Tongue Shapes for American English /ɹ/ in Children with and without History of Residual Speech Sound Disorder

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Background

American English /ɹ/

- Articulation:
  - Literature has typically discussed /ɹ/ in terms of a binary "bunched" or "retroflex" shape.
    (Espy Wilson & Boyce, 1999;
    Zhou et al., 2008;
    Archangeli et al., 2011;
    Mielke et al., 2016)

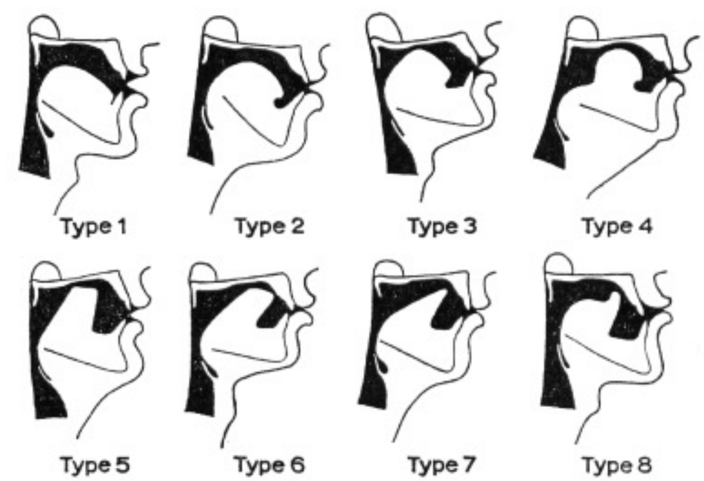
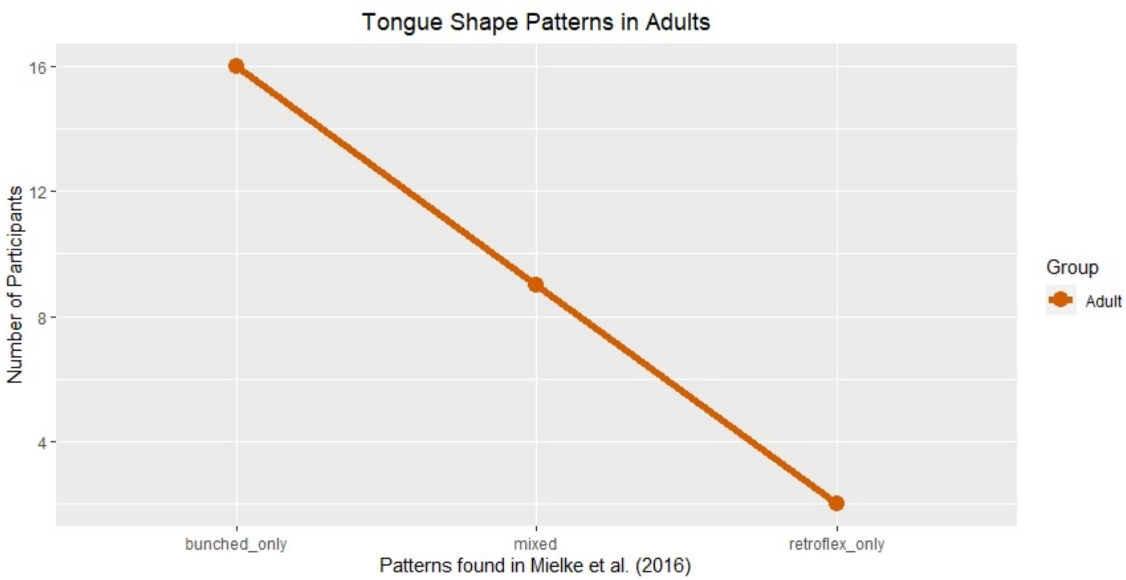


FIGURE 1. The Delattre and Freeman /ɹ/ taxonomy (Delattre & Freeman 1968:41), printed with the permission of Walter de Gruyter GmbH. Copyright 2009.

American English /ɹ/

- Tongue shapes for /ɹ/ vary within as well as across speakers with a greater number of bunched only speakers in American English (Mielke et al., 2016).



American English /ɹ/

- Typically developing children exhibit broadly adult-like /ɹ/ patterns, but there is large variation between individuals and across /ɹ/ contexts (McGowan et al., 2004; Magloughlin, 2016).

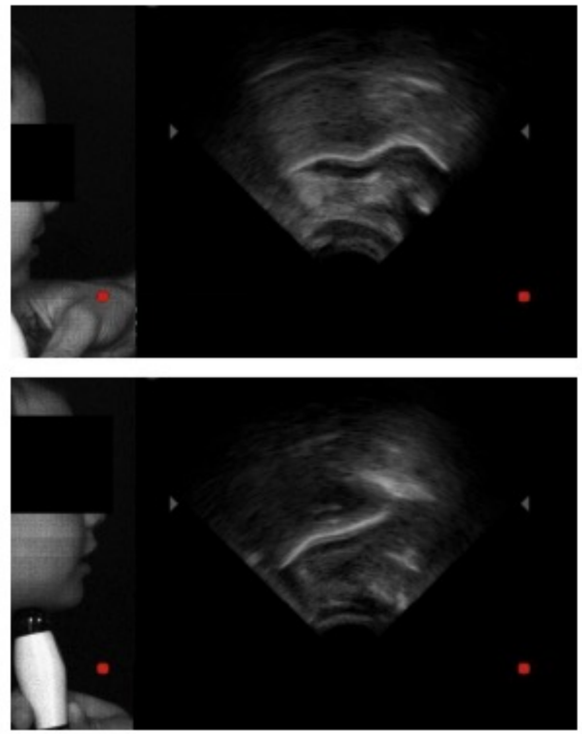
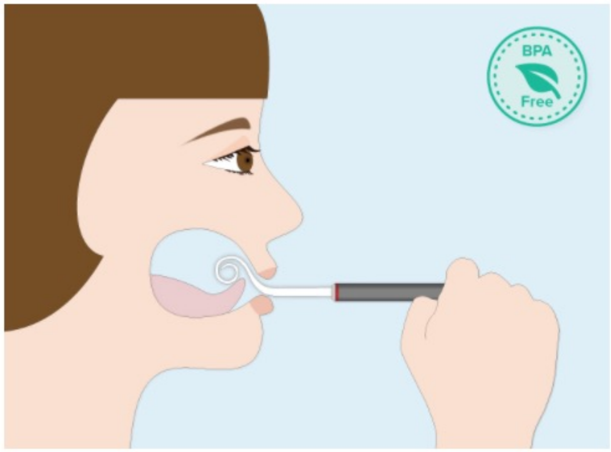


Fig. 8. Adult-like postvocalic /ɹ/ in target word pear (Session 2): Male Twin 1 (top) exhibiting a bunched, tip-down tongue posture, and Male Twin 2 (bottom) exhibiting a retroflex, tip-up tongue posture.

American English /ɹ/

- Receives a lot of attention in the clinical literature because it is later developing and considered one of the most difficult sounds to master.
- Ball et al. (2013) describes retroflexion as easier and more commonly cued during treatment.
- Flipsen (2022) describes a “Speech Buddies” device commonly used to aid /ɹ/ development. It cues retroflex tongue shapes.



Ultrasound Biofeedback

- A systematic review demonstrated positive effects for using ultrasound biofeedback in treatment of residual speech sound disorder for /ɹ/ (RSSD; Sugden et al., 2019).
- So, what is it?
  - Client views their tongue on the screen during portions of treatment.
  - Clinician initially cues bunched and retroflex to see which receives better response.
  - Template is laid on screen for client to match during productions.

Group 1: With History of RSSD

- 30 American English speakers aged 9-15 who received treatment for /ɹ/
  - 17 males and 13 females
  - Additional 4 participants were excluded due to zero productions of perceptually accurate /ɹ/

- Three phases of 10-week treatment study:
  - 1 week of intensive motor-based treatment (3x)
  - 1 week of intensive ultrasound biofeedback treatment (3x)
  - 8 weeks of low-intensity ultrasound biofeedback treatment (2x per week)

Group 2: Without History of RSSD

- 36 American English speakers aged 9-15 who had no known speech, language, or hearing issues
  - 17 males and 19 females

- Completed the same evaluation tasks as the biofeedback group in two 2-hour sessions on separate days

Research Questions

- Do child speakers show within- and between-speaker variation in tongue shape patterns for /ɹ/ consistent with expectations from adult studies?

- Do patterns differ across groups of children with and without history of RSSD affecting /ɹ/?

Methods

Syllable Repetition Task

- Consisted of 45 opportunities for /ɹ/ production (Miccio 2002):
  - Syllabic and postvocalic /ɹ/ in 9 syllables/disyllables

mer	der	erg/er	ear	air	ire	or	ar	our

  - Prevocalic /ɹ/ in 6 CV syllables

ree	ray	rai	roo	row	ra

Syllable Repetition Task

- During the task, the treating clinician provided a visual and auditory model of each syllable and cued the child to repeat with their “best /ɹ/ sound”; the clinician also perceptually scored each production.
- All targets were repeated 3 times each
- All targets differed from the wordlists used in all other tasks

Articulatory Coding

- Get Contours and SLURP in the ultrasound tracing processes (Tiede, 2020; LaPorte & Ménard, 2018).

- Images selected were the most representative /ɹ/ images nearest to the temporal midpoint of the acoustically measured steady state.

Articulatory Coding

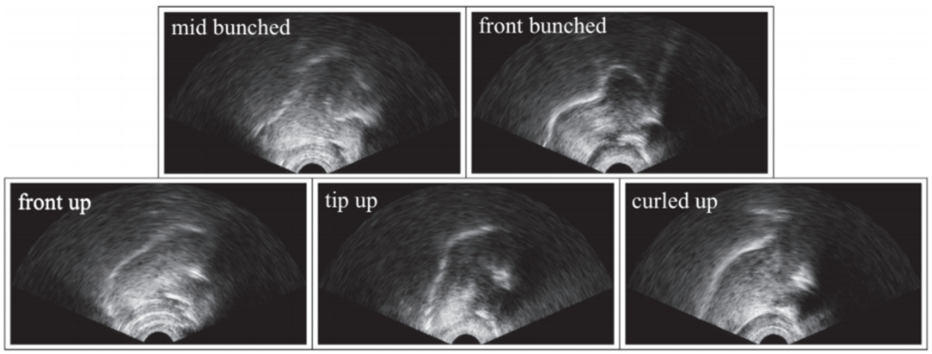


Fig. 2. Raw ultrasound frames showing typical examples of each of the five /r/ configurations. The tongue tip is on the right side of the image. The top two images are bunched, while the bottom three are retroflex. The final retroflex configuration exhibits curling up of the tongue with a bright white line where the tongue tip is expected.

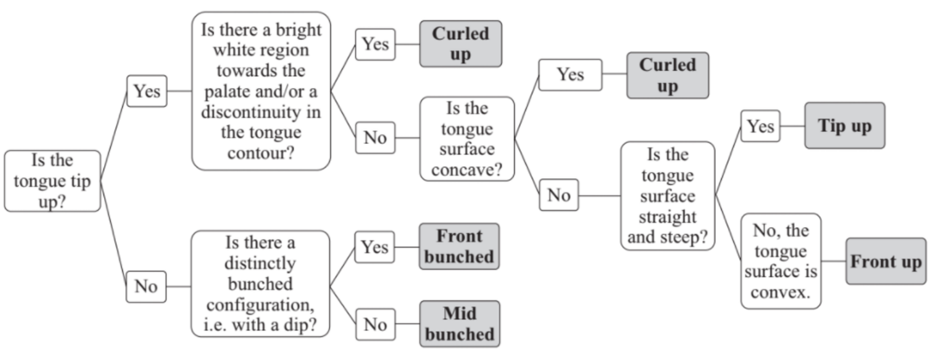
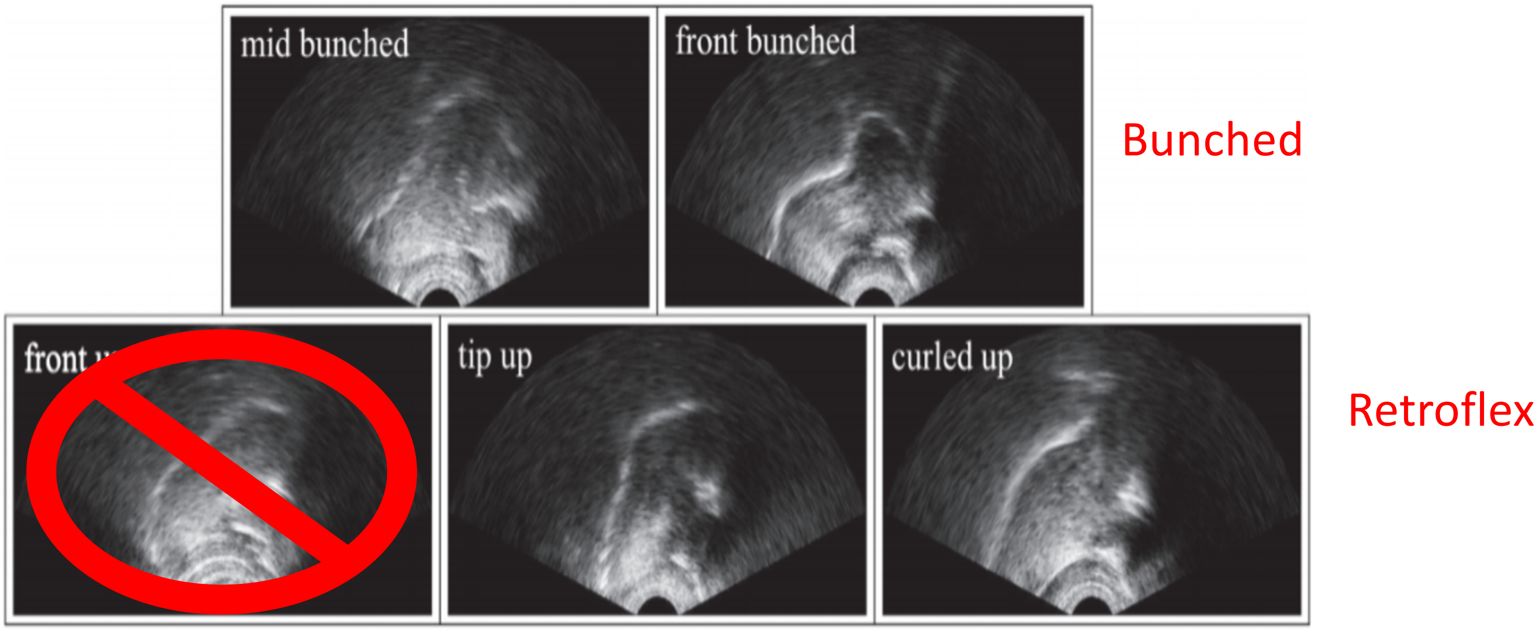


Fig. 3. Decision tree used to classify tongue shapes into five distinct categories for /r/ from ultrasound data.

Figure 1: /ɹ/ tongue examples and classification tree from King and Ferragne (2020) which includes two bunched shapes, two retroflex shapes, and one in-between (front-up).

Articulatory Coding



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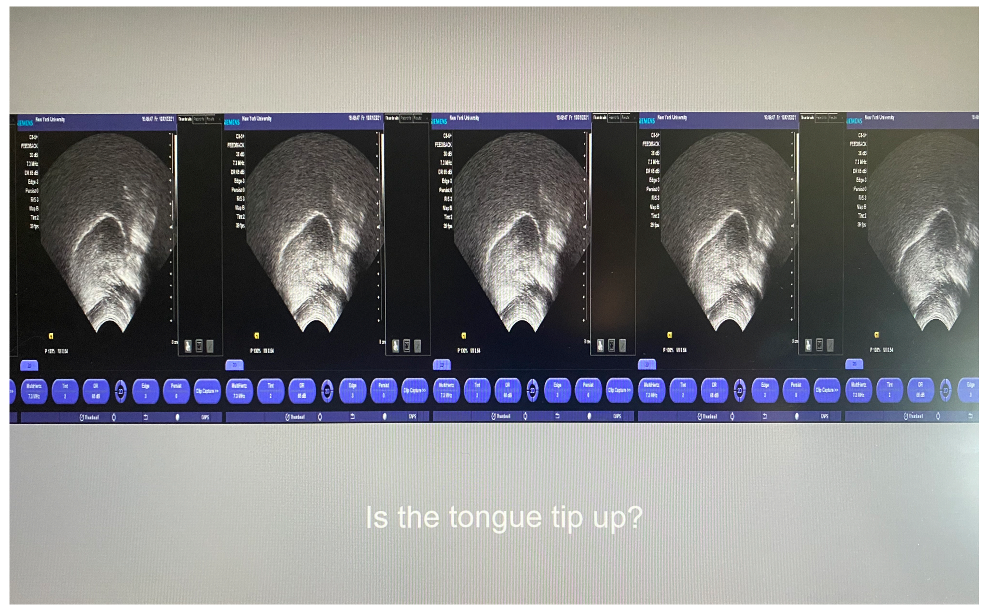
Articulatory Coding

- Developed a PsychoPy Coding Program following King & Ferragne 2020

- Viewed concatenated target image + 2 preceding and following images while coding

- Images did not include tongue tracing

- All concatenated images from both groups were randomized for blind classification



Articulatory Coding – In Progress

- Quantitative Image Coding
  - TRACTUS Matlab suite (Carignan, 2014) uses the ultrasound image as observation and pixel intensity values as dimensions. Outputs prinicpal components related to image variance.
  - Linear Discriminant Analysis (LDA) will be performed on the principal components to classify tongue shape types as bunched or retroflex.
  - Using LDA classification as a measure of reliability for the qualitative coding.

Results

General Coding Results

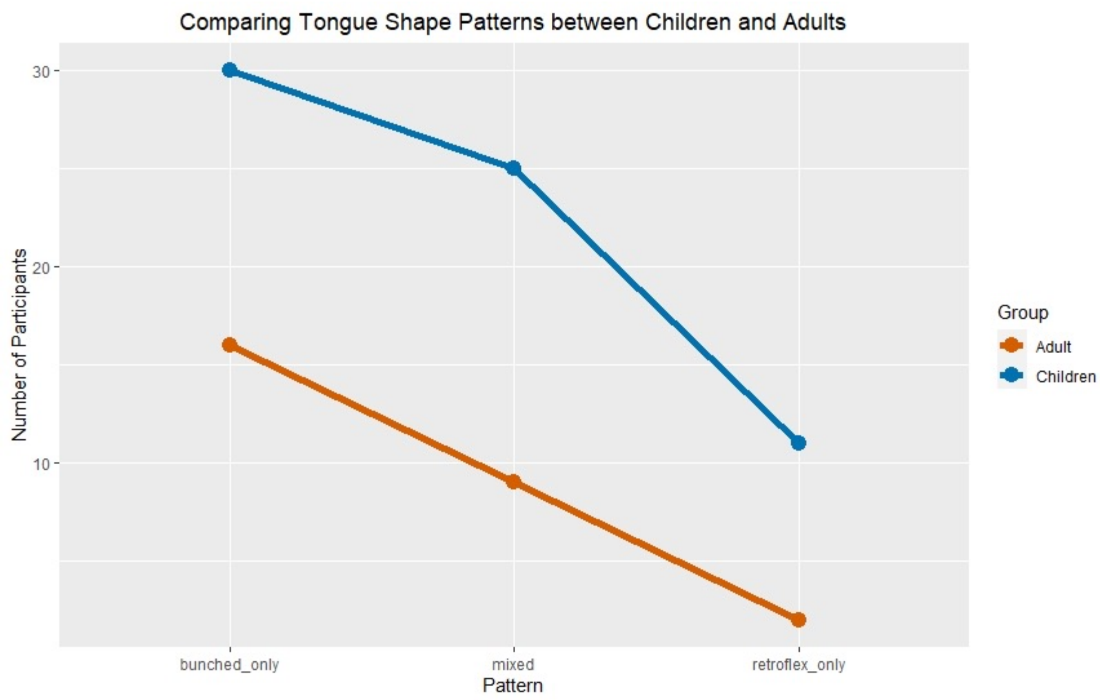
- Total of 2698 coded images
  - 1078 images for the group with history of RSSD
  - 1620 images for the group without history of RSSD

- Bunched vs. Retroflex Ratio
  - 65.2% bunched (1760)
  - 29% retroflex (783)
  - 5.7 % flagged (155)

RQ1: Do child speakers show within- and between-speaker variation in tongue shape patterns for /ɹ/ consistent with expectations in adult studies?

- Patterns appear consistent!
  - Adults n= 27 (from Mielke et. al, 2016)
  - Children n =66

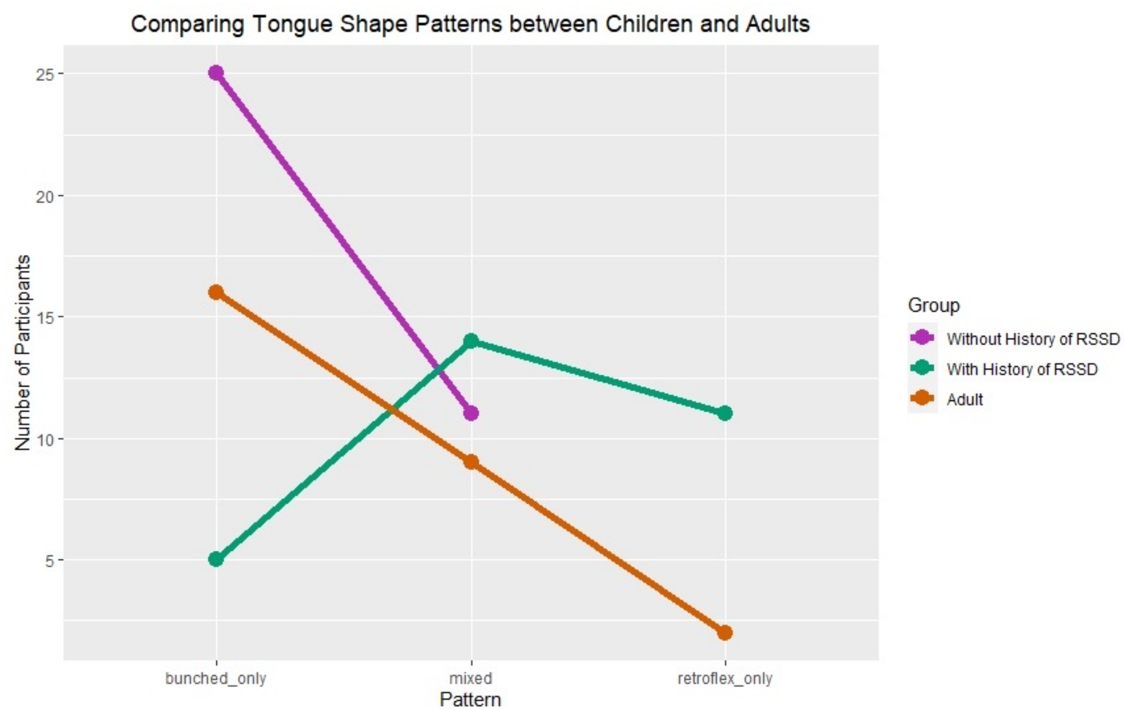
- Tongue Shape types were grouped into 3 categories:
  - Bunched Only
  - Mixed – Used both types
  - Retroflex Only



RQ2: Do patterns differ across groups of children with and without history of RSSD affecting /ɹ/?

- Patterns are not consistent when children are split into groups.

- Number of Participants in each group:
  - Without History of RSSD = 36
  - With History of RSSD = 30
  - Adults = 27



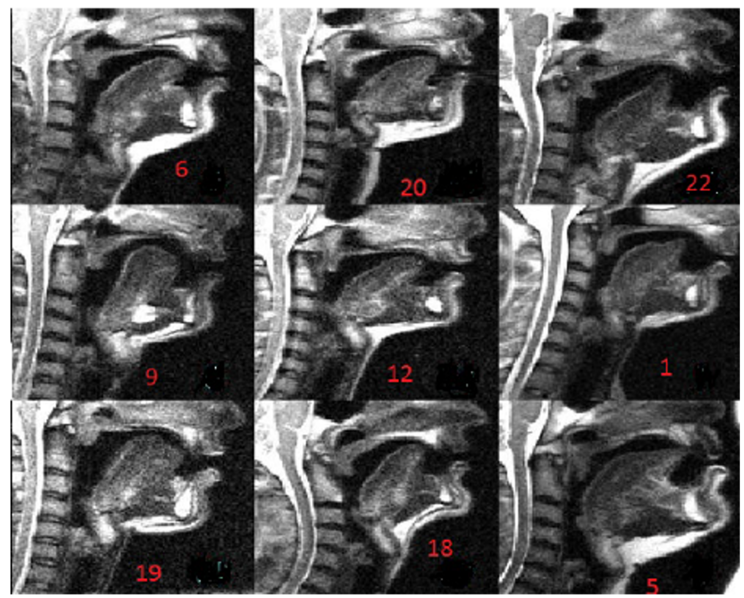
RQ2: Do patterns differ across groups of children with and without history of RSSD affecting /ɹ/?

- Group Differences
  - For the group of children without RSSD, 93.9% of tokens were coded as bunched.
  - For the group of children with RSSD, 69.8% of tokens were coded as retroflex.
  - Statistically significant (β= -10.99, SE = 1.91, p < .001) according to mixed effects logistic regression: Bunched_or_Retroflex ~ Group + (1|Subject)

Discussion

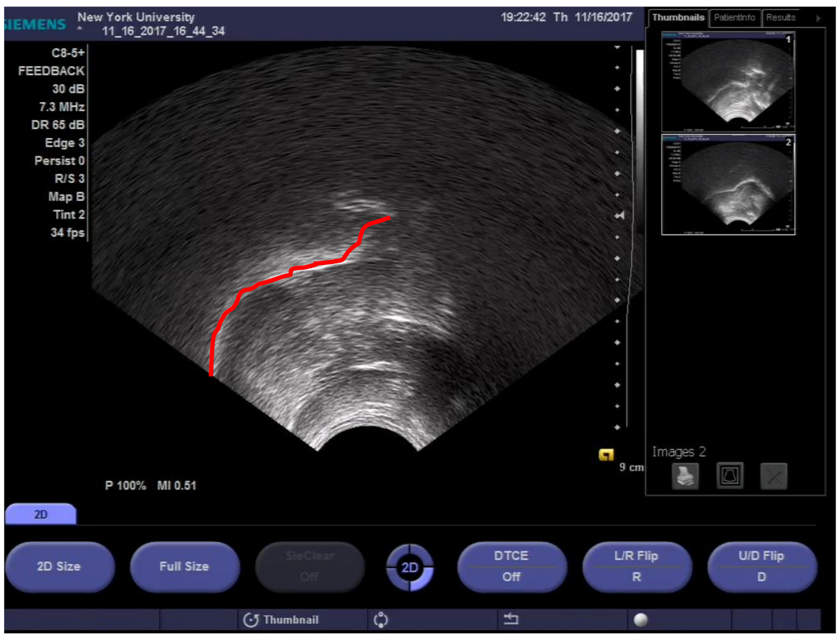
Why the significant difference in tongue shapes?

- Could this be an effect of clinician cueing?
  - Clinicians cued both bunched and retroflex shapes at the beginning of treatment.



Why the significant difference in tongue shapes?

- Are retroflex tongue shapes easier to acquire in the context of treatment for RSSD?
  - Note: our data only include the perceptually accurate tokens.
  - Follow up analysis on positional and vowel influence.



Why the significant difference in tongue shapes?

- Could this be related to articulatory patterning for /ɹ/ in non-rhotic dialects?
  - Children with RSSD are functionally similar to speakers of non-rhotic dialects of English.

- Higher rates of retroflexion have been found in non- rhotic English dialects in New Zealand and the UK (Heyne et al., 2018; King & Ferragne, 2020).
  - Retroflex is favored in the prevocalic contexts.
  - Bunched is favored in the postvocalic contexts.
    - These contexts are “r- less” in non-rhotic dialects
    - Therefore, non-rhotic speakers experience less articulatory pressure to bunch than their rhotic counterparts.

In Conclusion

- This finding furthers our understanding of tongue shape types for /ɹ/ among American English-speaking children 9-15 years old.
    - Very few studies have explored /ɹ/ tongue shapes in children – usually in much younger ages.
    - None have compared across children who learned to produce perceptually accurate /ɹ/ during treatment and typically developing children.

- This study helps to provide evidentiary support to clinician intuition concerning retroflex versus bunched tongue shape cueing.
    - Clients undergoing ultrasound biofeedback and other types of treatment for /ɹ/ may be most responsive to clinician cueing of retroflex shapes, at least early on, but we don't know if the success of this approach is either complete or lasting.

Thank you!!

- To you for listening and feedback!
- Many thanks to my collaborators, committee members, and BITS lab assistants for help with data processing.
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Questions?

Please feel free to contact me: are326@nyu.edu

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