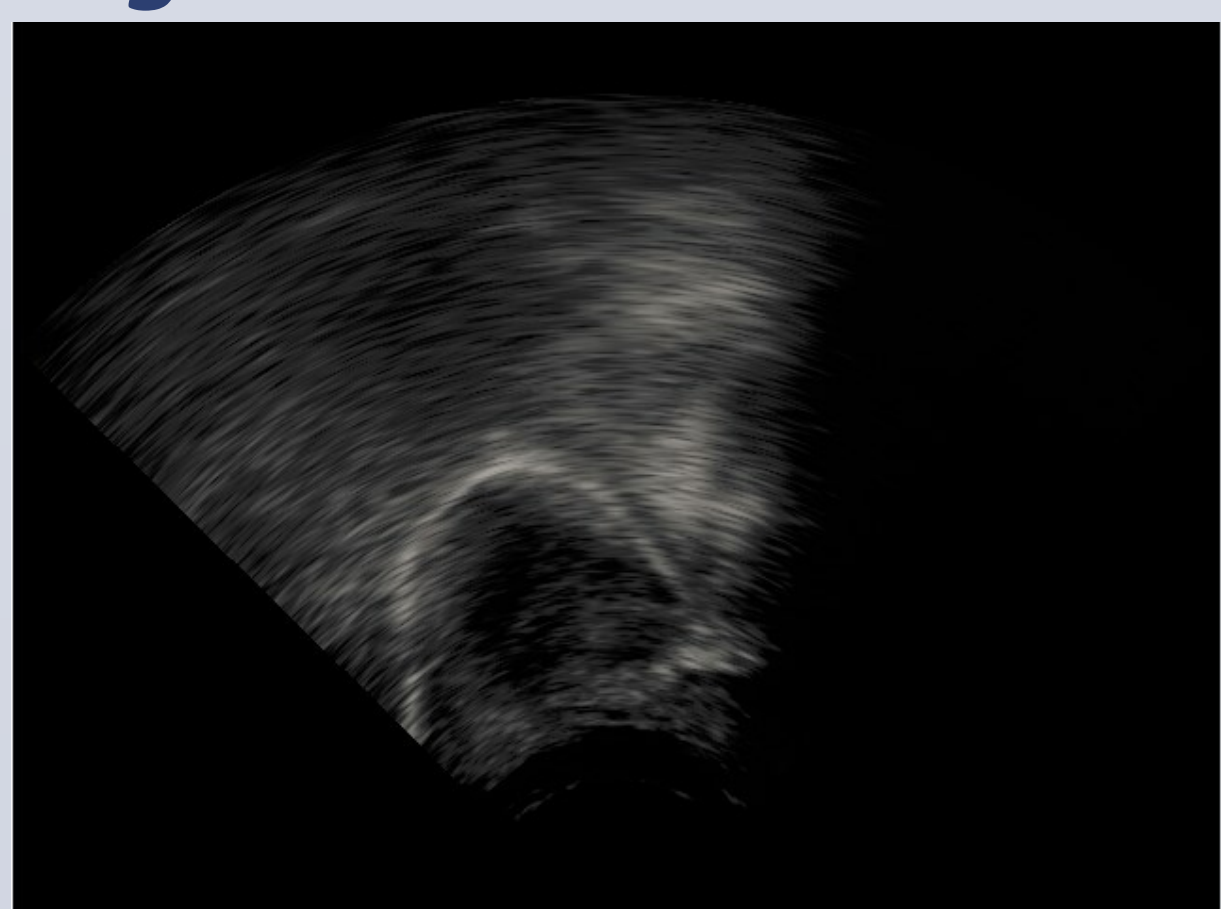➢ Speak Mandarin without any accent

Movement Recording

➢ Devices:

    ➢ Kinect for Windows V1

    ➢ USG: Terason T3000

    ➢ EMA: NDI WAVE

➢ Data acquisition system

Lip Movement

Linguistic Materials

➢ Short Chinese sentences having words with three cardinal vowels (/a/, /i/ and /u/).

ID	X-axis (m)	Y-axis (m)	Z-axis (m)
1	-0.01072254	0.03575364	0.61540090
2	-0.00050928	0.03667182	0.60343380
3	0.00996060	0.03691253	0.59397000
4	0.02205119	0.03714915	0.60125030

Tongue Movement

Head and Ultrasound Probe Movement

➢ NDI WAVE magnetic sensing system:

    ➢ Three receivers for head

    ➢ Two receivers for USG probe
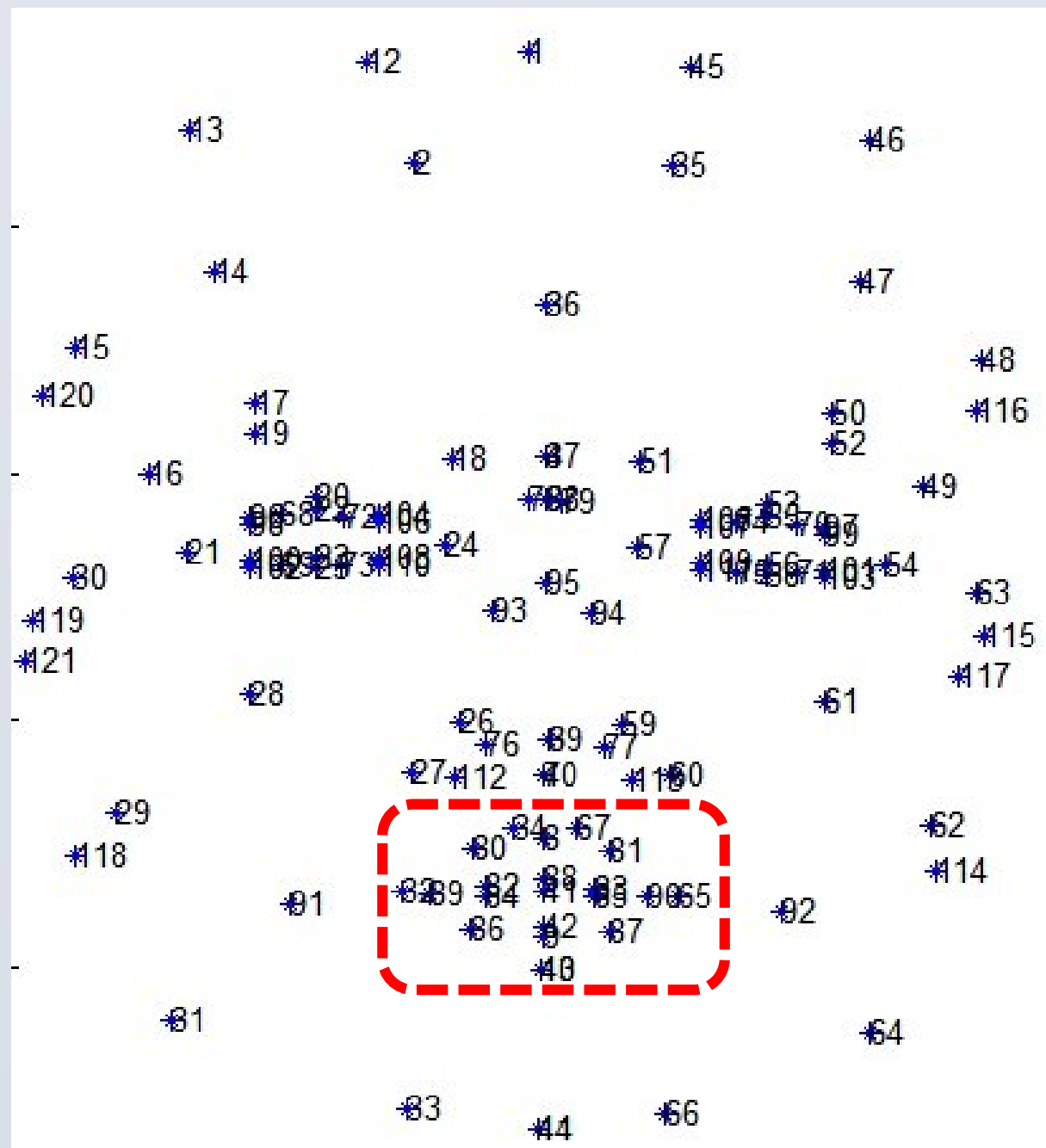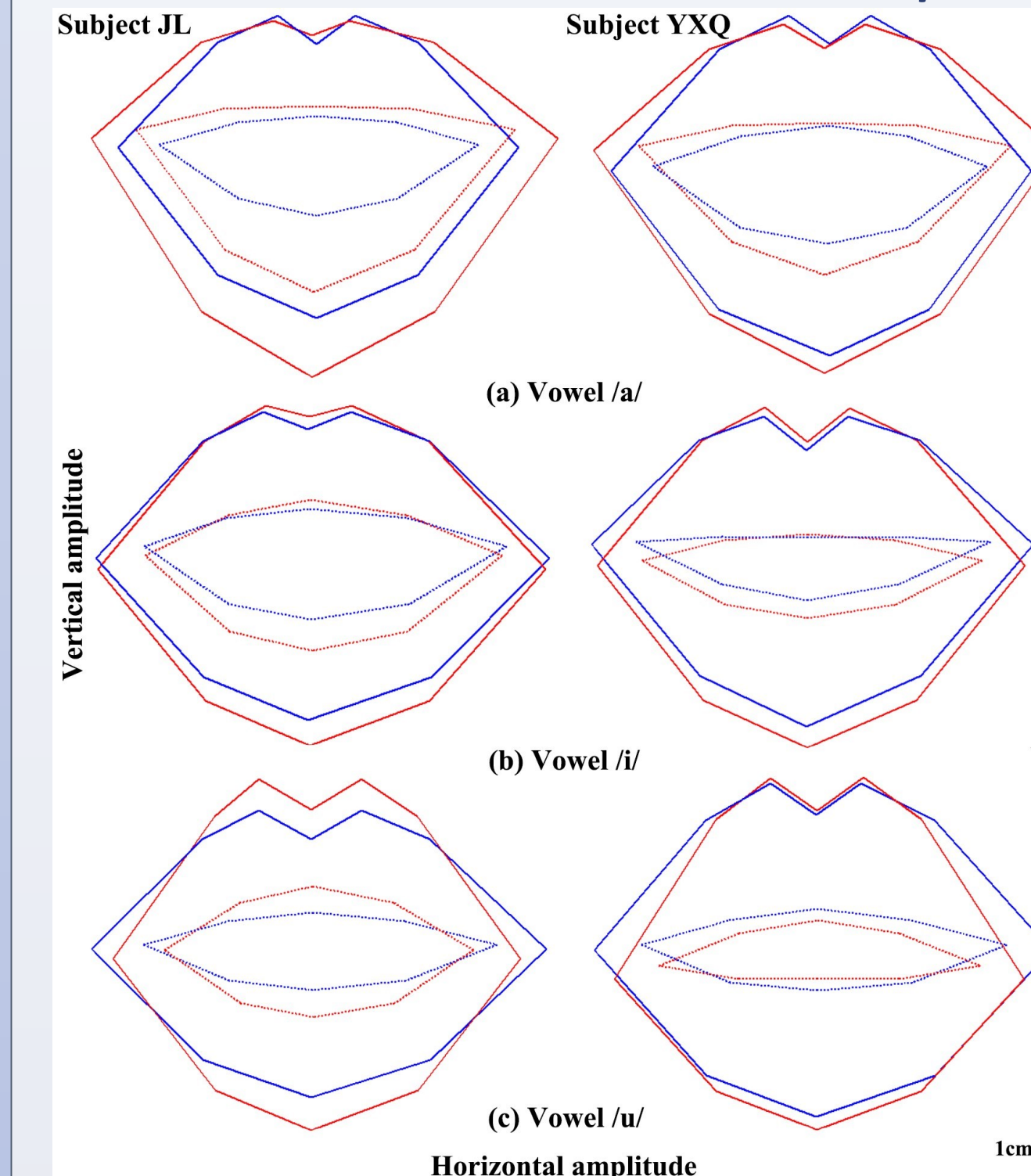
Data Post-processing

➢ Lip and tongue information synchronization and alignment

Deformation Analysis

➢ 3D lip model reconstructed from 18 3D lip points

➢ Tongue contour described by 33 points from EdgeTrack program
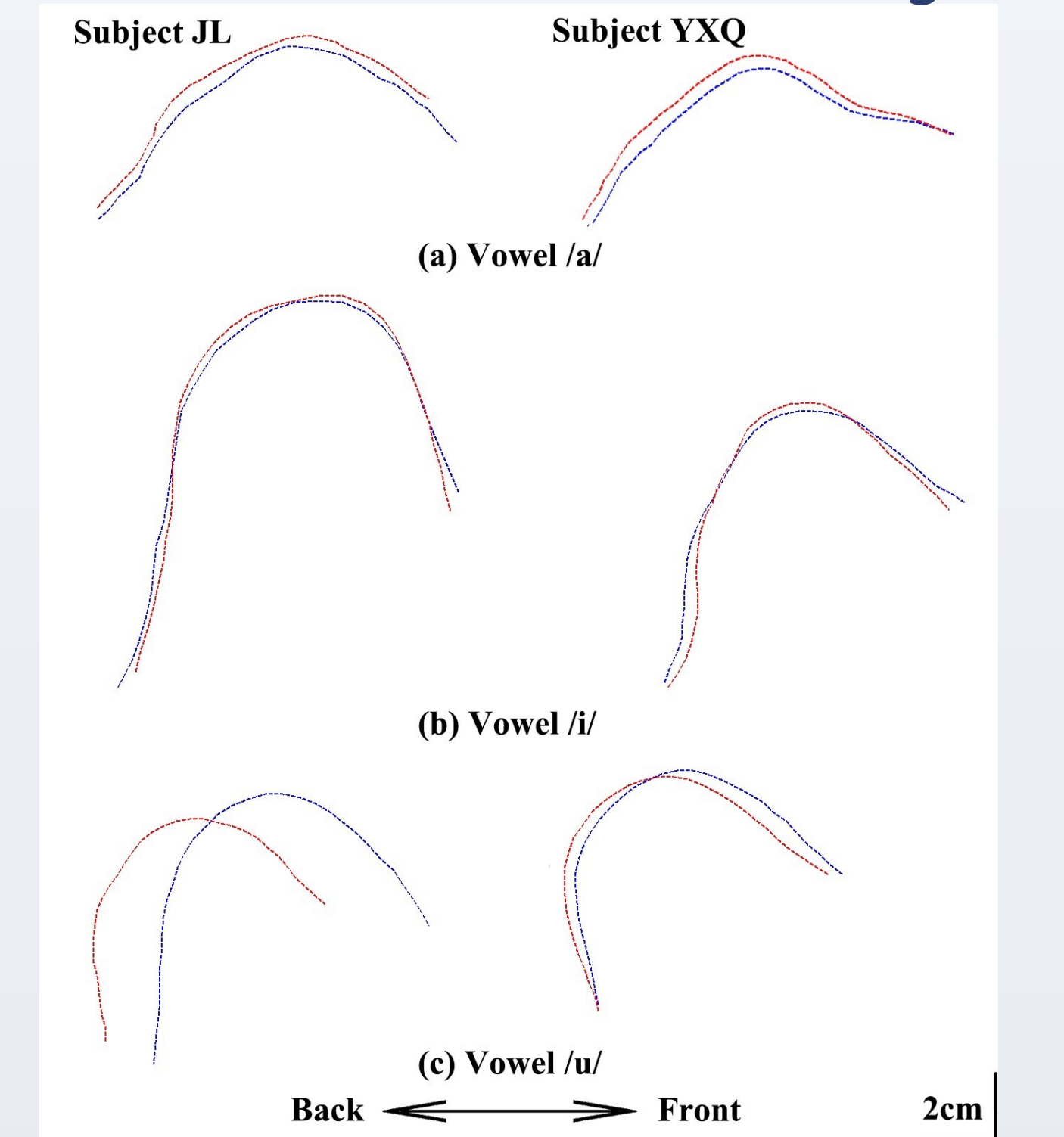
Results

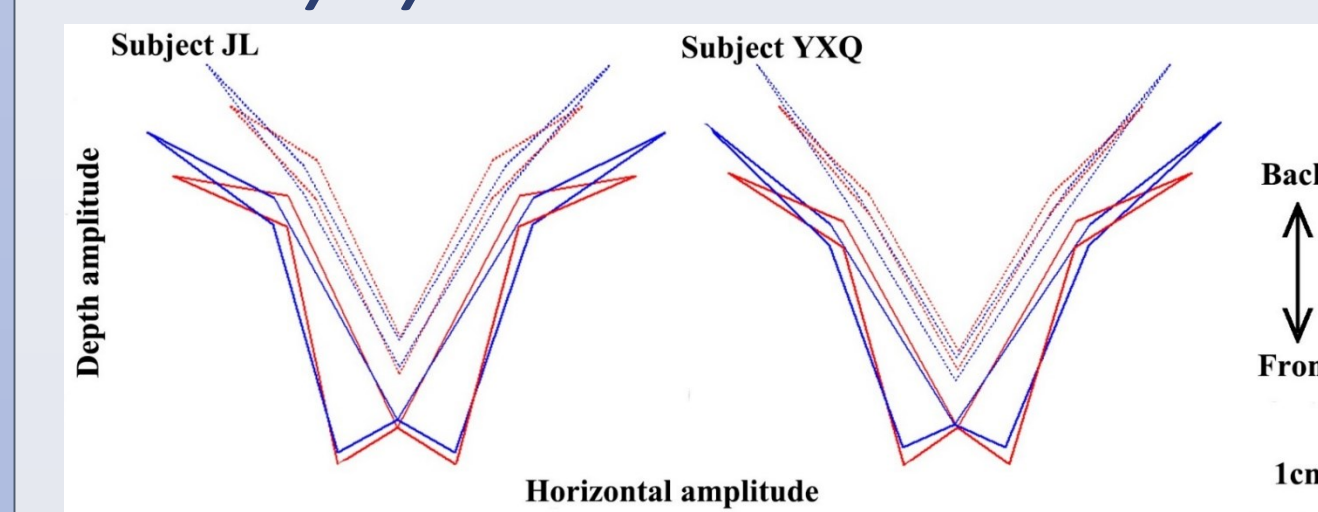### Lip and Tongue Deformation at **Strong** and **Weak** Syllables

Front-views on 3D mean lip

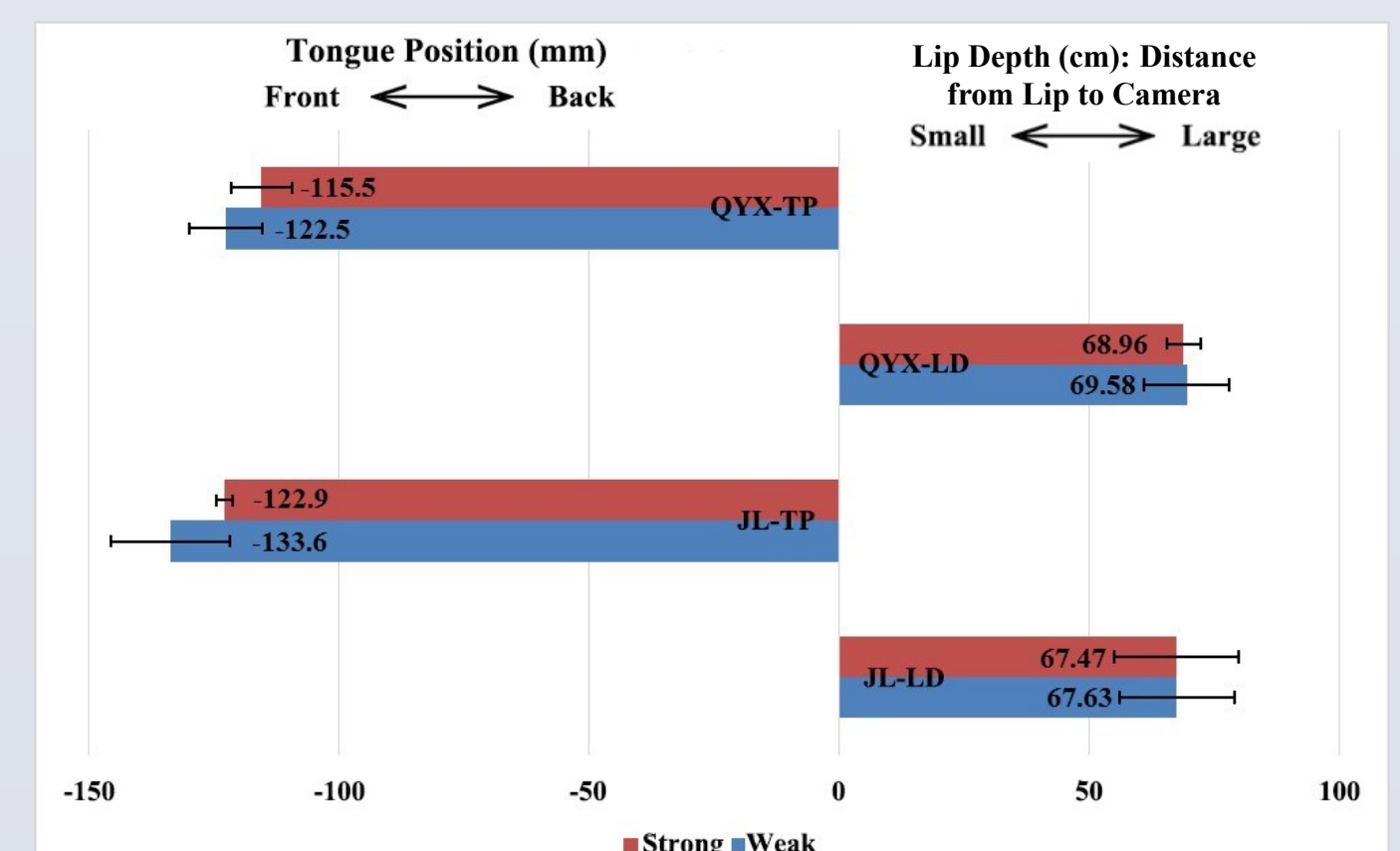*Lateral-views on mean tongue*

Top-views on 3D mean lip at vowel /u/
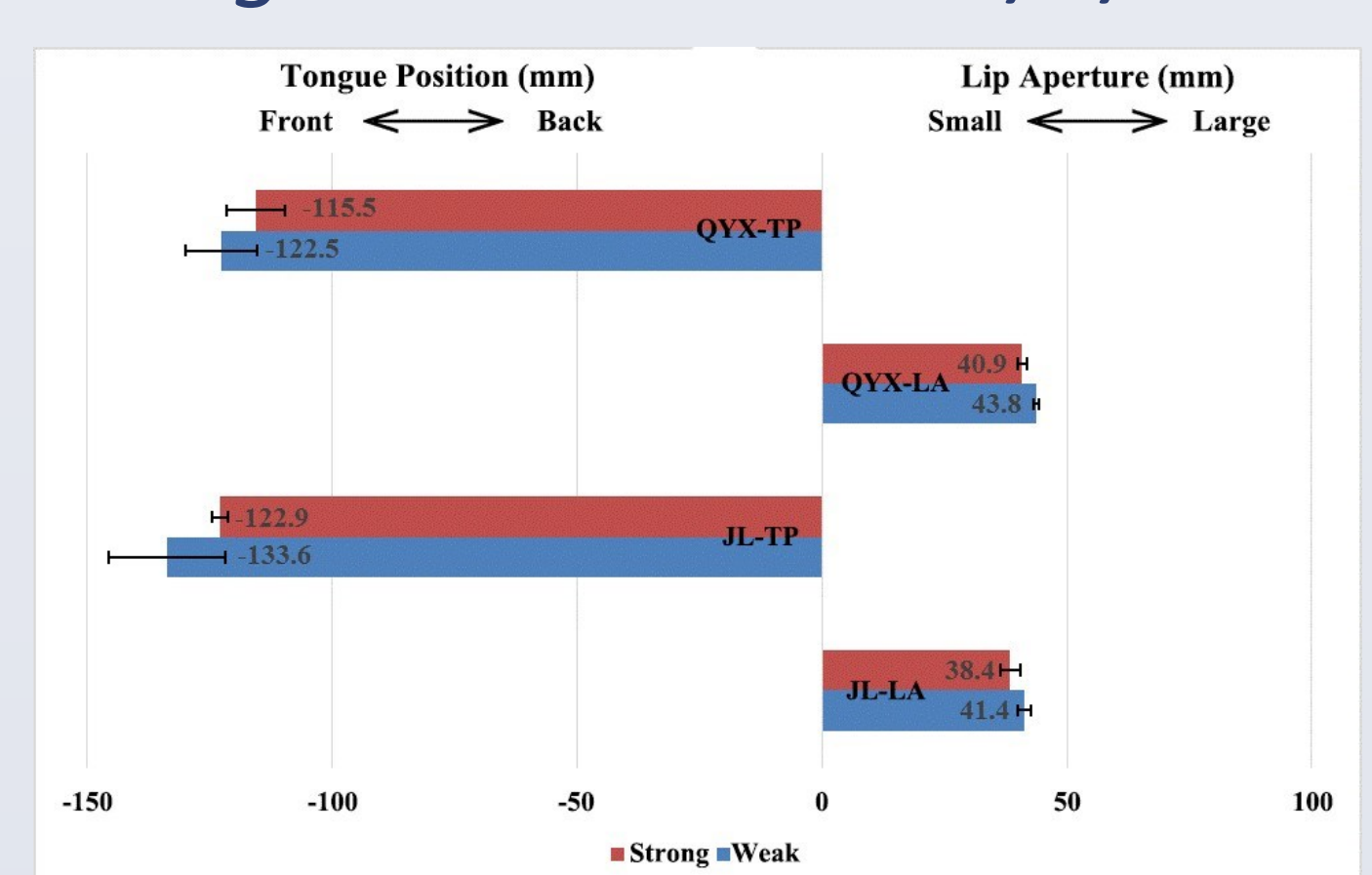
Co-variation of lip shape and tongue position

Tongue position vs. lip shape at strong and weak vowel /a/

Tongue position vs. lip shape at strong and weak vowel /u/
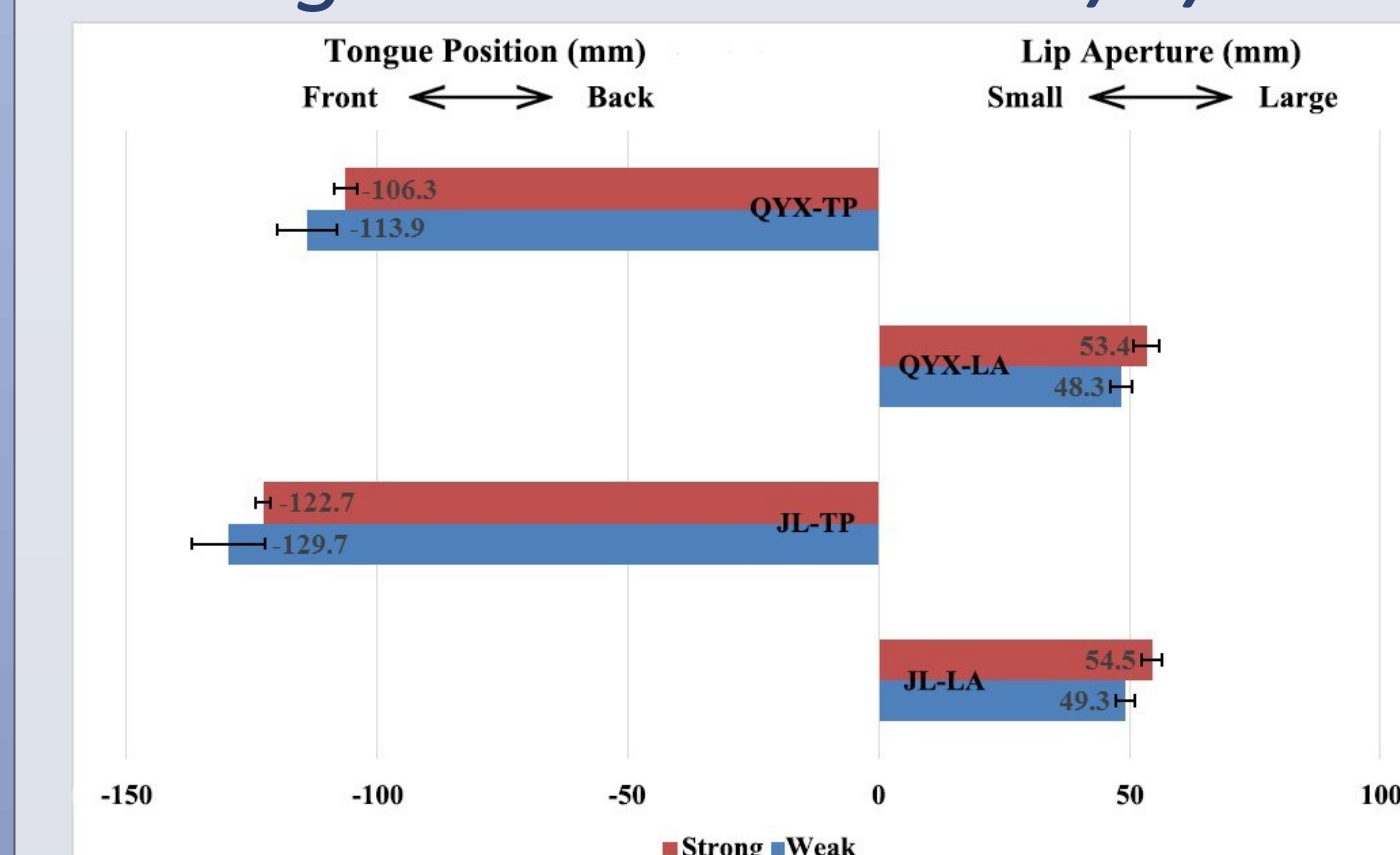
Conclusion

➢ This study attempted to reveal the patterns of articulatory co-variation by comparing lip and tongue articulation of vowels with emphatic variations.

➢ Those observations above support the hypothesis that when the mouth opens wide, the tongue moves back, and when the lips protrude, the tongue is retracted.

➢ The tendency of synergistic co-variation between the lips and tongue suggests their simultaneous extreme articulation at strong syllables than at weak syllables unlike in a previous report[4].

References

[1] W. J. Hardcastle, J. Laver, and F. E. Gibbon, *The handbook of phonetic sciences*, John Wiley & Sons, 2010.

[2] B. Gick, I. Wilson, and D. Derrick, *Articulatory Phonetics*, John Wiley & Sons, 2012.

[3] V. L. Gracco, and A. Lofqvist, "Interarticulator programming in VCV sequences: Lip and tongue movements," *The Journal of the Acoustical Society of America*, vol. 105, no. 3, pp. 1864-1876, 1999.

[4] J. S. Perkell, M. L. Matthies, and M. A. Svirsky, "Trading relations between tongue-body raising and lip rounding in production of the vowel/u: A pilot "motor equivalence" study," *The Journal of the Acoustical Society of America*, vol. 93, no. 5, pp. 2948-2961, 1993.

Acknowledgements