Speech Errors in Fast Speech of Alveolar and Alveo-palatal Consonants: A Preliminary Study Using Ultrasound

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Introduction

- Speech errors occur even in typical speakers during fast speech.

- Speech errors are often gradual (Slis and van Lieshout, 2016; Dawson, 2020)
  ➞ difficult to identify based on auditory perception alone.

- We focused on alveolar and alveo-palatal consonants, /sa ɕa/ and /ta tɕa/,
  and observed the spectral Center of Gravity (CoG) and tongue movements
  - CoG corresponds to the length of the front cavity (Stevens, 1998)

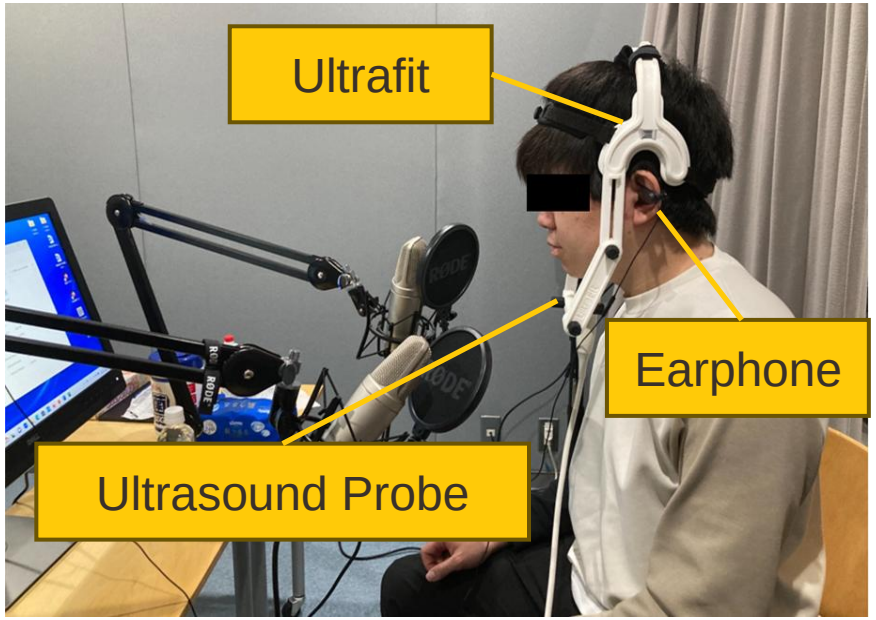
【Hypothesis】

As the tongue body elevates, the CoG would also increase.

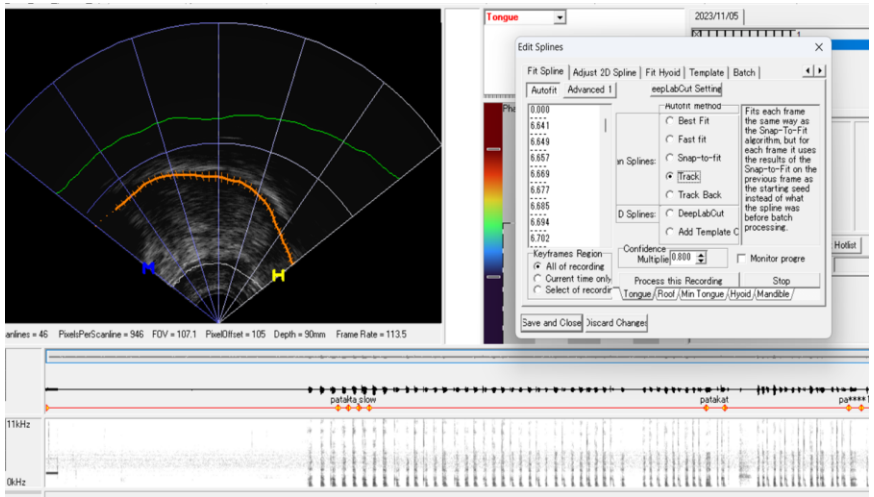
Methods

Participants: Native Japanese speakers
(M:2, F:1)

Experiment:
Pronounced repeatedly in time with the metronome
(BPM = 480, 6s)
Stimuli ➞ /sa ɕa/ and /ta tɕa/



Analysis:
1. Auditorily judgements of each token
   as correct or error
2. Measurements of each consonant's spectral CoG
3. Analysis of ultrasound image in AAA
(Articulate Instruments Ltd., 2023)



Results 1. /sa ɕa/

Error rate:

SP01 = 59%, SP02 = 24%, SP03 = 25%

(updated from the values listed in the abstract)

Mean CoG for correct utterances:

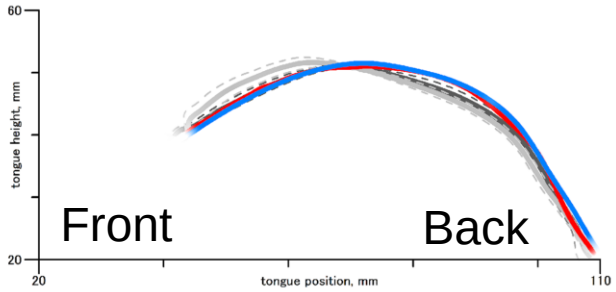
SP01→**/s/** was higher than /ɕ/

SP02 & SP03→ **/ɕ/** was higher than /s/

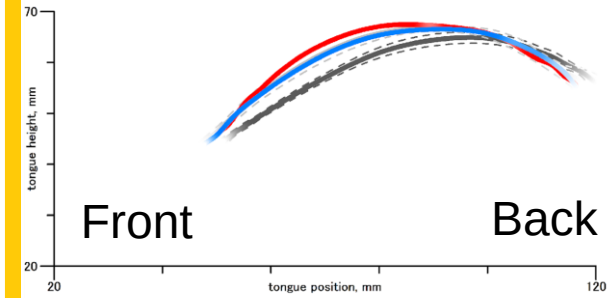
Four patterns of error pronunciation➡

adapted from Shimizu et al. (2024)

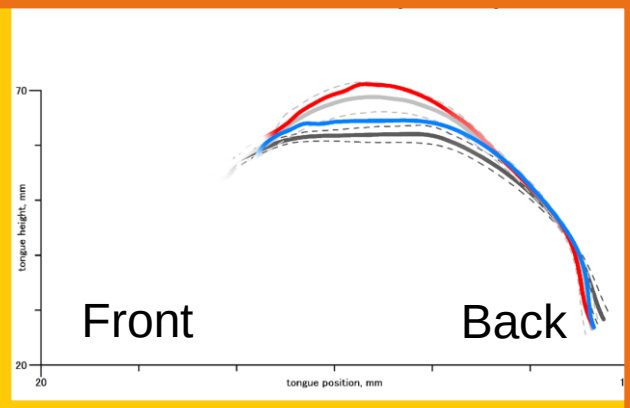
1. Intended /ɕ/ resembled tongue shape of /s/ (SP01)



2. Intended /s/ resembled tongue shape of /ɕ/ (SP02)



3. Metathesis (SP03)



4. Tongue contours are intermediate between /s/ and /ɕ/ (SP03)

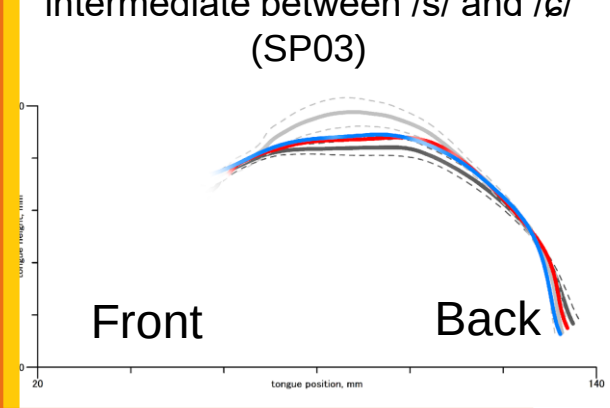


Fig.1 Average tongue contours of the correct pronunciation (**dark gray is /s/,** light gray is /ɕ/) and the tokens judged to be errors (**red is intended /s/**, **blue is intended /ɕ/**). The left side is tongue tip.

Results 2. /ta tɕa/

Error rate:

SP01 = 50%, SP02 = 50%, SP03 = 37%

(updated from the values listed in the abstract)

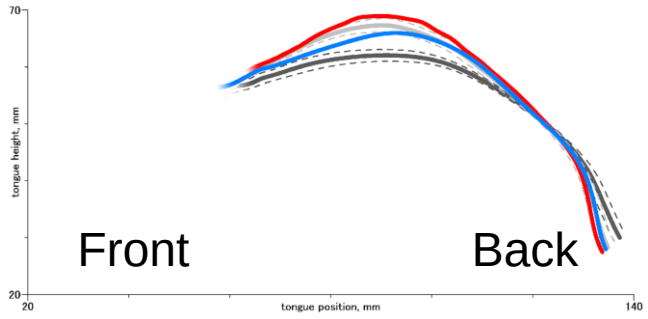
Mean CoG for correct utterances:

/tɕ/ was higher than /t/

Tongue contours:

- The same four error patterns observed in “sa sha”.
- In some cases, the tongue elevation changed without corresponding changes in CoG.

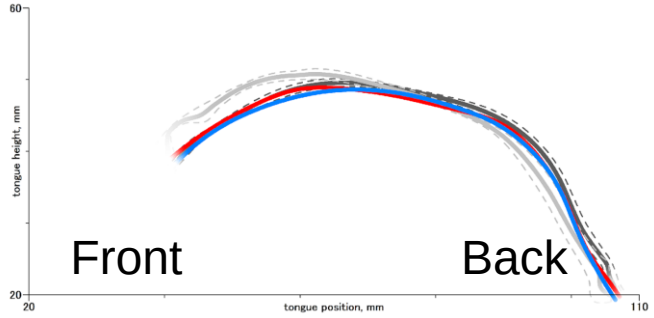
SP03



Tongue shape
Intended /t/ was higher than **intended /tɕ/.**

CoG
Intended /t/ (2521.3 Hz)
was higher than **intended /tɕ/** (929.7 Hz).

SP01



Tongue shape
Intended /t/ and **intended /tɕ/** resembled /t/.

CoG
Intended /tɕ/ (3268.1 Hz)
was higher than **intended /t/** (1971.7 Hz).

Fig.2 The overlay of the average tongue contour (**dark gray is /t/,** light gray is /tɕ/) of the correct pronunciation and the tokens judged to be incorrect (**red is intended /t/**, **blue is intended /tɕ/**). The left side is tongue tip.

Summary

- Some speakers found /sa ɕa/ more difficult, while others struggled more with /ta tɕa/.

- Errors were categorized into four types.
  1. intended /s, t/ resembles tongue shape of /ɕ, tɕ/
  2. intended /ɕ, tɕ/ resembles tongue shape of /s, t/
  3. metathesis
  4. tongue contours are intermediate between two targets

- CoG does not always reflect tongue elevation during errors.

References

Dawson, K. M. (2020) “Speech Motor Control in Younger and Older Adults: The Effect of Age and Individual Differences on Speech Error Production Age and Individual Differences on Speech Error Production.” City University of New York.

Slis, A. W., & Van Lieshout, P. H. H. M. (2016) “The effect of phonetic context on the dynamics of intrusions and reductions.” *Journal of Phonetics*, *57*, 1–20.

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