**Goal of study:** Test the feasibility of distributed delivery and data collection using an app-based implementation of visual-acoustic biofeedback for residual /r/ errors.

**Criteria for inclusion:** Participants must be native speakers of English, ages 8-15, who have difficulty producing correct /r/ sounds. We are especially interested in finding participants who have received speech therapy targeting /r/ for at least one year with limited success. Participants should have no major problems hearing or understanding language.

**Note:** For the duration of the study, our standard study protocol should replace any /r/ therapy the child is currently receiving.

1. **Setup and evaluation**
   - See “Checklist for Interested Clinicians”
     - All forms listed below should be uploaded (via [https://byunlab.github.io/start](https://byunlab.github.io/start)) prior to initiating study data collection. Obtain approval from your school principal or other administrative head.
       - Parent permission form
       - Participant assent form
       - “Clinician Questionnaire 1: Speech and Language History.”
       - “Clinician Questionnaire 2: Speech and Language Evaluation.”

2. **Pre-treatment assessment and intro to biofeedback**
   - Please use a microphone while using the staRt app as a formal pilot tester. An in-line microphone that is integrated into a set of earbuds is perfectly adequate. The microphone can be clipped onto a stationary object a few inches in front of user's mouth, or the user can wear one earbud and let the microphone hang in front of their chin. It is not ideal to have the user hold the microphone by hand while using the app, because this may lead to variable intensity as the user moves around.
   - We are happy to provide a tabletop microphone or set of earbuds for you to use in formal pilot testing—just let the team know during the initial setup process.

   **A note on scoring:** The following categories are available to rate a speaker's /r/ productions during Quiz or Quest sessions.
   - **Try again:** Use this rating for productions that represent a different phoneme (e.g. /w/ or /u/) or for severe distortions that lack rhotic quality.
   - **Good:** Use this rating for productions that approximate a correct rhotic quality but feature a mild to moderate degree of distortion.
   - **Great:** Use this rating for strongly rhotic productions.

*Note: Please attempt to rate the characteristics of the /r/ sound in each word, independent of speech errors elsewhere in the word or other deviations such as nasality or hoarse vocal quality.

   - Administer Long Word Quiz measure.
     - Tap “Quiz” > “Long Word Quiz”
     - Elicit all words and select “YES” to upload recording to our team.
   - Administer Syllable Quiz measure.
     - About the Syllable Quiz:
       - This is a stimulability task following Miccio, 2002
       - Please model each syllable and ask the participant to repeat using his/her best /r/ sound.
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- Syllables are repeated three times each.
- Tap “Quiz” > “Syllable Quiz”
- Elicit all words and select “YES” to upload recording to our team.
- Note: We ask you to administer the Syllable Quiz after the Word Quiz because we don’t want the models provided during the stimulability task to have a carryover effect on word production.

- Complete the staRt tutorial.
  - Assist the participant in navigating through the interactive tutorial step by step, answering questions and checking the participant’s comprehension of key concepts.
- Complete 5 minutes of “free play.” This is an unstructured interaction with the biofeedback display; you may provide any cues you like to help the participant achieve perceptually accurate /r/.

Where should I put the target during biofeedback practice?

The app will automatically place the starfish slider at a possible target frequency determined based on the age, gender, and height you entered in the participant’s profile. If the slider appears to be all the way off to one side, try clicking “Reset target.” Some users prefer to set a target at a lower frequency to challenge the child to hyperarticulate the /r/ sound. You can feel free to do so by dragging the starfish slider to the left. However, we suggest that you not place the slider any lower than around 1550 Hz.

3. Treatment

- If you sign up as a formal pilot tester in the app (“Formal Testing” button in the Profiles page), the app will automatically prompt you to follow the schedule of steps listed below. Look for pop-up messages telling you what to do next within a session. However, we strongly recommend that you print out this document and keep it handy in case there is an error and the pop-up window fails to display.
- Scheduling:
  o Each “Quest” elicits 100 trials of syllables or words containing /r/ in each session, divided into blocks of 10 trials.
  o Each participant should complete 8 Quests of each type (biofeedback and traditional), 16 in total.
  o If possible, we suggest that you schedule sessions twice per week, approx. 30 minutes per session. However, you are free to adjust the number and length of sessions to fit your schedule. We are working on developing a feature that will allow you to log out of a participant’s profile partway through a Quest and pick up where you left off at a later time. Unfortunately, this feature has not yet been fully implemented.
  o Each Quest will be randomly assigned to feature either biofeedback or traditional treatment (i.e., no biofeedback). The app will prompt you with the appropriate setting for each session. If you are not automatically prompted with an assignment, contact our team at nyuchildspeech@gmail.com and we will look up the appropriate condition for the current session.
- In each Quest:
  o Before eliciting structured trials, complete 5 minutes of “free play” elicitation with the participant. The biofeedback display should be ON for a biofeedback Quest and OFF for a no-biofeedback Quest. You can use any shaping strategies, placement cues, and phonetic contexts to try to elicit accurate /r/. Please avoid using any external devices (e.g., bite sticks, tongue depressors).
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Before you begin a Quest, staRT gives you the option to target one or more specific /r/ variants in practice. **You should use your clinical judgment to choose the categories that you regard as most beneficial for your client.** However, try to be consistent in the categories you select for biofeedback versus traditional sessions, as differences in target selection could negatively impact our ability to measure the difference in efficacy between the two conditions. You may include up to 5 categories in each practice session.

In biofeedback treatment sessions:
- If you think that the biofeedback display is not optimal, **you can adjust it under Profile > Settings** — see staRT user manual for instructions.
- You are free to give any cues pertaining either to articulator placement/perceptual aspects of /r/ or to the biofeedback display.
- **Where should I put the target during biofeedback practice?** See text box above.

In traditional treatment sessions:
- You may give any cues pertaining to articulator placement or perceptual aspects of /r/.
- The biofeedback display should be OFF during free play AND quest portions of the session.

Each Quest will elicit 100 trials of syllables or words containing /r/, divided into blocks of 10 trials.
- Scoring: See text box on p. 1.
- Pausing for feedback: During the pause for feedback, you are encouraged to provide the client with qualitative information about his/her performance in the last block of 10 trials. You can also provide one or more cues for the learner to focus on during the next block of trials. These cues can be articulator placement cues or perceptual models. In the biofeedback condition only, cues may include references to the biofeedback display.

**Adaptive Difficulty:**
- All participants begin at the lowest level (“Syllable Quest”).
  - In Syllable Quest, the app will prompt you to provide a direct model for each trial.
- After the participant has earned a total of 100 points (where each “Great!” score is worth 1 point and each “Good” score is worth .5 points), they will move from Syllable Quest to Word Quest.
  - In Word Quest, direct models should be faded to only come at the start of the block (i.e., before the first item in each block).
- Within Word Quest, different levels of difficulty should appear based on the participant’s performance in previous blocks of trials. Possible levels of difficulty include: 1-syllable words, 2-syllable words, 1 or 2-syllable words with a competing phoneme (/w/, /l/, or /r/), carrier phrase, sentence level.
  - As a client moves up through the levels of complexity in Word Quest, they may encounter words that are challenging for them to read. In such cases, we encourage you to provide semantic and/or phonemic cues to try to elicit the word without directly modeling the /r/ target—even a nonword rhyme cue, e.g. “remnant” rhymes with “schmemnant.” If cueing is not successful, you can provide a direct model as a last resort.

4. **Post-treatment assessment**
   - Administer Long Word Quiz measure as described under Pre-treatment assessment.
   - Administer Syllable Quiz measure as described under Pre-treatment assessment.
   - Remember to select “YES” to upload each recording to our team.