Title: Neural changes in children with residual speech sound disorder (RSSD) after ultrasound biofeedback therapy

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Rationale: In typical speakers, speech generation involves a network of inferior frontal and superior temporal brain regions, ventral motor and premotor cortices, insula, and cerebellum.[1,2] Children with residual speech sound disorders (RSSD) have shown differences in speech processing, including speech production[3]. However, changes in speech processing after speech therapy have not been investigated. Therefore, the goal of the present study was to identify phonological and speech motor network activations during speech in children with RSSD before and after an ultrasound biofeedback therapy program.

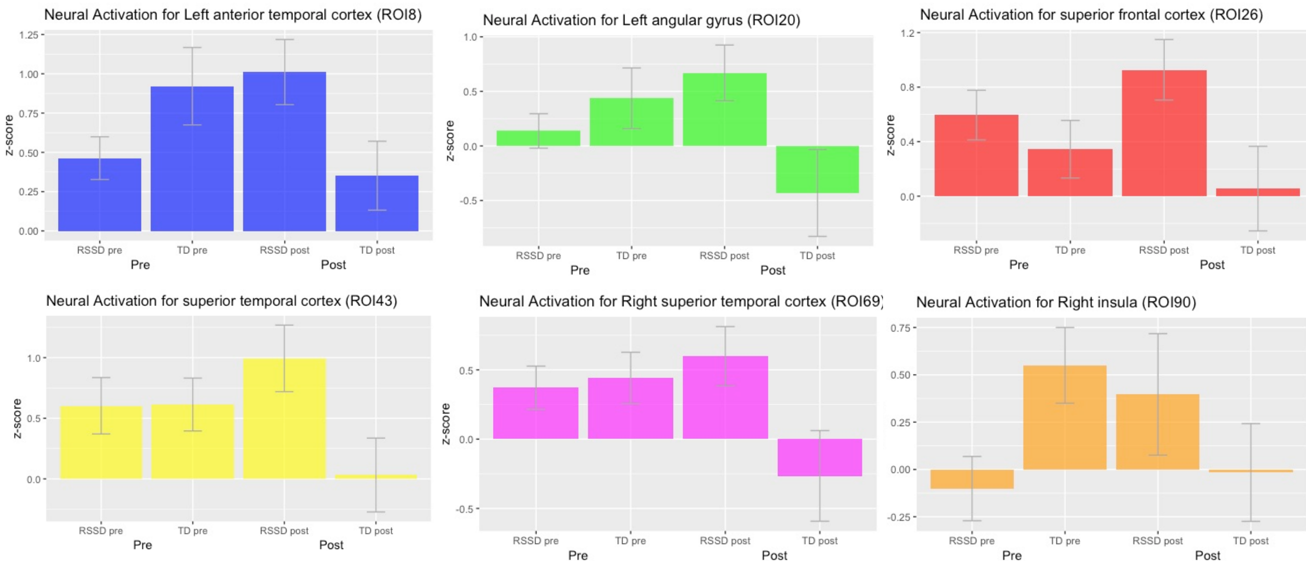
Syllable Repetition Task: We adapted the Syllable Repetition Task (SRT)[4] for fMRI in order to investigate neural activation during speech. The SRT consists of 2-, 3- and 4-syllable nonsense words with a limited set of phonemes. In our experiment, we adapted this task to create a "difficult SRT" with the phonemes /ɹ, s, l, tʃ, ɑ/. By including later-developing speech sounds, we are able to evaluate speech motor production processes in speech sounds that require more articulatory control. We hypothesized that children with RSSD would show patterns of hypoactivation at baseline, with normalized activation patterns after speech therapy.

Methods: Participants: 15 children with RSSD (6F; ages 8;0-12;6) and 13 children with typical speech development (TD; 7F; ages 8;10-14;0) completed the difficult SRT fMRI experiment at baseline. Children with RSSD then participated in an 8-week ultrasound therapy program for /ɹ/ articulation errors. After the conclusion of the program, children with RSSD (n=12) completed the fMRI experiment again. Children with TD (n=11) completed the experiment a second time after a period of 8 weeks (no intervention). All participants demonstrated expressive and receptive language skills within normal limits and passed a hearing and vision screening. All participants were scanned on a 3T Philips MRI scanner.

SRT: The subject heard a target word and was asked either to repeat the word immediately or to only listen. The task consisted of 18 target words, which were presented in both "speak" and "listen" conditions and counter-balanced across blocks of 6 targets each. A sparse acquisition was used, which allowed 6 seconds for the target presentation and the child's response without scanner noise, followed by 6 seconds of acquisition.

Analysis: We used a region of interest (ROI) analysis approach. Regions were identified a priori using the activation map of "speech production" generated by Neurosynth. Thirty-five of these regions contained 20 or more contiguous voxels and were used in the current analysis. Each participant's average activation (z-score) was calculated for each ROI. T-tests were performed at each ROI to compare differences in neural activation at Time 1(pre-therapy) and Time 2 (post-therapy) between RSSD and TD groups.

Results: At Time 1 (pre-therapy), children with RSSD differed significantly from children with TD in one region: children with RSSD showed *deactivation* in the right insula, whereas children with TD showed *activation* of this area. The difference was statistically significant (p=0.020). At Time 2 (post-therapy), children with RSSD demonstrated significantly greater activation than children with TD in five regions, including left anterior temporal cortex (p=0.041), left angular gyrus (p=0.032), superior frontal cortex (p=0.034), left superior temporal cortex(p=0.029), and right superior temporal cortex (p=0.041). Figure 1 shows ROIs and group activation differences.



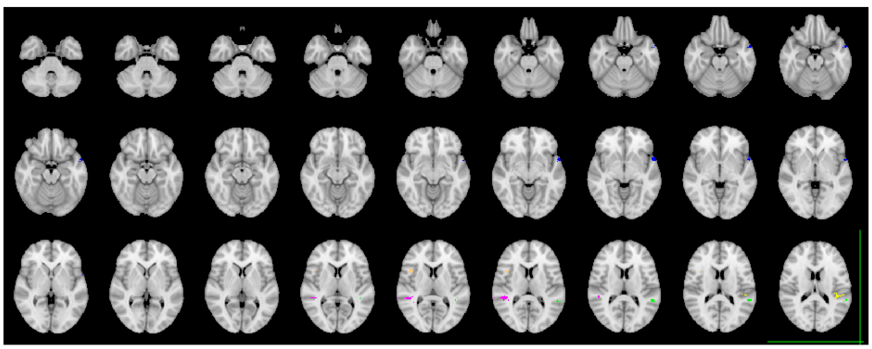


Figure 1. Regions of Interest that show significant differences between RSSD and TD on the SRT Difficult task.

Discussion: Children with RSSD demonstrated differences in neural activation in select brain regions on the difficult SRT. After participating in therapy, the RSSD group exhibited greater functional activation than the TD group in regions associated with language processing, such as word generation, applying semantic meaning to words, and working memory. Results suggest that children with RSSD may use more neural resources to complete the task after therapy.

References:

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