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Articulatory settings of English-French bilinguals reanalyzed by SS-ANOVA

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What we did

- Analyzed tongue shape data from ultrasound and to compare tongue shapes used Smoothing-Spline Analysis of Variance (SS-ANOVA) – "newer method" for English and French articulatory setting.

- Compared the above models with a previous method – "previous method" – that had measured 4 points on the tongue and had used the alveolar ridge.

Introduction

- One possible way to improve a second language speaking skill is to be aware of the underlying tongue position for a language, particularly when pausing for a short time between utterance; called inter-speech posture (ISP) [1].

- Previously, Wilson and Gick used ultrasound tongue shape data to investigate ISP between English and French spoken by bilinguals [1]. To analyze that data, MATLAB was used to measure distance between tongue surface and the center of ultrasound probe. The alveolar ridge point was found and used in measurement (see Figure 3). T-tests were used to compare mean tongue positions for two languages.

- There is a newer method to analyze the difference of ISP: to make model using SS-ANOVA. It compares whole tongue curves (stable points are not necessary), while previous method compared only 4 tongue points [2][3].

- With the newer method we were able to find differences between English and French more often than with the previous measurement method, especially for the posterior half of the tongue.

Method

Participants and Data Collection (from [1]):

- 11 bilingual English-French speakers, of whom 4 (ELB, NNG, PHI, PLA) had both languages' pronunciation perceived to be native.

- Used the same data that was collected in [1] to extract ISP frames from tongue shape movies by using Quick Time Player software.

Data Analysis:

• Newer Method

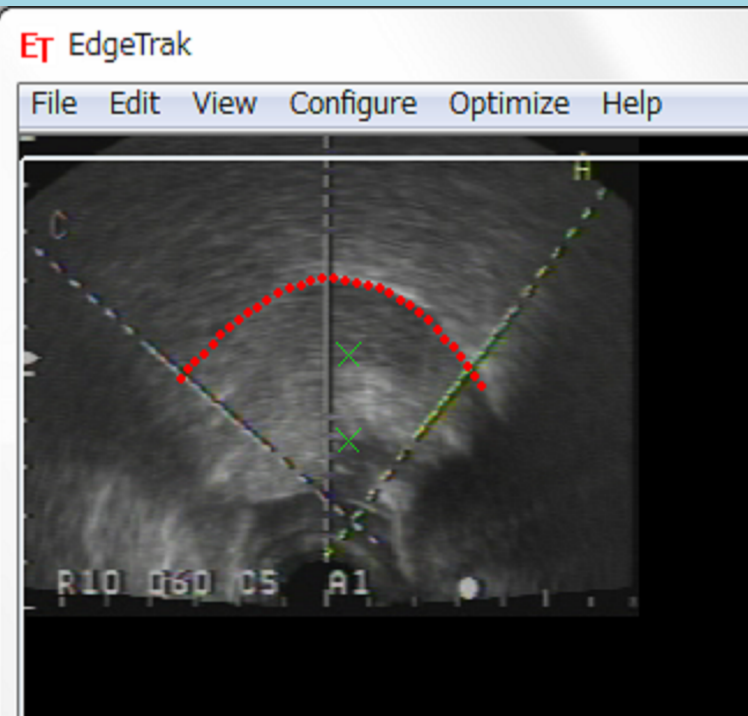- EdgeTrak [4] detected tongue surface in ISP data (see Figure 1).

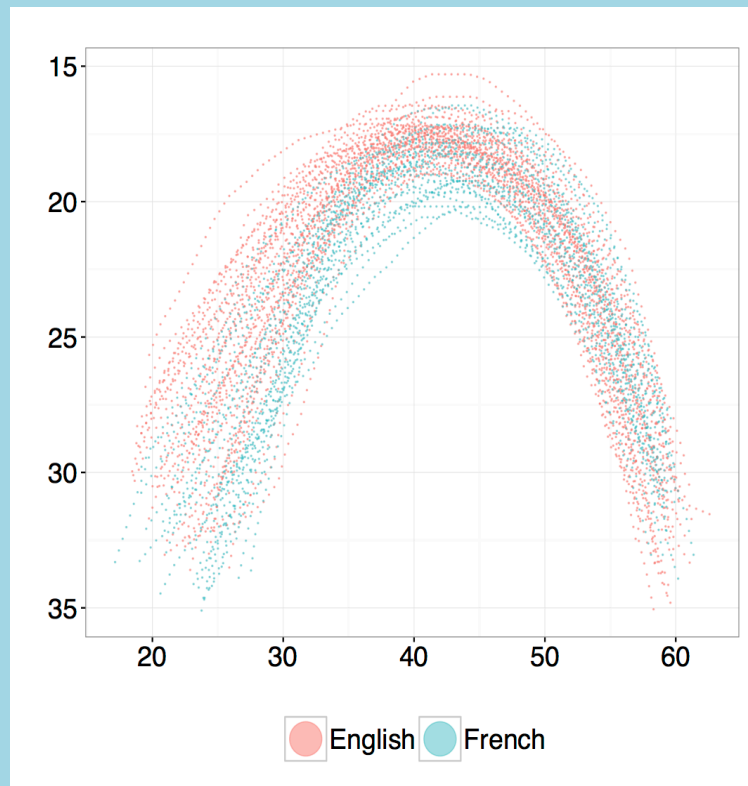**Figure 1: Automatic edge detection by EdgeTrak**

Figure 2:Tongue traces of ELB using newer method

- Made traces (Figure 2) and model from coordinate data using SS-ANOVA in R [2] (see Figure 4).
- Calculated center point of probe and drew 4 lines toward tongue surface through center point.

• Previous Method

- Figure 3 shows measurement by original 4-points method using MATLAB calculation.

- Alveolar point is determined by having participants' swallow.

- By clicking above the alveolar ridge point in the image, a straight line was drawn through this point and the probe center in MATLAB program.

- Tongue root point is determined clicking above the hyoid shadow in the image and straight line was drawn same to alveolar ridge.

- Two more straight lines are drawn that trisected the angle between the two lines.

- Clicked on the four points where each line intersected the surface of the tongue and calculated distance between each point and probe center by MATLAB.

Results

- SS-ANOVA method shows that tongue root is more retracted in English. Also the newer method showed all participants had higher tongue dorsum in English.

- In seven cases the newer method showed differences in tongue position that previous method failed to show. However, in four cases the newer method showed differences that the previous method could show (Table1).
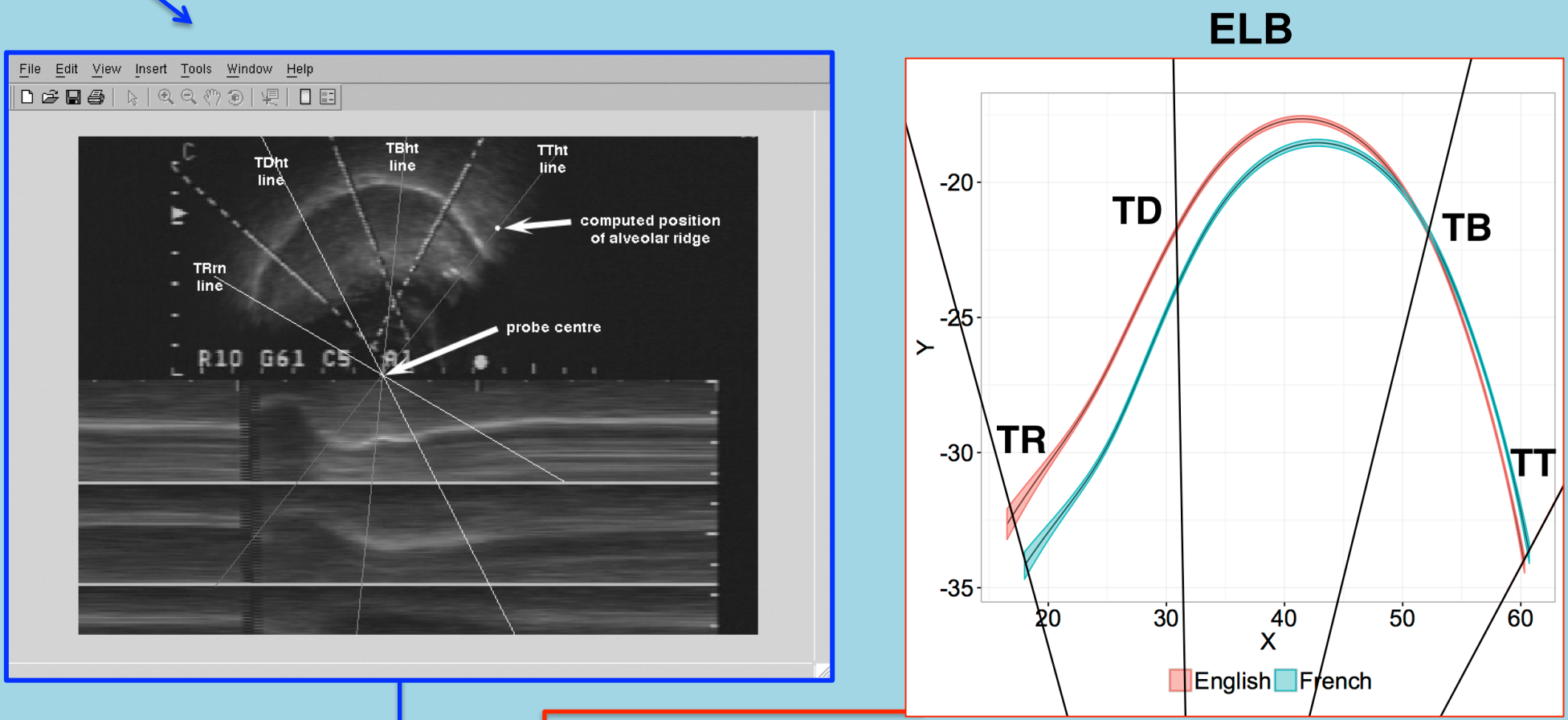

Figure 3: Measurement of one ISP by previous 4-points method

Figure 4: SS-ANOVA estimates and 95% confidence intervals of ISPs by newer method

	Participants							
	ELB		NNG		PHI		PLA	
Measurement	Old	New	Old	New	Old	New	Old	New
TTht	–	F>E	E>F	–	–	–	E>F	–
TBht	E>F	–	–	–	–	–	E>F	–
TDht	E>F	E>F	–	E>F	–	E>F	–	E>F
TRrn	–	E>F	F>E	E>F	–	E>F	–	E>F

Table 1: Differences between English and French ISP for 4 tongue points in 4 participants. Shaded in red means it is different result in each method. "–" means no difference between E and F.
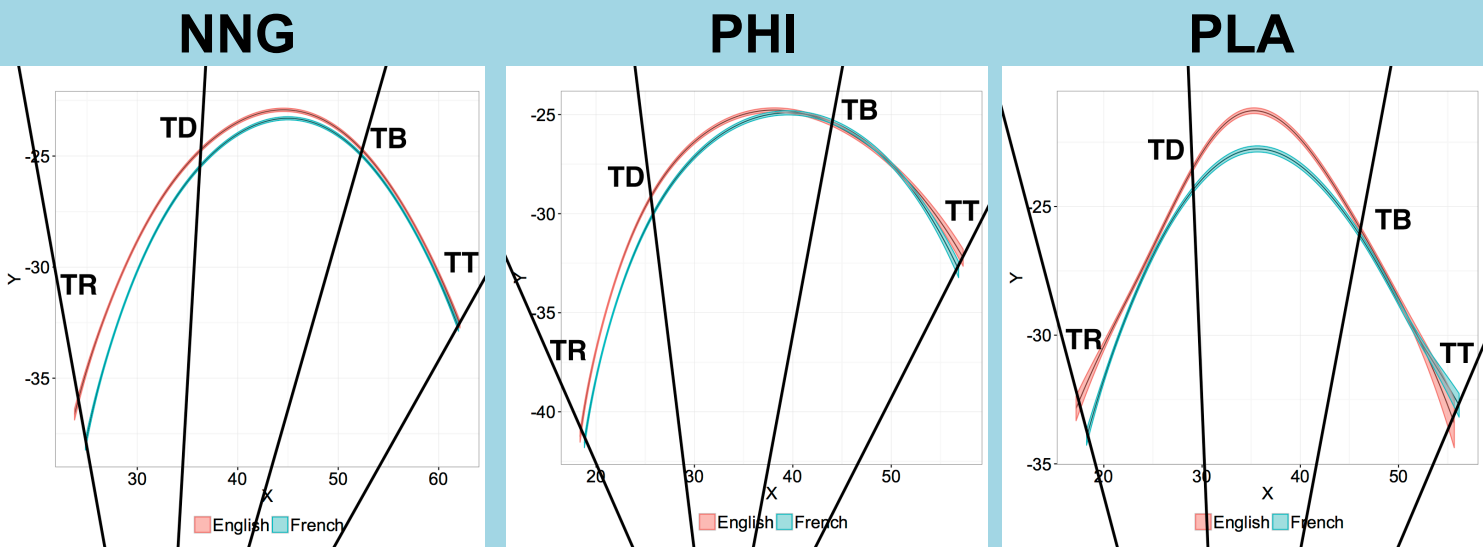

Figure 5 : SS-ANOVA estimates and 95% confidence intervals of ISPs by newer method

Discussion and Conclusions

- We used 2 measurement methods to statistically analyze ultrasound ISP data. Newer method showed more differences in the posterior tongue, but the previous method showed a few more in the anterior tongue.

- Newer method is not based on alveolar ridge or any stable bone point, while previous method is. That may result in measuring a slightly different tongue part in each method because alveolar ridge is difficult to pinpoint.

- Further to lip differences found in [1], newer method was able to find previously unknown differences between English and French ISP in tongue dorsum and tongue root.

- This ability may be due to greater variability in tongue tip and tongue body position across ISPs in a given language. The TT/TB is freer to move and may be less resistant to coarticulation with phonemes before/after ISP.

References

[1] I. Wilson and B. Gick "Bilinguals Use Language-Specific Articulatory Settings", JSLHR, 57(2): 361–373, 2014.

[2] L. Davidson, "Comparing tongue shapes from ultrasound imaging using smoothing spline analysis of variance" JASA, 120(1): 407–415, 2006.

[3] M. Heyne and D. Derrick, "Using a radial ultrasound probe's virtual origin to compute midsagittal smoothing splines in polar coordinates", JASA, 138(6): 509–514, 2015.

[4] M. Li, C. Kambhamettu, and M. Stone. "Automatic contour tracking in ultrasound images." Clinical Linguistics & Phonetics 19(6–7): 545-554, 2005.