

# CONTRASTIVE TONGUE SHAPE OF THREE SIBILANT FRICATIVES IN TAIWAN MANDARIN READ SPEECH

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## 1 Introduction

This study investigates the production of three sibilant fricatives in Taiwan Mandarin, dental [s], retroflex [ʂ], and alveopalatal [ɕ], using ultrasound recording. Previous studies have pointed out that some speakers of Taiwan Mandarin lose the contrast between dental and retroflex sibilants in connected speech [1, 2]. In the literature on speech production, it has been well recognized that factors like speaking rate and speaking style significantly affect articulatory movements in such a way that fast speech or casual speech tends to result in the undershooting of articulatory targets and the loss of phonetic contrasts [3]. In this study, we investigated whether the loss of the contrast between dental and retroflex sibilants in Taiwan Mandarin would be conditioned by speaking style. We examined whether the contrast between dental [s] and retroflex [ʂ] in Taiwan Mandarin was maintained in the production of citation forms in read speech.

## 2 Methods

### 2.1 Participants

Two native speakers of Mandarin from Taiwan (one female and one male) participated in the study. Both of them self-reported living in Taiwan until adolescence. Importantly, they had participated in our previous study and had shown a significant overlap in tongue shape between dental [s] and retroflex [ʂ], when followed by the vowel /a/ [2].

### 2.2 Recording

Participants read 36 nonce words visually presented in written form on a computer screen. Half of the words are shown in Table 1. Each item comprises three syllables, and the second syllable contained one of three sibilant fricatives (dental [s], retroflex [ʂ], alveopalatal [ɕ]) followed by one of three vowels (/a/, /i/, /o/) with either tone 1 or tone 4. The items were divided into two lists according to tone category. In each list, the items were presented in random order. Participants read each list seven times. Ultrasound and audio recordings were made during the production.

### 2.3 Measurements

The ultrasound recordings were analyzed for each participant. For each token of production, a frame of ultrasound video was extracted from the mid-point of the target fricative sound. EdgeTrak was used to trace tongue shape in the ultrasound

Table 1: Items

	Tone	/a/	/i/	/o/
s	1	加撒湖	八司館	八搜宮
	4	帕薩碑	霸四亭	駕嗽館
ʂ	1	搭沙堂	搭師碑	拉收亭
	4	法刹湖	納市樓	納受道
ɕ	1	搭瞎館	發吸園	發休道
	4	大夏堂	納戲園	法秀橋

still image [4], and SSANOVA was used to compare tongue shapes [5].

### 2.4 Results

Figures 1 - 3 compare tongue shapes by fricative type for each vowel context. Both speakers showed clearly non-overlapping tongue shapes for three fricatives in all vowel contexts. However, they differed from each other in the way they made the contrast between dental [s] and retroflex [ʂ].

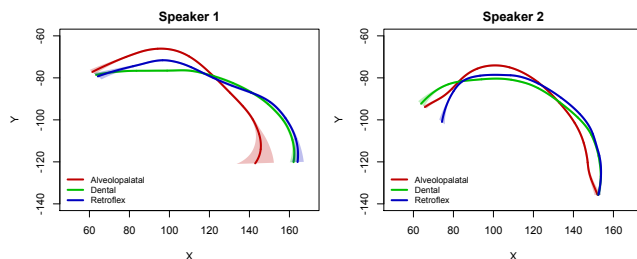


Figure 1: Three sibilants in the /a/ context

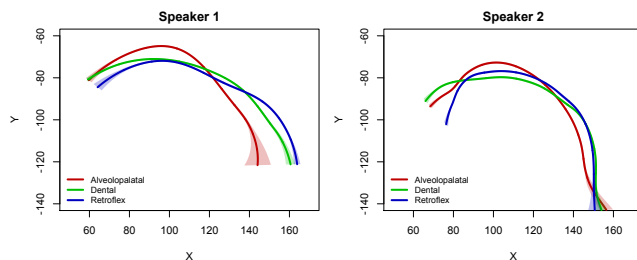


Figure 2: Three sibilants in the /i/ context

Speaker 1 made the contrast through differences in tongue tip position the tongue body height in the /a/ context, but through differences in tongue tip position and tongue root position in the /i/ and the /o/ contexts. Speaker 2 did not show such variation; the contrast was made through differences in tongue tip position and tongue body height.

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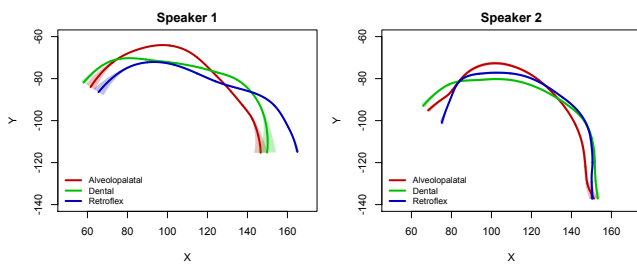


Figure 3: Three sibilants in the /o/ context

Figures 4 - 6 compare tongue shapes by vowel context for each fricative type. As revealed in Figure 4, Speaker 1 showed a vowel-dependent variation in the production of dental /s/. The tongue body was lower and the tongue root was more retracted in the /a/ context than in the other two contexts. This was probably due to coarticulation between the fricative and the following vowels; the tongue height of the following vowels affected the height of the tongue body of the preceding fricative.

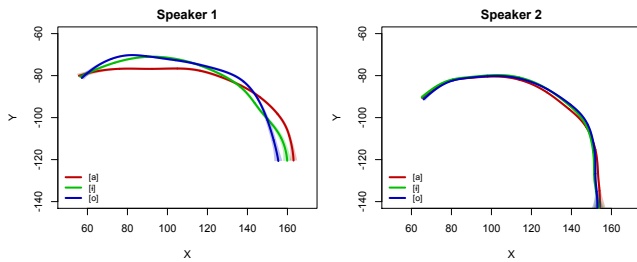


Figure 4: Dental [s] across three vowel contexts

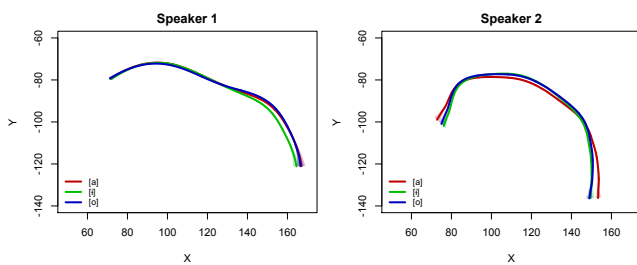


Figure 5: Retroflex [ʂ] across three vowel contexts

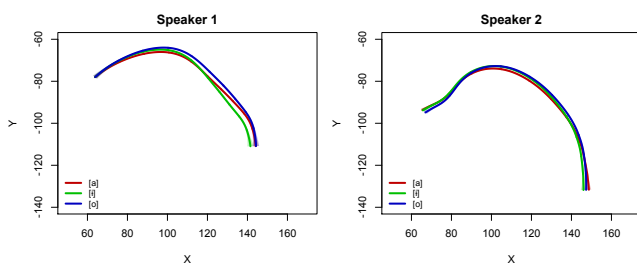


Figure 6: Alveolopalatal [ç] across three vowel contexts

Both speakers exhibited consistent tongue shapes for retroflex [ʂ] and alveolopalatal [ç] across vowel contexts (Fi-

gures 5 - 6). Tongue shape for retroflex [ʂ] was characterized by the lowering of the tongue tip. This gesture probably contributed to the formation of a large front cavity, an articulatory target for the production of retroflex sibilants in Mandarin. Tongue shape for alveolopalatal [ç] was characterized by the raising of the tongue body and the advancement of the tongue root. These gestures probably contributed to the formation of a long and narrow constriction channel from the alveolar to palatal regions, an articulatory target for the production of alveolopalatal sibilants in Mandarin.

### 3 Discussion

Speakers in this study showed clearly distinctive tongue shapes for all three sibilant fricatives across vowel contexts. These speakers had been known to show a significant overlap in tongue shape between dental [s] and retroflex [ʂ] in connected speech [2]. Therefore, the results of this study suggest that the loss of the contrast partly depends on speaking style. It is more likely to happen in connected speech than in read speech. The results of this study also revealed an interesting vowel-dependent variation in the production of dental [s] but not retroflex [ʂ] and alveolopalatal [ç]. The reason why this variation happened only in the production of dental [s] is probably that the production of the dental fricative requires the active involvement of the tongue tip alone, while the production of post-alveolar fricatives requires the active involvement of the tongue as a whole. This means that for the production of the dental fricative the tongue body can remain more susceptible to coarticulation with the following vowels but for the production of post-alveolar fricatives the tongue body does not show the same susceptibility to coarticulation.

### References

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