Tongue Shape Complexity of Correct and Distorted Rhotics in School-Age Children

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Purpose

To evaluate tongue shape differences in correct and misarticulated rhotics (/r, ɝ/) in children with and without speech sound errors. It was hypothesized that children with Residual Speech Errors (RSE) would produce less complex tongue shapes for rhotics than children with typical speech. It was also hypothesized that tongue shape complexity would increase as a result of ultrasound feedback therapy

Background

Rhotic phonemes are among the latest to develop in American English speaking children and they are also among the most frequently misarticulated sounds in children with RSE. One potential reason for the difficulty in acquiring this class of sounds is the complex lingual configuration. Articulation of rhotics in adults requires the formation of two constrictions with the tongue: a pharyngeal constriction with the tongue root retracting in a posterior direction, and an oral constriction with the tongue tip, blade, or anterior dorsum approximating the hard palate (Delattre & Freeman, 1968).

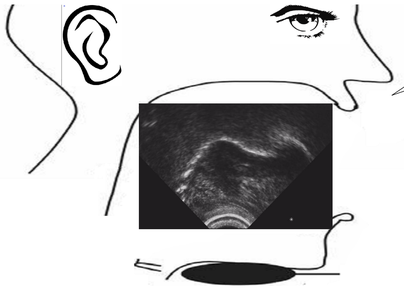
Ultrasound imaging of the tongue is being used increasingly in clinical research to provide visual feedback to children with rhotic errors. In this study we explored tongue complexity from ultrasound images of children with correct and misarticulated rhotics.

Participants

Children ages 10-14
- N=12 with Typical Speech
- N=15 with Residual Speech Errors (RSE) on rhotics (10 had data at two time points)

	Group Summary: means (Std Dev)	
	Typical Speech	RSE
Age	11y 8m (13 m)	11y 7m (12 m)
Goldman-Fristoe Test of Articulation-2 Std Score	103 (2)	55 (17)
PPVT-4 Std Score	116 (13)	108 (15)
CELF-4 Recalling Sentences	10.1 (3.0)	8.6 (3.8)

Method



Sagittal views of /r/ production

Participants read the sentence at least 12 times, along with isolated words *Robby, Cross, Church, Street*

An Aloka SSD-1000 ultrasound was used to collect tongue images along with acoustic recordings. The probe was stabilized on a microphone stand.

- The task was completed once for children with typical speech.
- For children with Residual Speech Errors (RSE) the task was completed mid-way through treatment (MID) and after 7 sessions of treatment targeting rhotics (POST) (Preston et al., 2014)

Analysis of Tongue Curvature

Listening and visualizing the acoustic waveform were used to locate rhotics in *Robby, Cross, Church,* and *street* to identify appropriate video frame

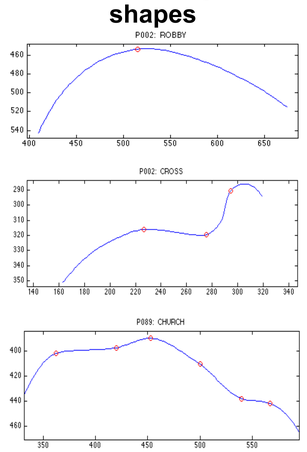
Using the most representative frame for the rhotic, tongue contours were manually tracked in Matlab in a customized program (GetContours)

The number of inflection points (NINFL, or number of non-zero sign changes) was computed based on the signed curvature (range 1-5).

$$k = \frac{x'y'' - y'x''}{(x'^2 + y'^2)^{3/2}}.$$

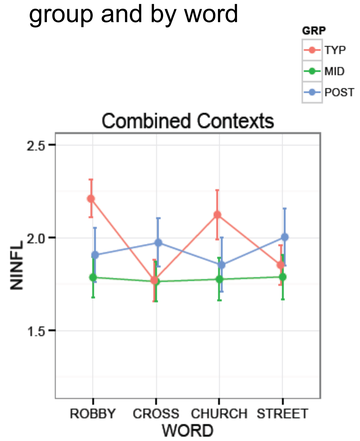
where primes denote derivatives with respect to offset along the curve.

Sample tongue shapes



Results: Tongue Shape Complexity

Number of inflections by group and by word



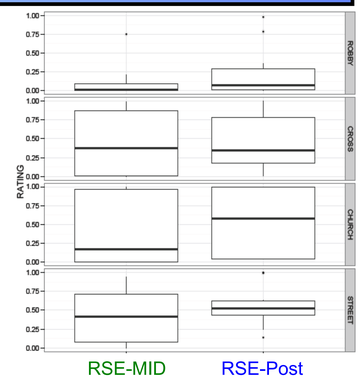
Between Group Comparison:
- Children with typical speech had significantly more inflections in tongue contours for rhotics than children with residual speech errors (TYP>RSE-MID). Linear mixed model showed significant main effect for group (p=0.016)

Within-Group Comparison (Children with RSE)
- Significant increase in the number of inflections (NINFL) for rhotics over the course of treatment (RSE- POST>RSE-MID, t[39]=2.3, *p* =0.014)

Results: Perceptual Judgments

Four listeners perceptually judged accuracy of each rhotic (without ultrasound image) as correct or incorrect.

Linear mixed model showed there was a significant increase in rating of rhotic accuracy following treatment (RSE-POST>RSE-MID, p<.0001)



Summary & Conclusions

•Residual speech error (RSE) group had fewer tongue contour inflections than typical (TYP) group on words with rhotics

•For RSE group, number of tongue contour inflections for rhotics increased over the course of treatment (p<.02). Perceptual rating of rhotics also improved in over the course of treatment (p<. 0001).

•Results suggest that number of inflections may be one way to characterize tongue shape complexity of rhotics, and that this may be sensitive to clinical status and to change in articulation over time. Simpler tongue shapes may reflect undifferentiated tongue shapes - failure to separately control anterior and posterior aspects of the tongue (Gibbon, 1999)

References

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