TECHNOLOGY-ENHANCED TREATMENT FOR SPEECH SOUND DISORDER VIA TELEPRACTICE


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2023 ASHA CONVENTION
BOSTON, MA
SESSION 1057

DISCLOSURES

TARA McALLISTER

Relevant Financial Relationships:

- Grant funding from NIDCD
- Salary from NYU
- Registration waiver for the 2023 ASHA convention
- Dr. McAllister is a member of Sonority Labs, LLC, a for-profit entity that was created to explore the possibility of commercialization of the staRt app for visual-acoustic biofeedback. The staRt app is currently distributed as a free download, but in the future it may be sold or licensed in a for-profit capacity.

Relevant Nonfinancial Relationships:

- No significant nonfinancial relationships to report.

ELAINE HITCHCOCK

Relevant Financial Relationships:

- Grant funding from NIDCD
- Salary from Montclair State University
- Registration waiver for the 2023 ASHA convention

Relevant Nonfinancial Relationships:

- No significant nonfinancial relationships to report.

JONATHAN PRESTON

Relevant Financial Relationships:

- Grant funding from NIDCD
- Salary from Syracuse University

Relevant Nonfinancial Relationships:

- No significant nonfinancial relationships to report.

ROAD MAP

1. EVIDENCE BASE

What is biofeedback, and what type of evidence supports its use?

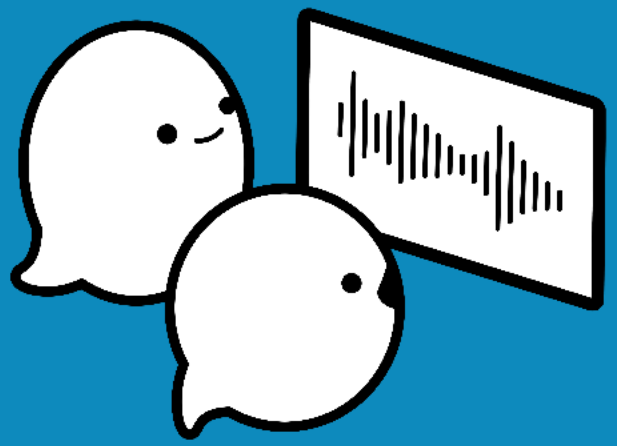
2. CLINICAL GUIDANCE

Clinical considerations for biofeedback delivery, in-person and via telepractice

3. WHAT'S NEXT?

Future directions

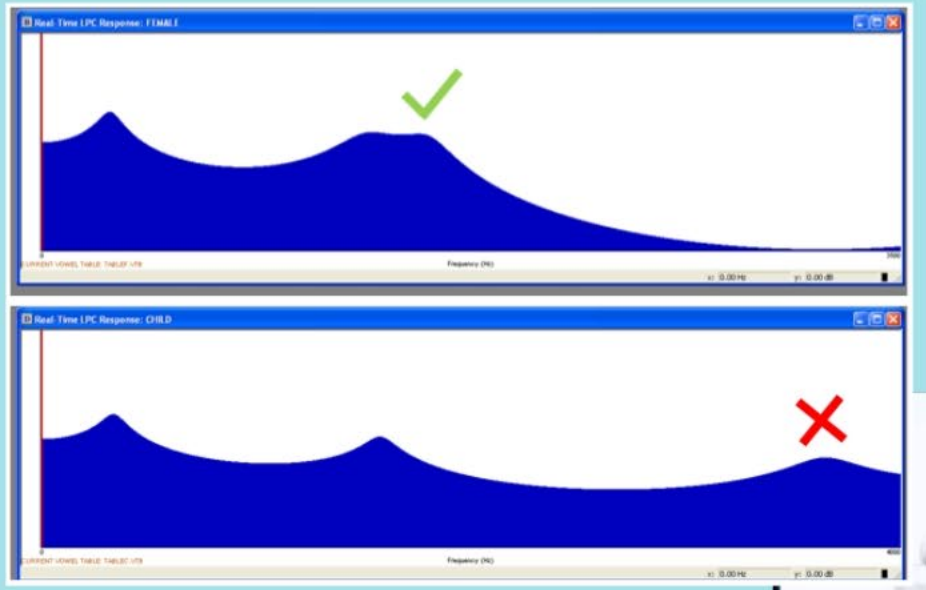
EVIDENCE BASE

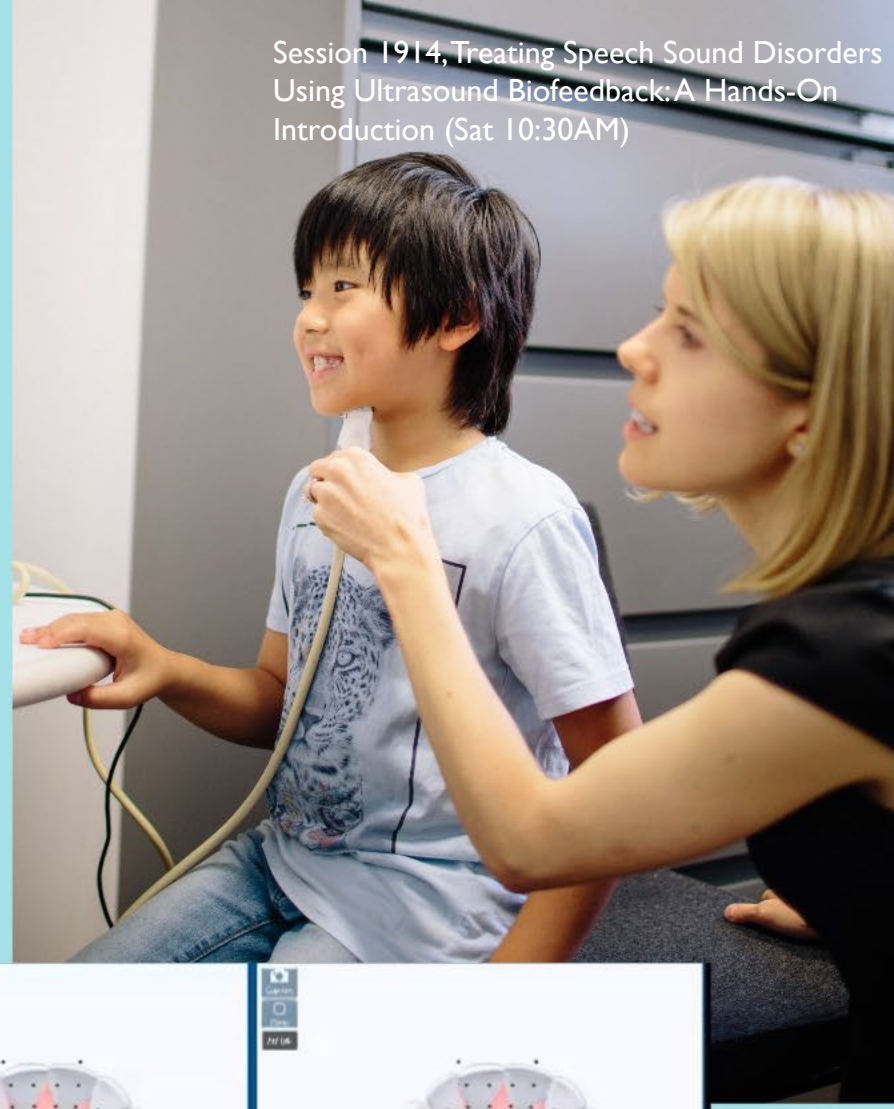


OUR RESEARCH

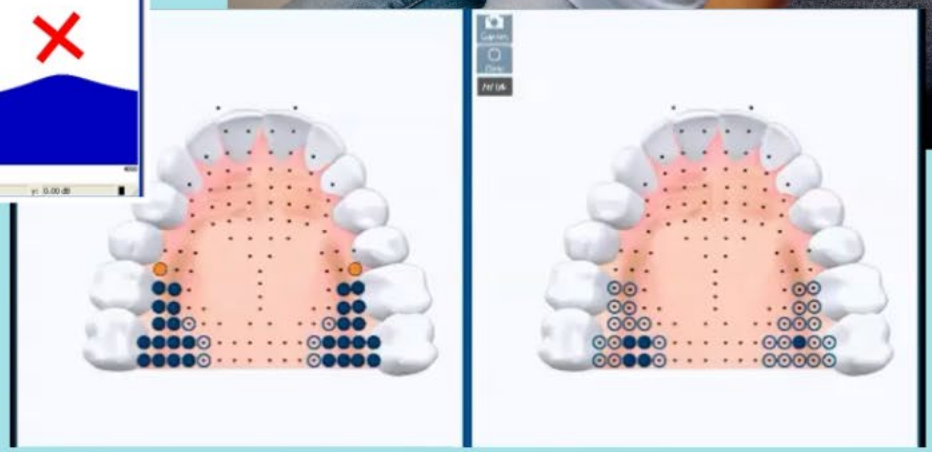
DO OUTCOMES FOR TREATMENT INCORPORATING VISUAL BIOFEEDBACK REPRESENT AN IMPROVEMENT OVER TRADITIONAL TREATMENT METHODS?

Biofeedback: Using instrumentation to create a real-time image of aspects of speech that may not be perceived under ordinary circumstances.





Session 1914, Treating Speech Sound Disorders Using Ultrasound Biofeedback: A Hands-On Introduction (Sat 10:30AM)



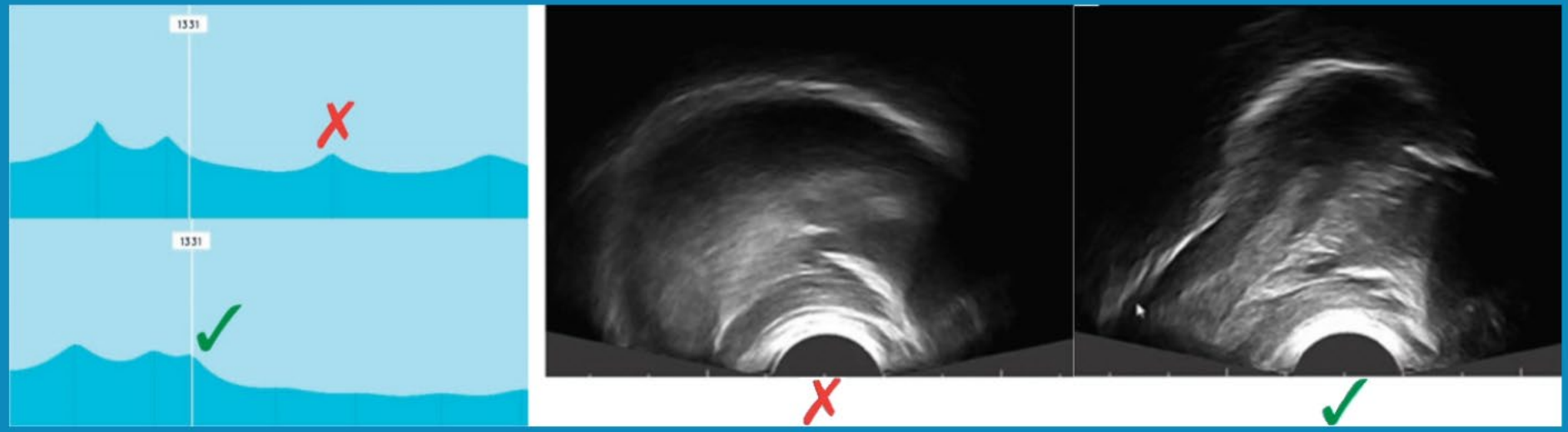
WHY BIOFEEDBACK?

1. *Adds a new sensory modality (visual).*

2. *Provides new insight into subconscious processes with the goal of bringing them under conscious control (Huang et al., 2006).*

3. *Enables comparison of speaker's production with a visual target, which can encourage self-monitoring.*

4. *Can provide enhanced motivation (if only because it's novel).*



SSD AND RSSD

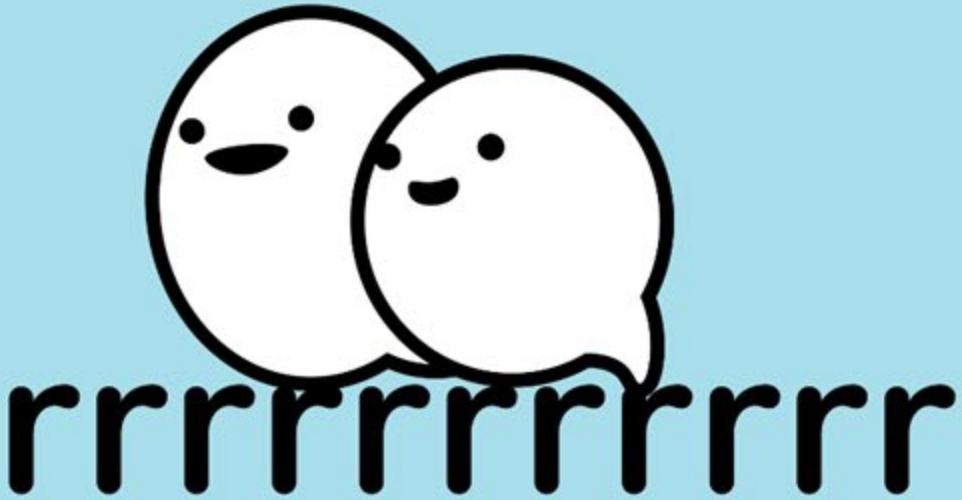
- Speech difficulties continuing past 8-9 years of age may be classified as residual speech sound disorder (RSSD).
- Can have negative impact on academic, social, or psycho-emotional development (Hitchcock, Harel, & McAllister Byun, 2015).
- Sounds like /ɹ/ are also subject to variation across dialects!
- We have a conversation with participating families to determine personal and dialectal appropriateness of /ɹ/ as a target.

"When you are learning through poetry how to speak English, it lends to a great understanding of sound, of pitch, of pronunciation, so I think of my speech impediment not as a weakness or a disability, but as one of my greatest strengths."

Amanda Gorman

WHY IS R A GOOD BIOFEEDBACK TARGET?

- Prevalence of residual deviations of /ɹ/ is likely a consequence of its articulatory complexity (Gick et al., 2007).
- Characteried by significant variability in tongue shapes in typical speakers' production, such as bunched versus retroflex (Boyce, 2015)



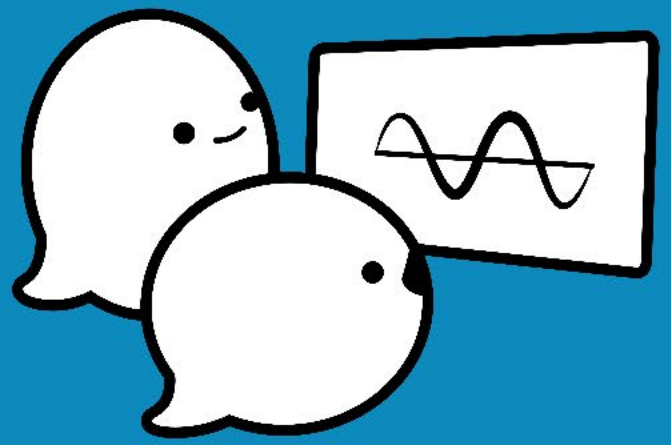
/r/ rrr /r/

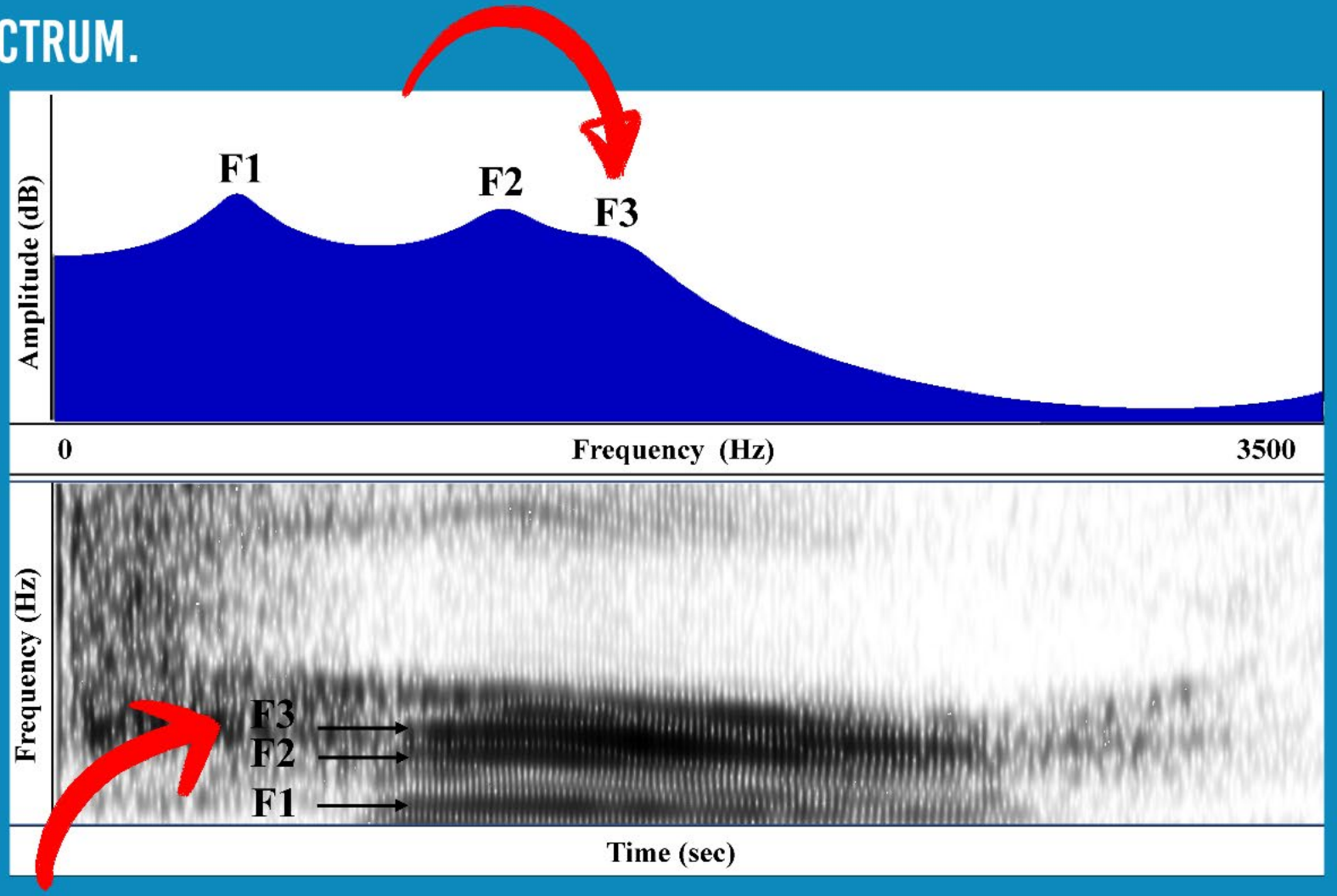
BUT ALL TONGUE SHAPES FOR R SHARE THE SAME ACOUSTIC HALLMARK.

- This is what we leverage in visual-acoustic biofeedback (VAB)

BIOFEEDBACK FOR R

THE LOWERED FREQUENCY OF THE THIRD FORMANT (F3) CAN BE VISUALIZED IN A SPECTROGRAM OR A LINEAR PREDICTIVE CODING (LPC) SPECTRUM.





BIOFEEDBACK FOR R

EVIDENCE BASE FOR VAB

1. Early case studies (Shuster et al., 1992, 1995)

2. McAllister Byun & Hitchcock (2012): 11 children who received an initial period of traditional treatment followed by visual-acoustic biofeedback found that significant improvements in perceptual and acoustic measures of /ɹ/ production occurred only after the transition to biofeedback for all but one participant.

3. McAllister Byun (2017): In a single-case randomization study, 3/7 participants showed a statistically significant advantage for visual-acoustic biofeedback over traditional treatment, while none showed a significant advantage in the opposite direction.

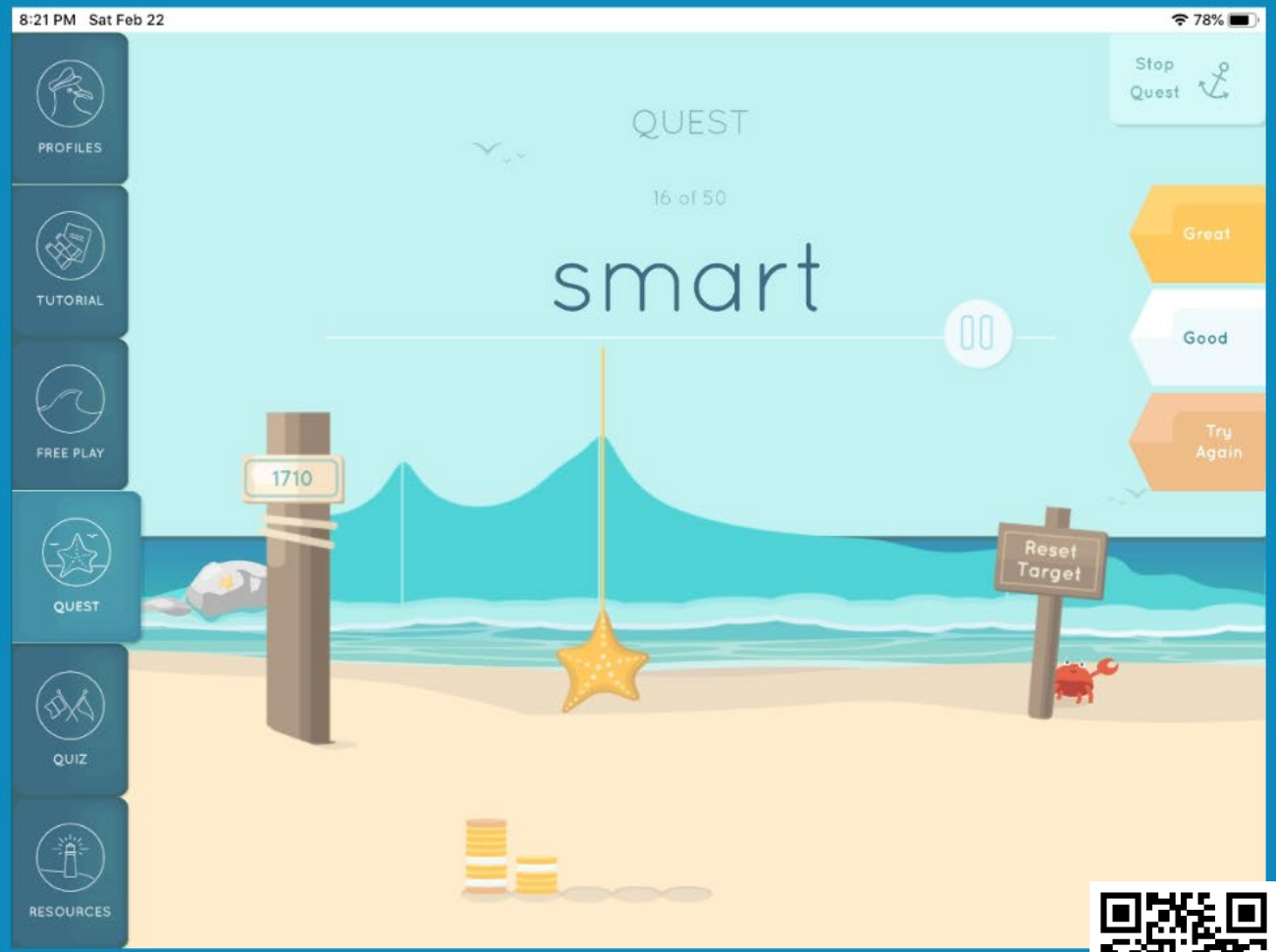
4. C-RESULTS: Ongoing randomized controlled trial that will provide the first well-powered between-group comparison of traditional articulatory treatment versus biofeedback.

LIMITATIONS OF BIOFEEDBACK

- Significant barriers to uptake of tech-enhanced interventions:
  - Cost of the required technology
  - User-friendliness of the technology; need for training

- From an **IMPLEMENTATION SCIENCE** perspective, there is a need to increase the real-world impact of biofeedback research.
  - Not sufficient to demonstrate efficacy of a method; also need to consider factors that impact its clinical uptake.

RESEARCH TO PRACTICE



start IOS APP (RELEASED 2020)

ASHA
AJSLP

Tutorial

Tutorial: Using Visual–Acoustic Biofeedback for Speech Sound Training

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ABSTRACT

Purpose: This tutorial summarizes current practices using visual–acoustic biofeedback (VAB) treatment to improve speech outcomes for individuals with speech sound difficulties. Clinical strategies will focus on residual distortions of /ɹ/.
Method: Summary evidence related to the characteristics of VAB and the populations that may benefit from this treatment are reviewed. Guidelines are provided for clinicians on how to use VAB with clients to identify and modify their productions to match an acoustic representation. The clinical application of a linear predictive coding spectrum is emphasized.
Results: Successful use of VAB requires several key factors including clinician and client comprehension of the acoustic representation, appropriate acoustic target and template selection, as well as appropriate selection of articulatory strategies, practice schedules, and feedback models to scaffold acquisition of new speech sounds.
Conclusion: Integrating a VAB component in clinical practice offers additional intervention options for individuals with speech sound difficulties and often facilitates improved speech sound acquisition and generalization outcomes.
Supplemental Material: https://doi.org/10.23641/asha.21817722

A growing body of research has supported increased clinical use of visual biofeedback tools for remediation of speech sound deviations, particularly distortions affecting American English rhotics (Bacsfalvi et al., 2007; Bernhardt et al., 2005; Gibbon & Paterson, 2006; Hitchcock et al., 2017; McAllister Byun, 2017; McAllister Byun & Campbell, 2016; McAllister Byun et al., 2014, 2017; McAllister Byun & Hitchcock, 2012; Preston et al., 2013, 2014; Schmidt, 2007; Shuster et al., 1992, 1995; Sugden et al., 2019). Visual biofeedback offers a unique supplement to traditional treatment due to the inclusion of a visual representation of the speech sound, which can be used to make perceptually subtle aspects of speech visible (Volin, 1998). As a result, the learner can alter their speech production by attempting to match a representation of an accurate target displayed in an external image. This tutorial summarizes the literature and describes clinical application of one type of biofeedback, visual–acoustic biofeedback (VAB).

Past research has shown that individuals with speech sound distortions who show a limited response to traditional interventions may benefit from therapy incorporating visual biofeedback (e.g., McAllister Byun & Hitchcock, 2012; Preston et al., 2019). If the speaker has a poorly defined auditory target, he/she may have difficulty imitating a clinician's auditory model but may succeed in matching a clearly defined visual representation of the target speech sound. Instead of relying on internal self-perception, clients are instructed to use the external image to gain insight into articulatory (i.e., ultrasound and electropalatography) or acoustic (spectrographic/spectral) information that is otherwise difficult to explain or teach. Furthermore, research explor
nonspeech tasks has shown increas

Correspondence to Elaine R. Hitchcock: hitchcocke@montclair.edu.
Disclosure: Elaine R. Hitchcock is a 2017 recipient of a PENTAX Medical Research Grant award. Tara McAllister oversees the direction of the staRt app for visual-acoustic biofeedback. Tara McAllister has an ownership stake in Sonority Labs LLC, a small business that has licensed the staRt software for commercialization. The other authors have declared that no other competing financial or nonfinancial interests existed at the time of publication.

VAB TUTORIAL (2023)

TELEPRACTICE CONSIDERATIONS

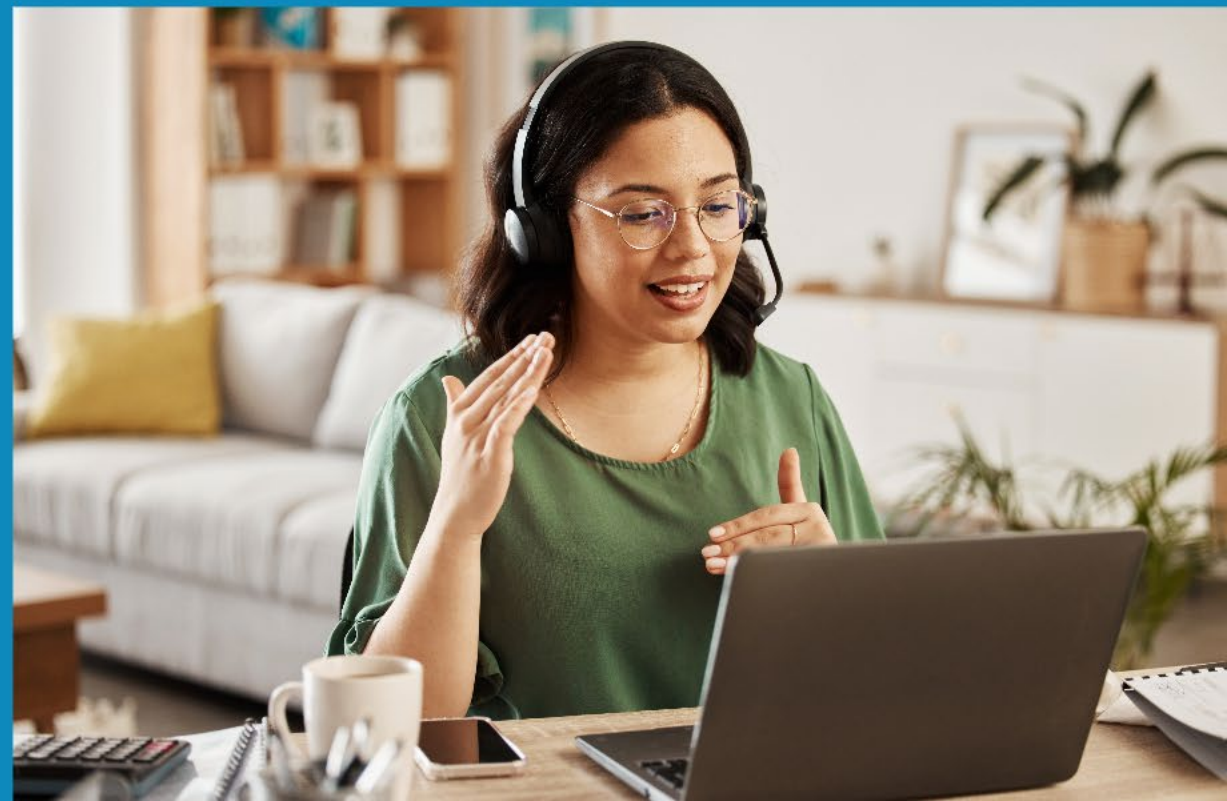
1. *Previous research suggests comparable outcomes across in-person and telepractice delivery of treatment for speech sound disorder (e.g., Grogan-Johnson et al., 2011, 2013).*

2. *However, the evidence base is small and has some shortcomings, such as limited description of the treatment methods used.*

3. *Prior to COVID-19, no research specifically investigated the use of telepractice for the population of children with RSSD.*

4. *And there were no studies of telepractice delivery of biofeedback.*

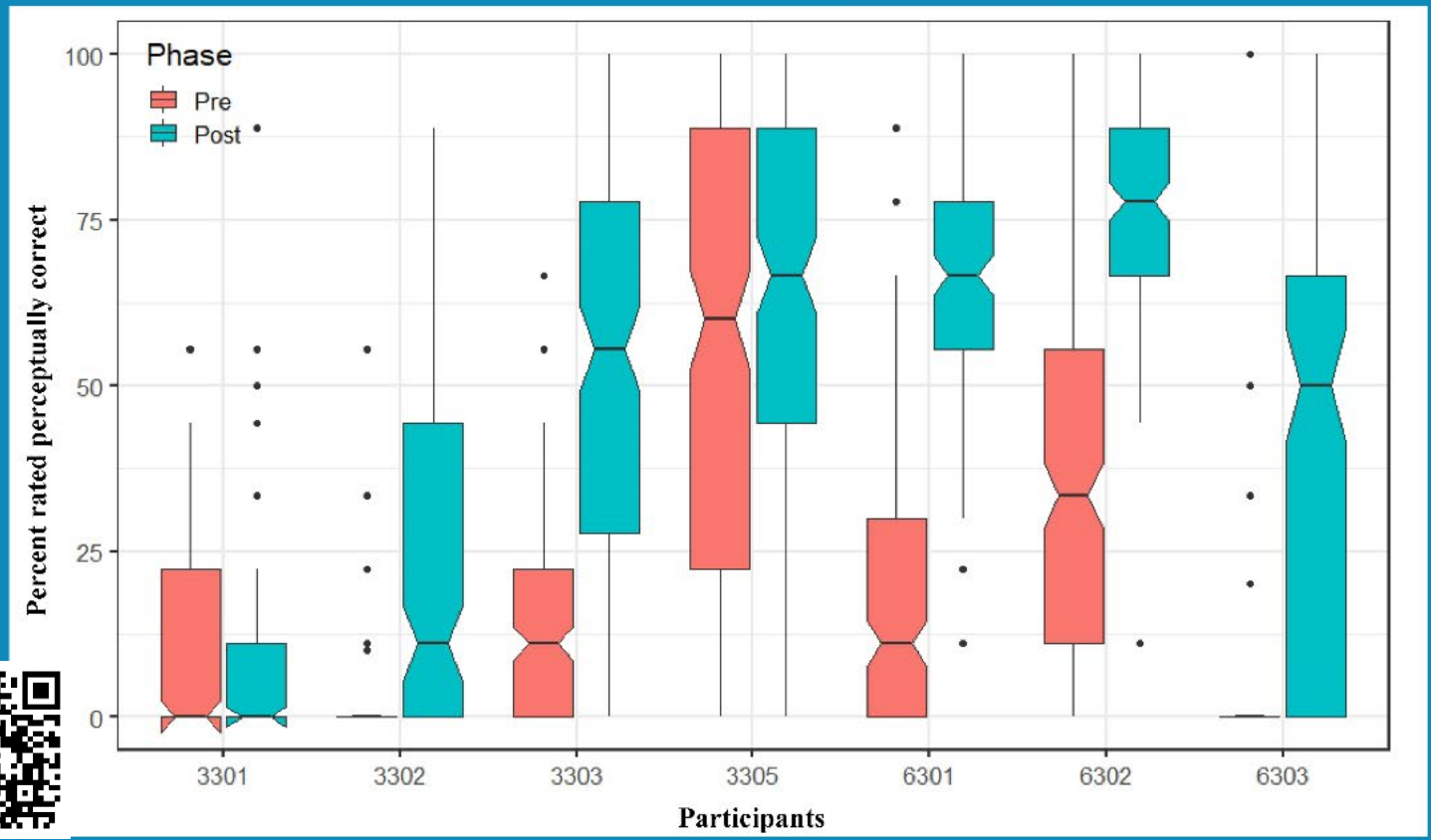
POSSIBLE BARRIERS: INTERRUPTIONS IN CONNECTIVITY, LAG IN VIDEO TRANSMISSION, LOW FREQUENCY RESOLUTION, ETC.



VAB IN TELEPRACTICE

OCHS ET AL (2023)

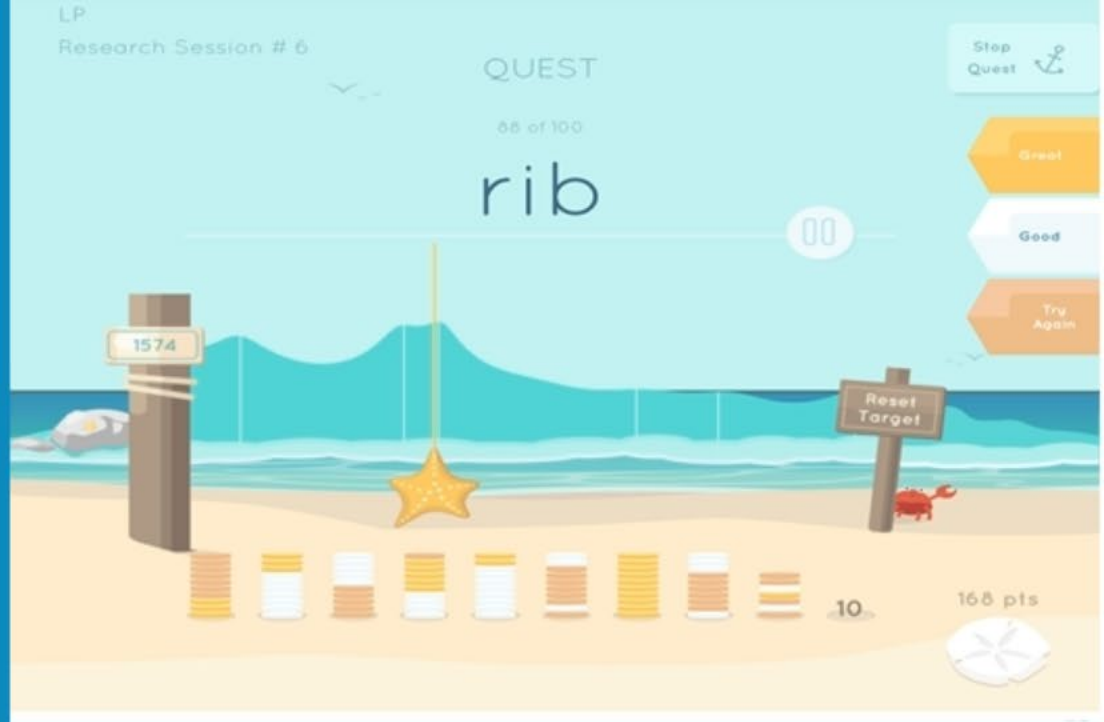
- Single-case experimental study
- 7 children with RSSD received 20 sessions of treatment via telepractice
  - One biofeedback and one traditional session each week
  - Treatment delivered using Sona-Speech over Zoom
- Six of the 7 participants showed a clinically significant response to treatment, although the magnitude differed across individuals and phonetic contexts (vocalic versus consonantal).
- Supports the feasibility of delivering visual-acoustic biofeedback via telepractice.

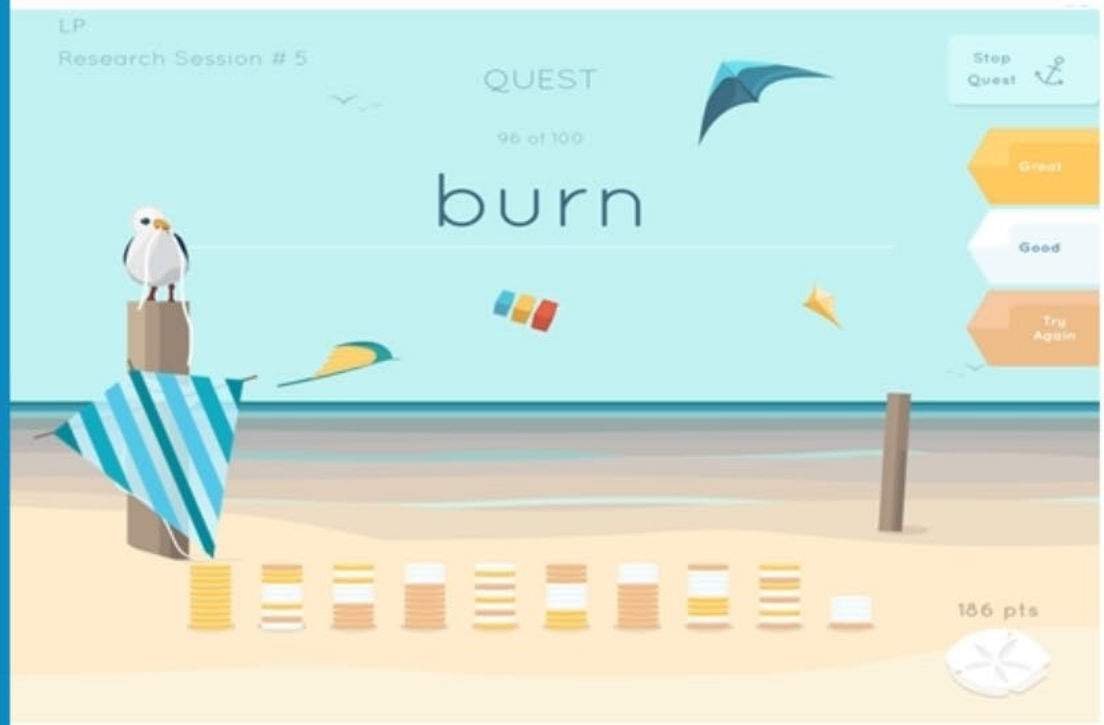


RESEARCH W/ START

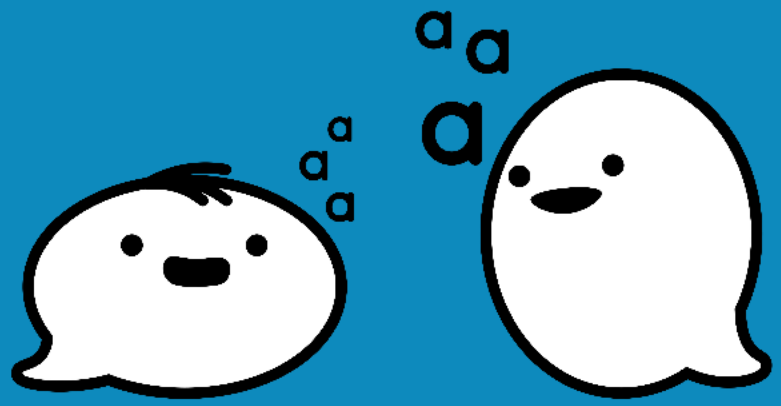
PETERSON ET AL (2022)

- Single-case experimental study
- 4 children with RSSD received an equal number of traditional and biofeedback treatment sessions in a randomized order (16 total)
- Both biofeedback and traditional treatment delivered through the staRt app.
- All 4 participants showed a clinically significant response to treatment, with effect sizes ranging from moderate to very large.
- One participant showed a significant advantage for biofeedback over traditional treatment.





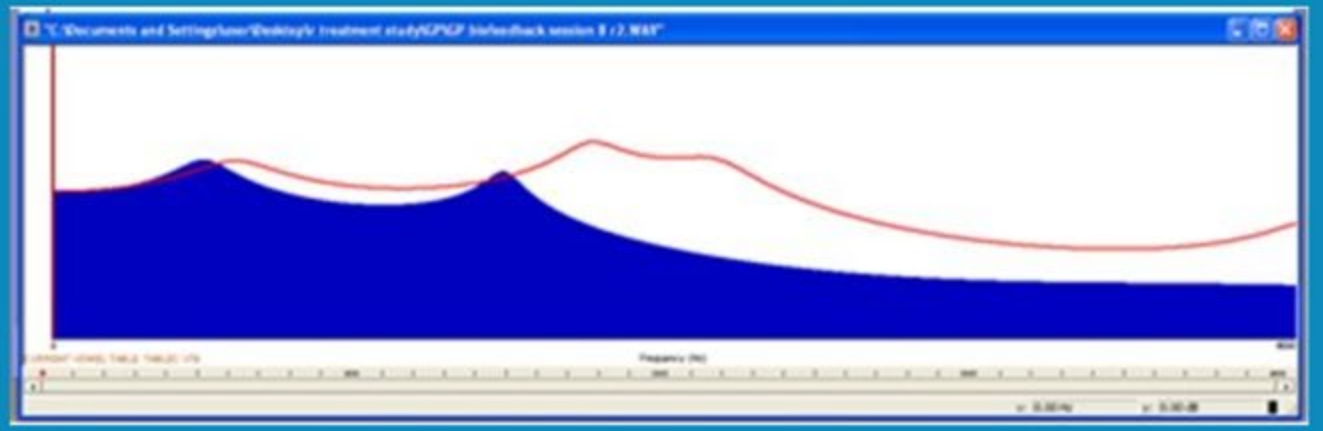
CLINICAL CONSIDERATIONS



SETTING A TARGET

- The target for /ɹ/ looks different depending on the software used.
- In Sona-Match, the red line shows a trace of the target pronunciation (all formants).
- In staRt, an adjustable slider sets a target for F3.

START APP



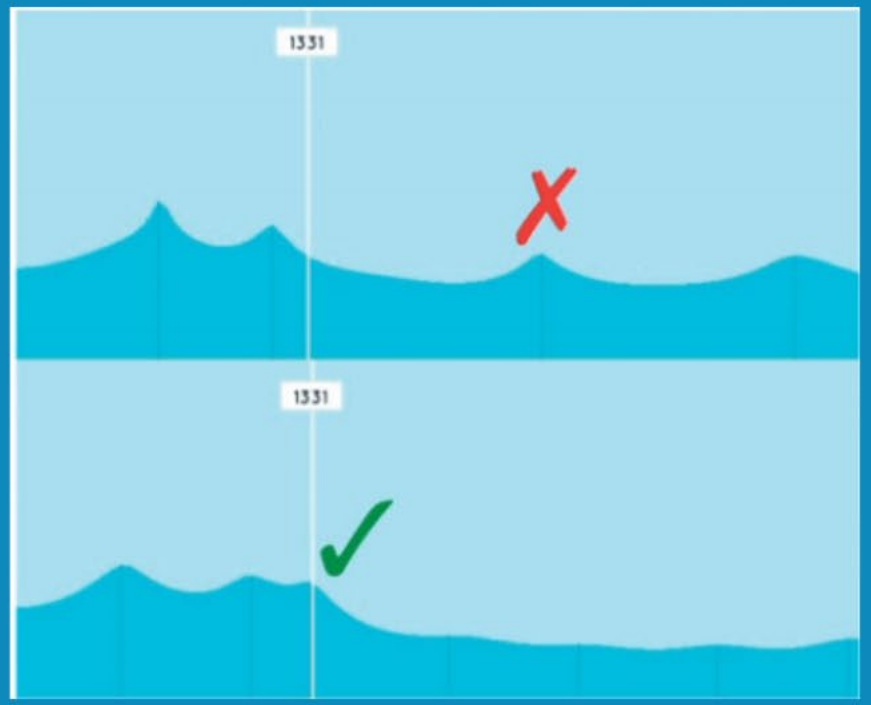
CSL SONA-MATCH

SETTING A TARGET

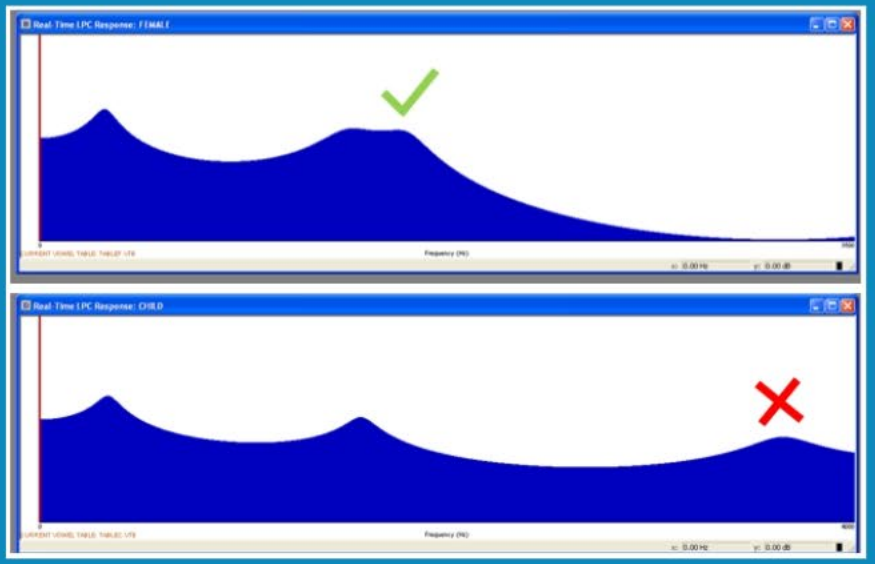
- In either software, the goal is the same: a lowered frequency of F3.

- We use the same acoustic target for /ɹ/ across phonetic contexts.
  - Previous research investigating whether consonantal and vocalic /ɹ/ have different acoustic properties has yielded mixed results.

START APP

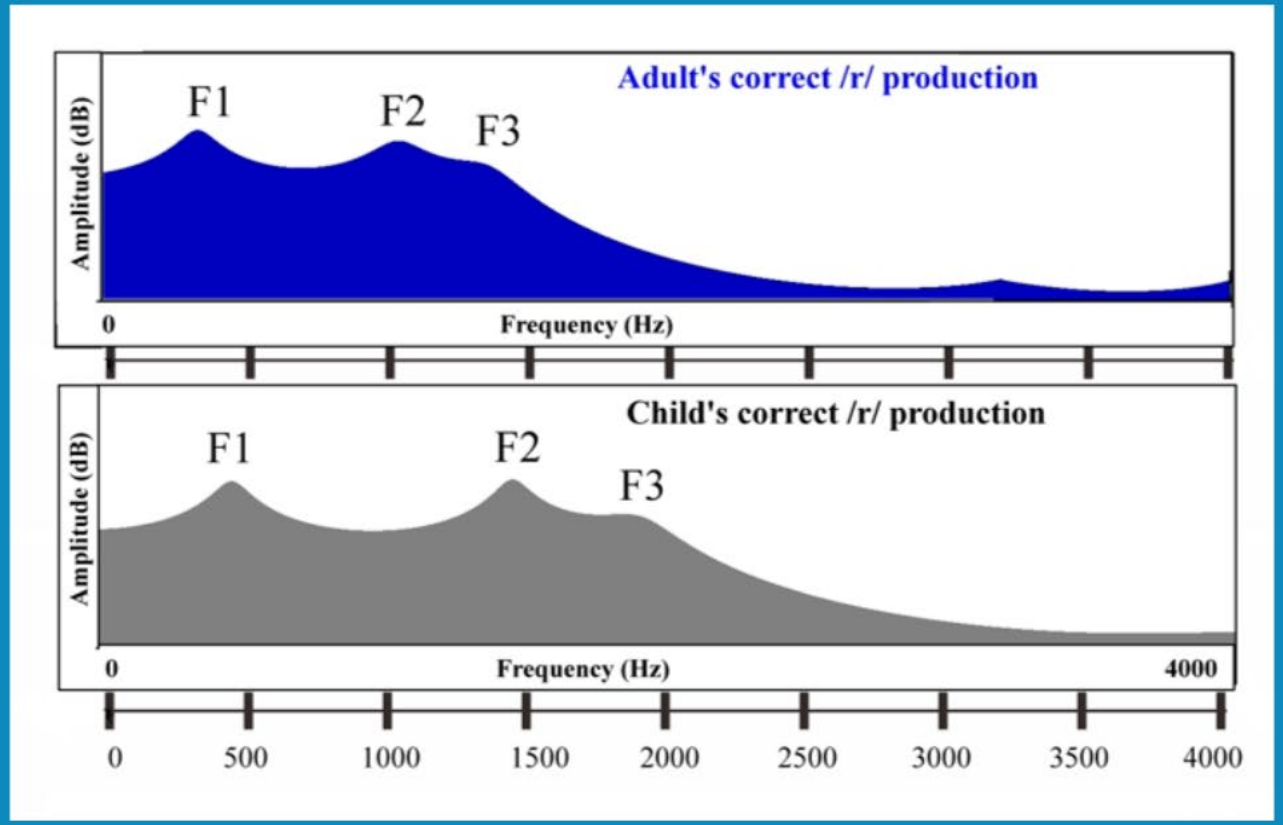


CSL SONA-MATCH



SETTING A TARGET

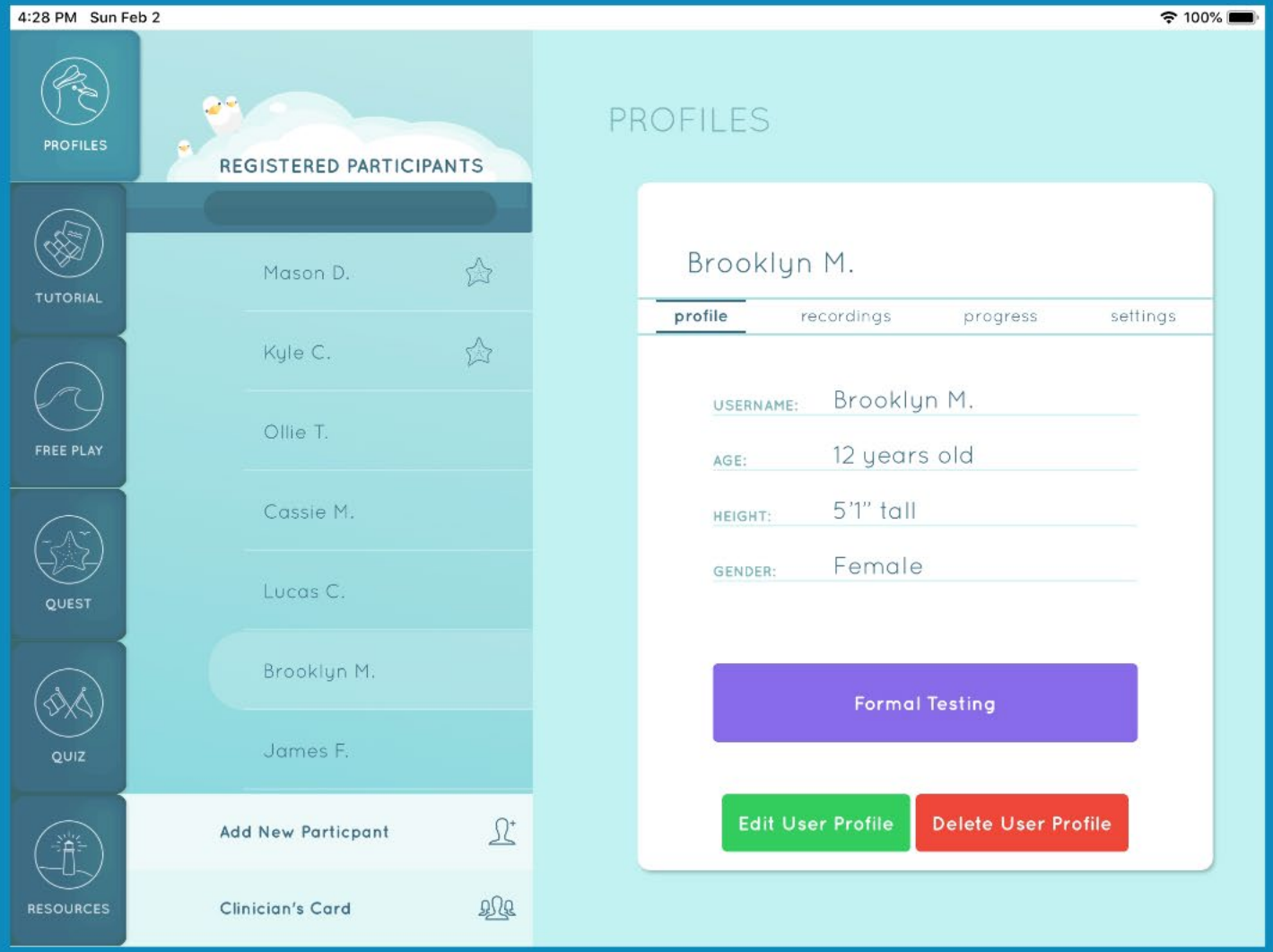
- Keep in mind that formant frequencies are influenced by vocal tract size.
  - Children's formants are higher than adults' due to their shorter vocal tracts.
- Targets should be appropriate for the participant's age and sex.
- If you are using CSL Sona-Match, you can download our sample templates for /ɹ/.
- As the participant begins to approximate /ɹ/, you can capture a template representing their own best production.



DOWNLOAD CSL TEMPLATES:

SETTING A TARGET

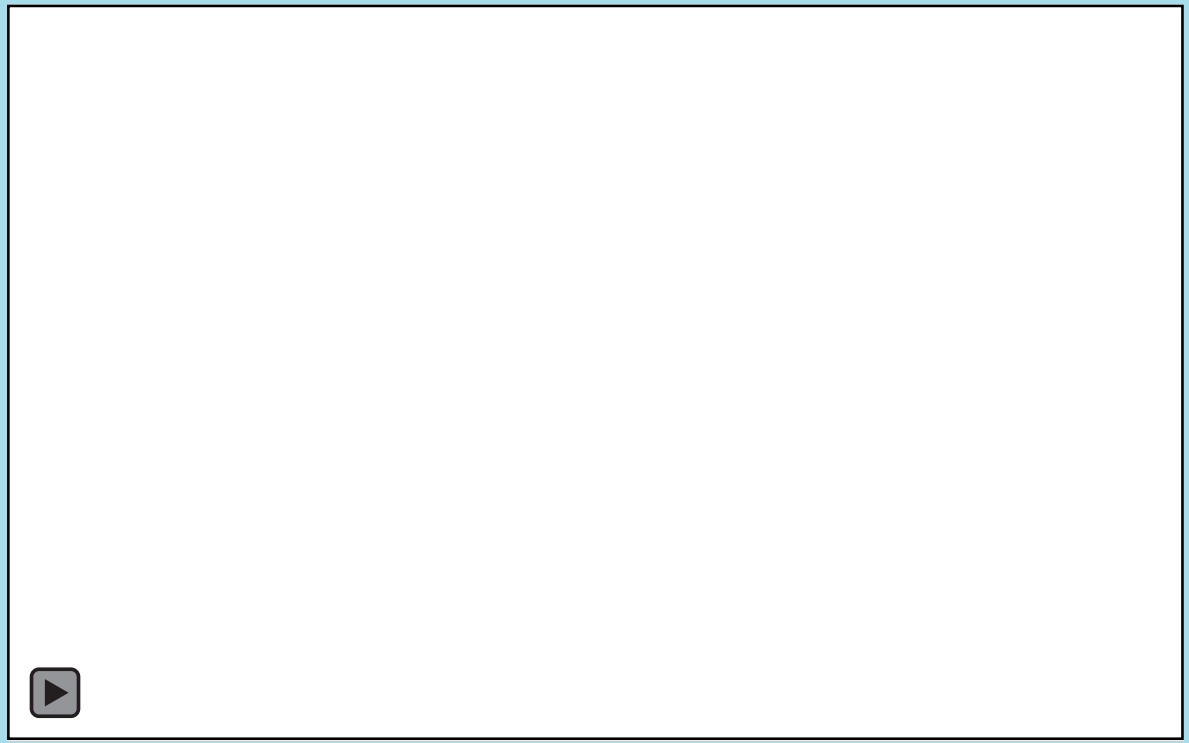
- In the staRt app, the target (starfish slider) is automatically placed at an F3 based on the values entered for speaker age, height, and gender (norms from Lee et al., 1999)
- F3 may need to be adjusted over the course of therapy by clicking and dragging the starfish slider.



ARTICULATORY EXPLORATION

A KEY FACTOR FOR SUCCESS

1-2 introductory sessions to ensure that the client understands:
a) how lingual movements modify the vocal tract
b) how those changes can be visualized via alterations of the formant peaks in the LPC spectrum



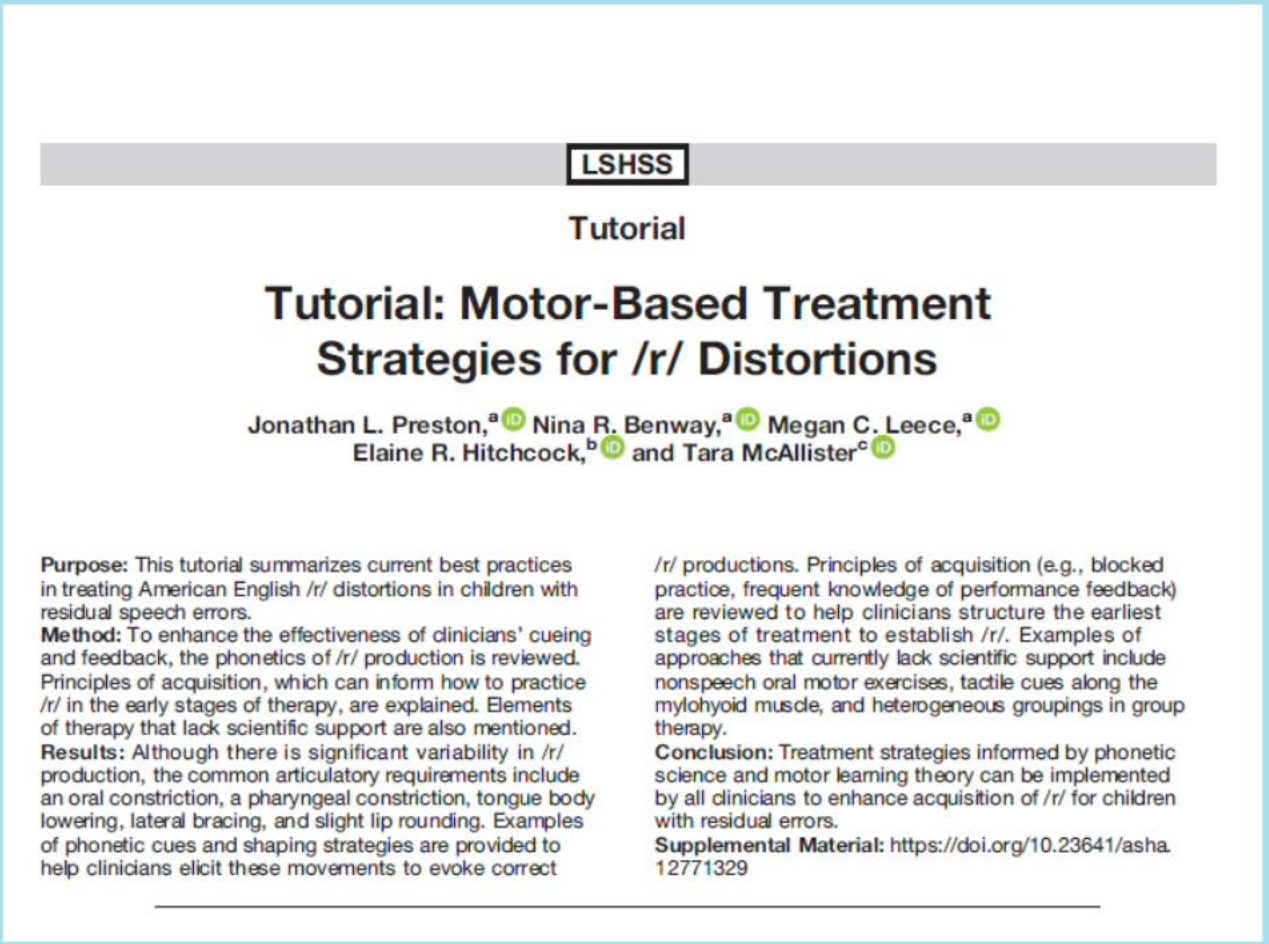
DOWNLOAD OUR SCRIPT FOR INTRODUCING BIOFEEDBACK:

WHAT CUES SHOULD I GIVE?

CAN I GIVE ARTICULATOR PLACEMENT CUES WHILE USING BIOFEEDBACK? YES!

- Articulator placement cues have been found to support children's ability to learn from the biofeedback display (McAllister Byun et al., 2016).
- You can feel free to integrate your preferred strategies (placement and shaping cues, facilitative contexts, etc.) while using biofeedback.

DOWNLOAD TUTORIAL:



LSHSS

Tutorial

Tutorial: Motor-Based Treatment Strategies for /r/ Distortions

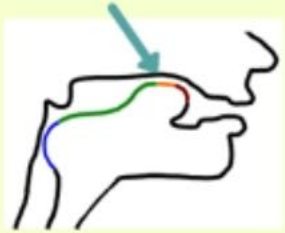
Jonathan L. Preston,[a] Nina R. Benway,[a] Megan C. Leece,[a] Elaine R. Hitchcock,[b] and Tara McAllister[c]

Purpose: This tutorial summarizes current best practices in treating American English /r/ distortions in children with residual speech errors.
Method: To enhance the effectiveness of clinicians' cueing and feedback, the phonetics of /r/ production is reviewed. Principles of acquisition, which can inform how to practice /r/ in the early stages of therapy, are explained. Elements of therapy that lack scientific support are also mentioned.
Results: Although there is significant variability in /r/ production, the common articulatory requirements include an oral constriction, a pharyngeal constriction, tongue body lowering, lateral bracing, and slight lip rounding. Examples of phonetic cues and shaping strategies are provided to help clinicians elicit these movements to evoke correct /r/ productions. Principles of acquisition (e.g., blocked practice, frequent knowledge of performance feedback) are reviewed to help clinicians structure the earliest stages of treatment to establish /r/. Examples of approaches that currently lack scientific support include nonspeech oral motor exercises, tactile cues along the mylohyoid muscle, and heterogeneous groupings in group therapy.
Conclusion: Treatment strategies informed by phonetic science and motor learning theory can be implemented by all clinicians to enhance acquisition of /r/ for children with residual errors.
Supplemental Material: https://doi.org/10.23641/asha.12771329

A FEW SUGGESTIONS FROM OUR TEAM

WHAT CUES SHOULD I GIVE?

ORAL CONSTRICTION



Narrowing in the palatal or palato-alveolar region. The narrowing may be the blade (bunched /ɹ/, pictured) or tip (retroflex /ɹ/, see "Lip Position" section).
Sample cue: "Lift the tongue tip like you're going to make a /t/, but don't touch the roof of your mouth."
Shaping strategy: shape from /l/ → /ɹ/
Facilitative contexts: /tr-/ or /dr-/ blends

LOWERING OF TONGUE BODY

Tongue body should be lowered behind the oral constriction. Often correct position here is dependent on achieving appropriate oral and pharyngeal constriction.
Sample cue: "Keep the body of the tongue low while you lift the front."
Facilitative contexts: /ɑɹ/, /ɹɑ/, /ræ/

TONGUE ROOT RETRACTION

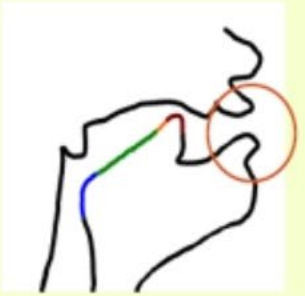
Posterior movement of the tongue root toward the back wall of the pharynx.
Sample cue: "Pull the back of your tongue straight back, not back and up."
Shaping strategy: shape from /ɑ/ → /ɹ/
Facilitative contexts: /ɑɹ/, /ɹɑ/, /ræ/

DOWNLOAD INFOGRAPHIC:

LATERAL ELEVATION

Sides of the tongue body contact the gums or molars, while central tongue body is lowered. Creates a "pit-like cavity" behind the oral constriction.
Sample cue: "Lift the sides up high like a bird's wings."
Shaping strategies: shape from /i/ → /ɹ/ or /ʃ/ → /ɹ/
Facilitating contexts: /ɪɹ/, /ɛɹ/

LIP POSITION

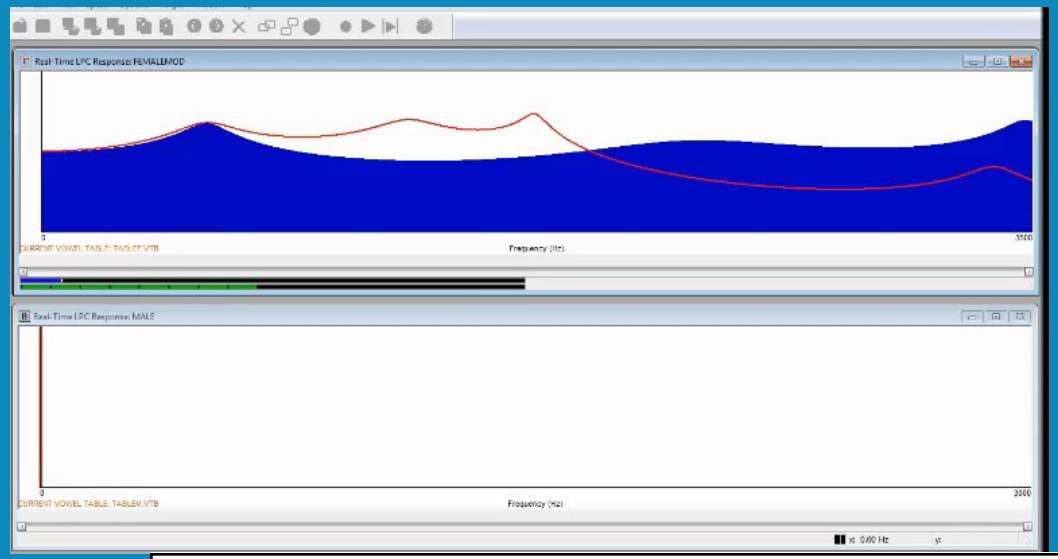


Lip position plays a small, secondary role in correct /ɹ/ productions. Some *slight* rounding of the lips is generally present on /ɹ/ productions; cueing should focus primarily on tongue position.
Sample cue: "Your lips should feel tight in the corners with a small opening in the middle."

PRE-PRACTICE

GOAL: INITIAL ACQUISITION OF A MOTOR PLAN FOR PERCEPTUALLY ACCURATE R

- Focus at the syllable level
- Provide frequent cues and verbal feedback
- Biofeedback should be available in most trials



Stim and syllable level practice

PRE-PRACTICE VIA TELEPRACTICE

GOAL: INITIAL ACQUISITION OF A MOTOR PLAN FOR PERCEPTUALLY ACCURATE R

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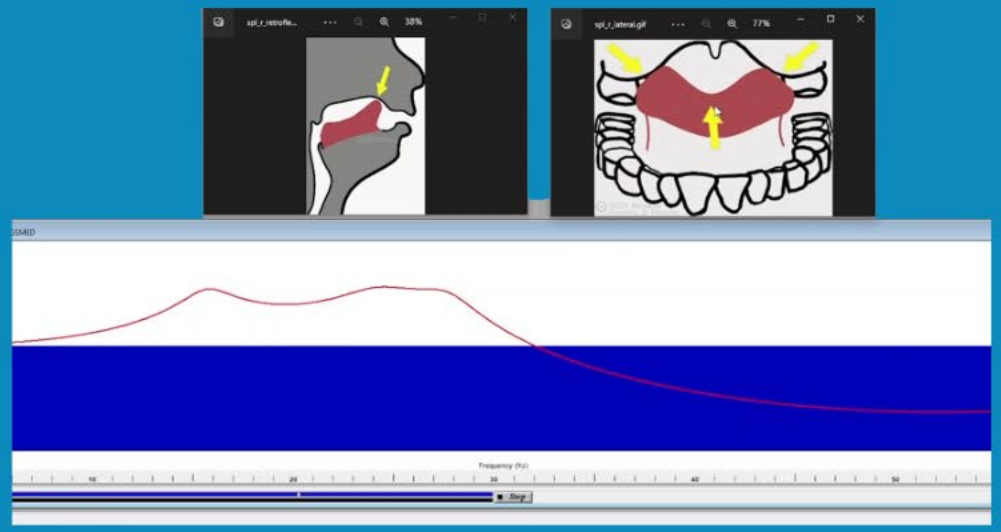
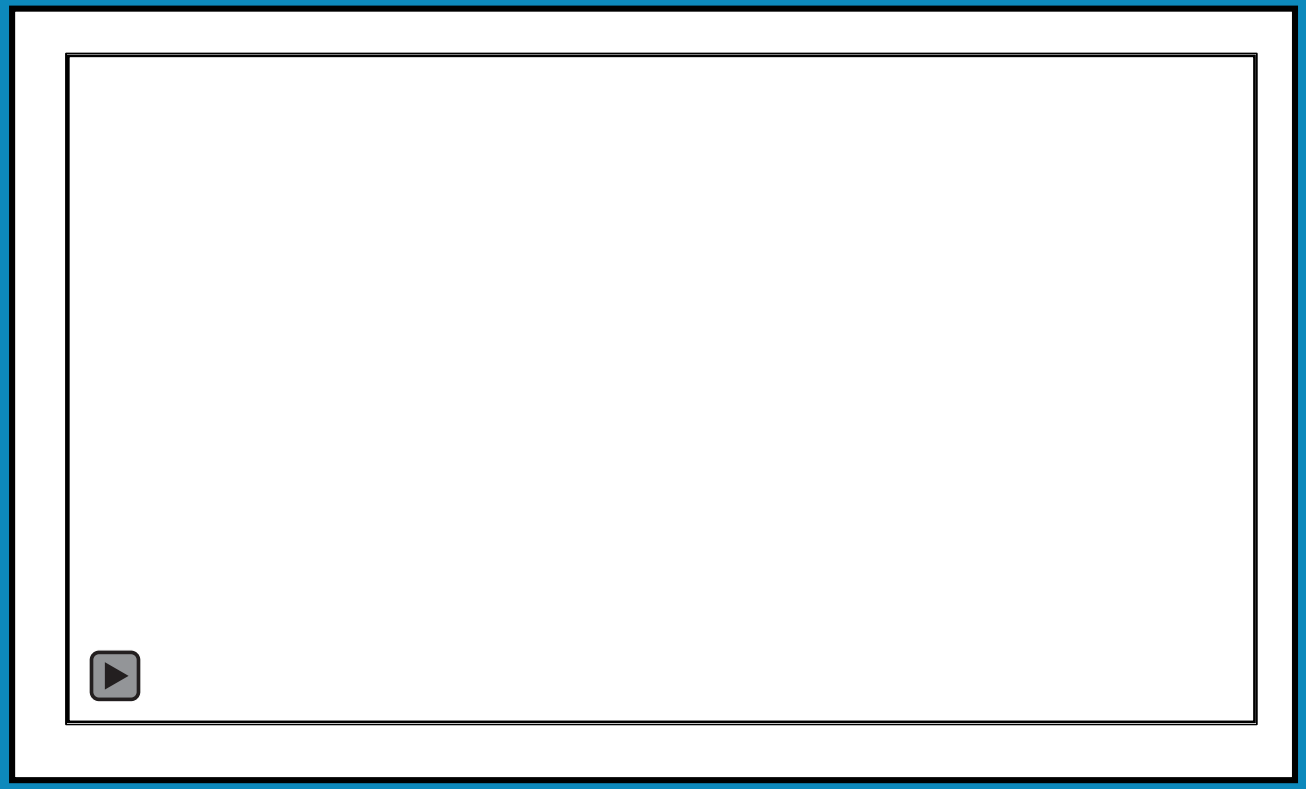




STRUCTURED PRACTICE

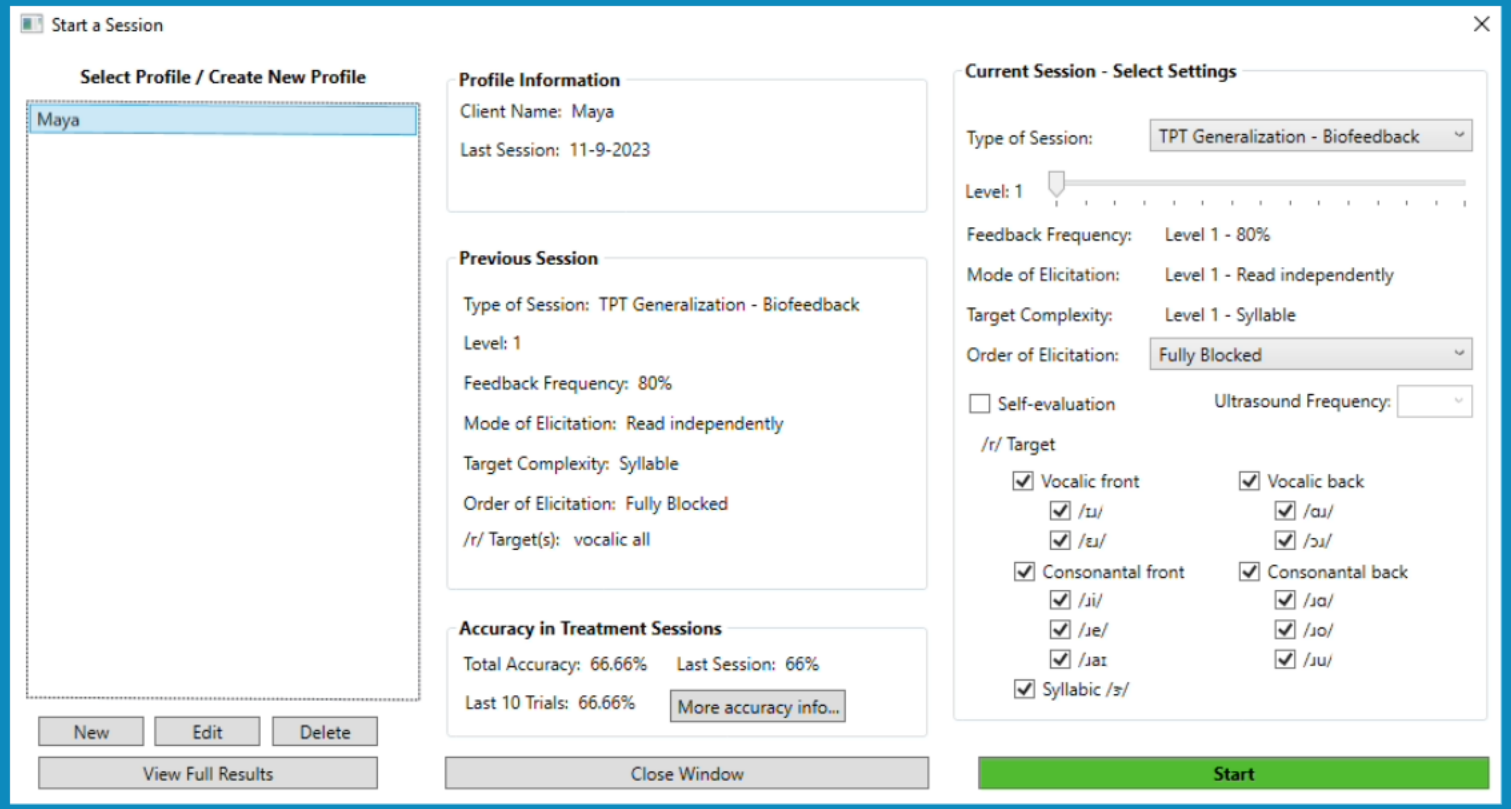
GOAL: GENERALIZATION OF THE NEWLY ACQUIRED MOTOR PLAN FOR R

- Step up the level of stimulus complexity
- Reduce the frequency of verbal cues and feedback
- **Fade the frequency of biofeedback** to avoid excessive dependence.

STRUCTURED PRACTICE

GOAL: GENERALIZATION OF THE NEWLY ACQUIRED MOTOR PLAN FOR R

- We use the Challenge Point Program (McAllister, Hitchcock, & Ortiz, 2021), a structured implementation of challenge point principles (Guadagnoli & Lee, 2004; Matthews et al., 2021).
  - Tallies the number of trials clinician rates correct in each block of 10
  - If 80% correct or greater, change one parameter to increase complexity.
  - If 50% correct or lower, decrease complexity.



DOWNLOAD CPP:

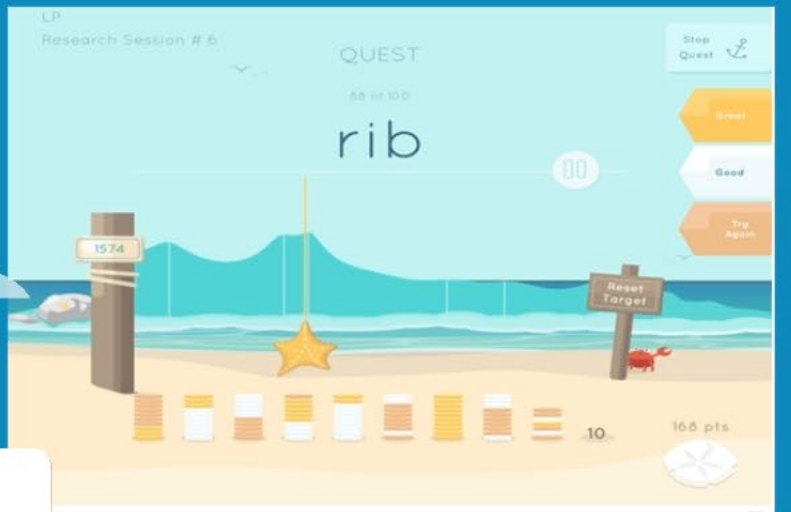
STRUCTURED PRACTICE

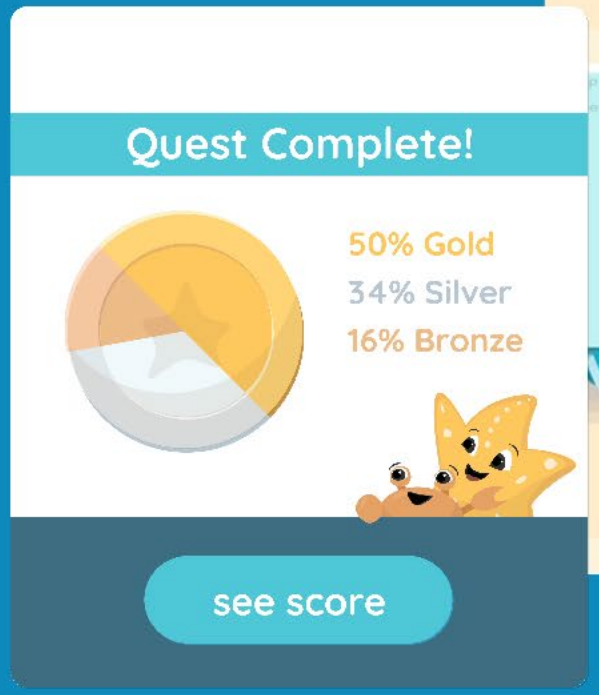
VIDEO: STRUCTURED PRACTICE

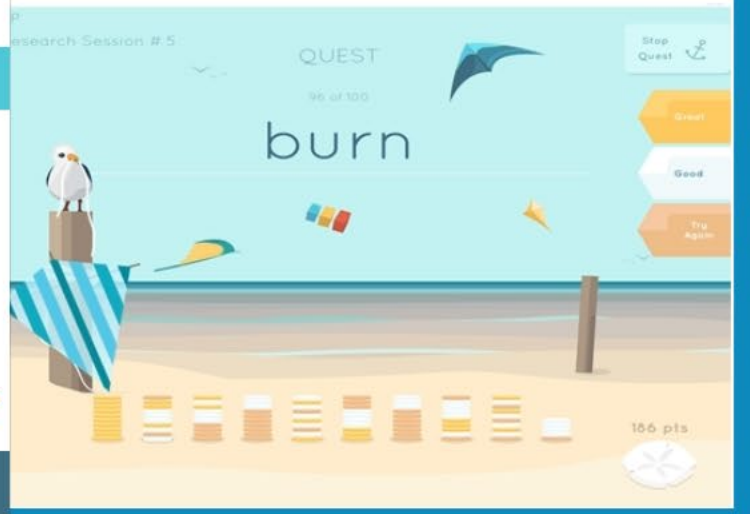
STUCTURED PRACTICE WITH START

USE 'QUEST' MODE

- Similar to CPP, clinician ratings are tallied and used to present stimuli with adaptive difficulty (syllable, word, phrase, sentence level).
- Biofeedback display can be toggled off.
- Gamified rewards reinforce number of trials completed and new records for accurate production.







TELEPRACTICE AND BIOFEEDBACK

TIPS FOR SUCCESS

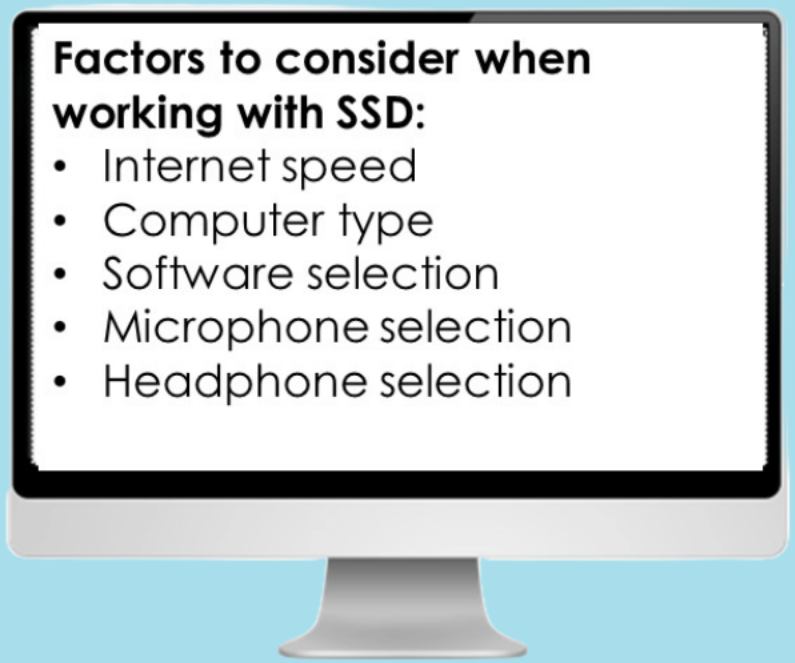
TELEPRACTICE AND BIOFEEDBACK

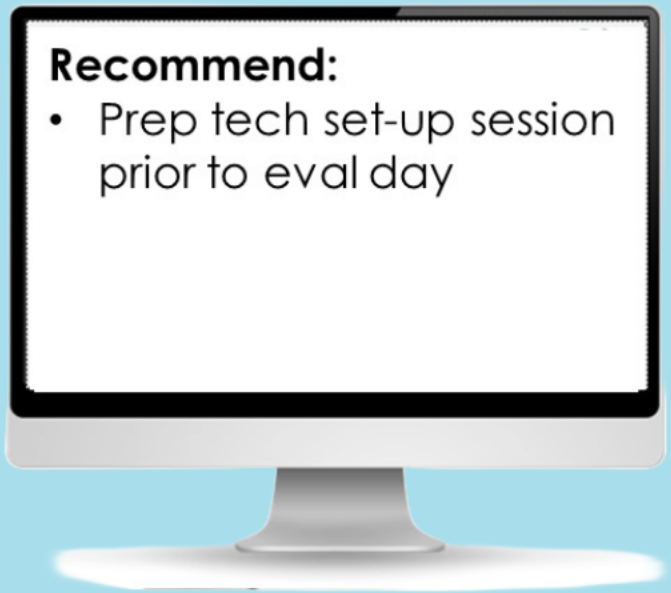
TELEPRACTICE is subject to a quickly evolving technological landscape.

- *Continuously revising and updating our procedures.*

TELEPRACTICE: TECHNOLOGY SETUP

Technology setup considerations:





TELEPRACTICE: TECHNOLOGY SETUP

- Adequate tech prep can mean the difference between a successful or unsuccessful session.
- We have prepared sample handouts for parents and clinicians to use to minimize technology challenges.

Thank you for your participation in our virtual speech therapy study.

What you will need prior to our first session:

A desktop or laptop computer with Windows or Mac operating system.
Tablets, cell phones and Chromebooks cannot be used for this study.

Zoom application downloaded on your computer.
If you don't have Zoom software installed, go to https://zoom.us/ and follow the prompts to install it.

Plug into the router.
To maximize the quality of the internet connection, please plug the computer into the router using an ethernet cable instead of using WiFi. If you do not have an ethernet cable or are not able to connect to the router, please contact the study team to discuss options.

Use headset with an in-line mic.
The headset we sent you must be used for all evaluation and treatment sessions. We will setup the headset with you during our first call.

Voice Recorder (for Windows) or Voice Memos (for Mac).
During sessions, we may ask your child to record his/her voice to their computer and upload the recordings to our research team. Voice Recorder and Voice Memos come standard on most Windows and Mac operating systems. Please check that your computer has one of these recording devices prior to our first session. If not, please contact the study team to discuss options.

Quiet space.
Make sure the space your child will be in during sessions is as quiet as possible. If possible - no siblings/pets/TV in the background. Please minimize ventilation noise or any other machine noise.

Be available for the first few minutes.
It helps to have a parent available for the first few minutes before we start the assessments to help troubleshoot sound or video issues.

If you have any questions, feel free to email us prior to your visit.

TELEPRACTICE: TECHNOLOGY SETUP

IMPORTANT CONSIDERATIONS

- Microphone directional pattern
- Frequency Response Bandwidth

Recommend a dedicated external, unidirectional microphone with the appropriate frequency response range for the target error sound.

Microphone	Plantronics - Blackwire 3325		Sennheiser GSP 670	
Frequency Response Bandwidth	100 Hz - 10,000 Hz		10 Hz – 7,300 Hz	
Cost	$46.00-69.99		$350.00	
Directional pattern	unidirectional		unidirectional	

FUTURE DIRECTIONS

NEW DIRECTIONS FOR start

LIMITATIONS OF THE START IOS APP

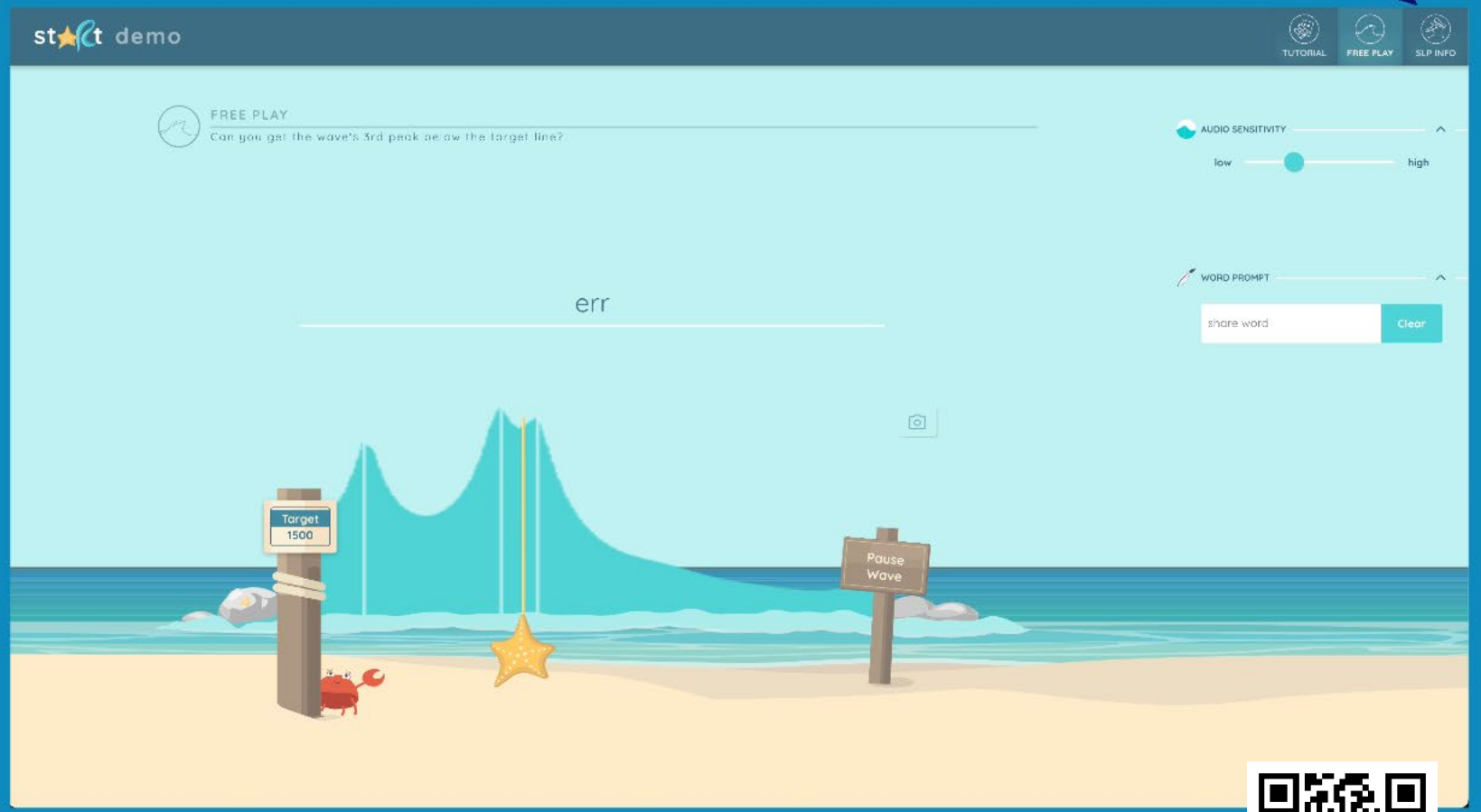
- Not optimal for telepractice - high processing load makes it hard to use with screen-sharing or mirroring technology.
- Not everyone has an iPad!

NEW DIRECTIONS FOR staRt

Use the SLP Info tab for suggested targets and links to resources for using staRt and biofeedback

INTRODUCING THE START WEB APP

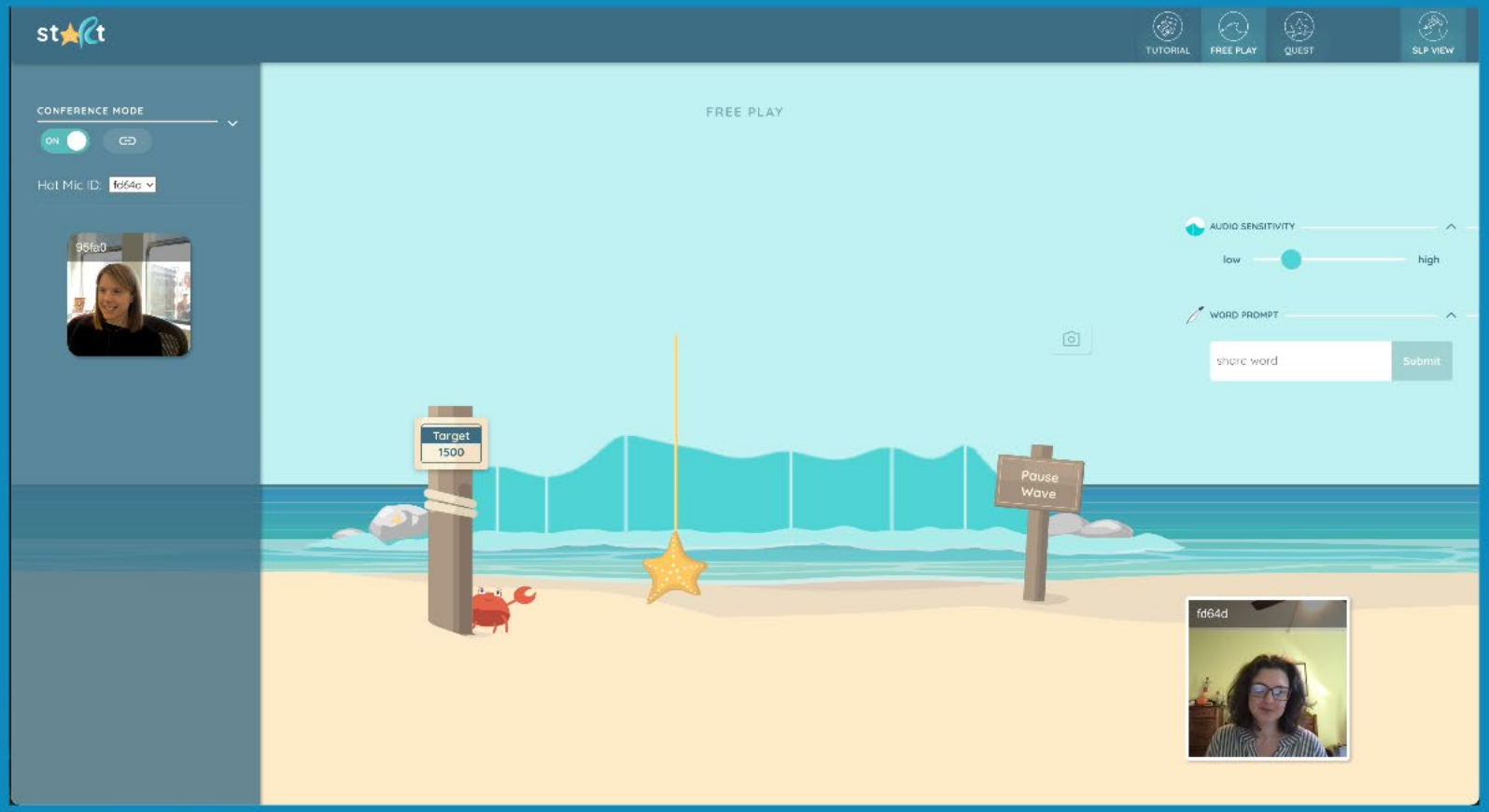
- Includes the staRt user tutorial and wave with adjustable slider.
- Can be used in-person on a desktop computer (Mac or PC).
- Can be screen-shared over Zoom for use in telepractice.
  - If possible, run the software on the client's device so they see the wave with no lag.
  - Try turning on Zoom 'Original Sound for Musicians' setting to prevent audio from dropping out during sustained sounds.



bitslabstart.com

WHAT WE'RE STILL WORKING ON

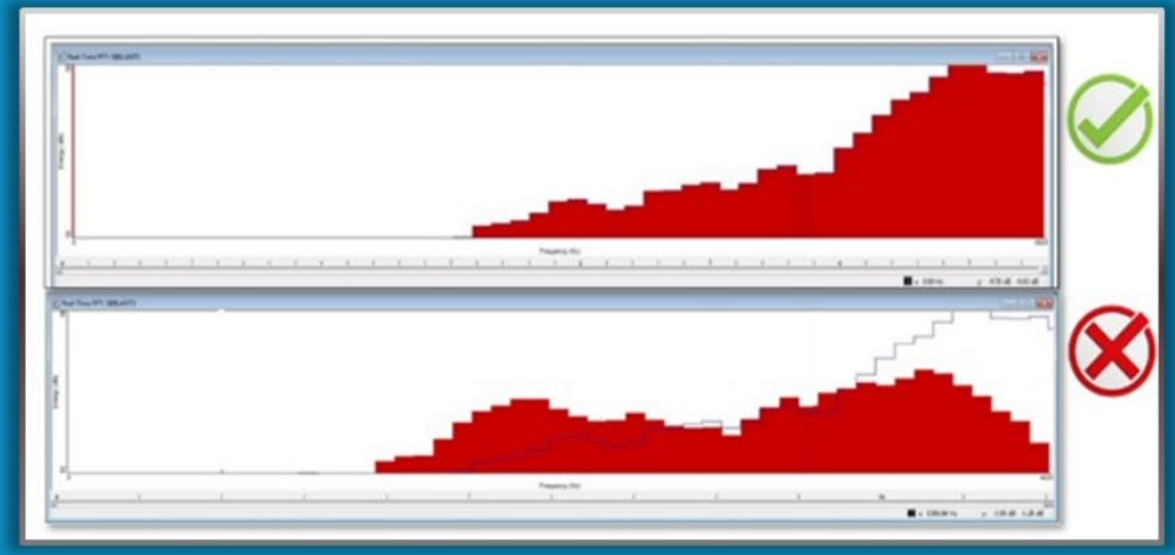
- Not yet available for mobile devices.
- Quest mode (word presentation, scoring, and progress tracking) is still being ported.
- Some lag will still be present when used over Zoom.
  - We have an option to connect in a video chat window within the website, which allows us to transmit the wave with no lag.
  - Is this a feature you would like to use?
  - We want to hear from you!



NEW DIRECTIONS: SPECTRAL OPTIONS

- Many children with RSSD have difficulty with sounds /s, z, sh, ch/ sounds, which cannot be visualized using an LPC spectrum.

Sibilant sounds are best visualized using a Fast Fourier Transform (FFT) spectrum.



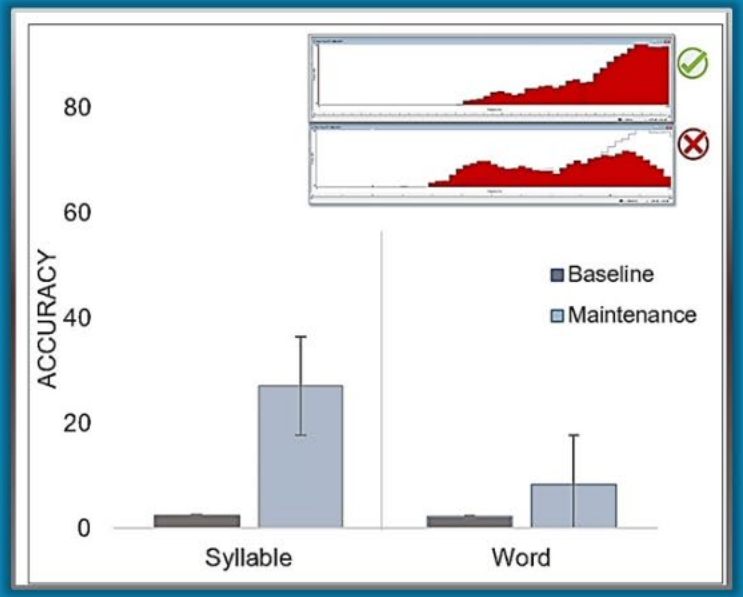
NEW DIRECTIONS: USING THE FFT SPECTRUM

PILOT CASE STUDY

- Participant: Male, aged 9
- No success in previous treatment
- 2x per week for 5 weeks of biofeedback treatment via telepractice using FFT spectrum.

RESULTS:

- Changes in perceptually rated accuracy of /s/ sounds revealed gains exceeding the conventional threshold to be considered clinically significant.
- Preliminary evidence that biofeedback via telepractice can provide an effective form of treatment for /s/.



Average baseline and maintenance gains for syllable and word probes from the pilot participant.

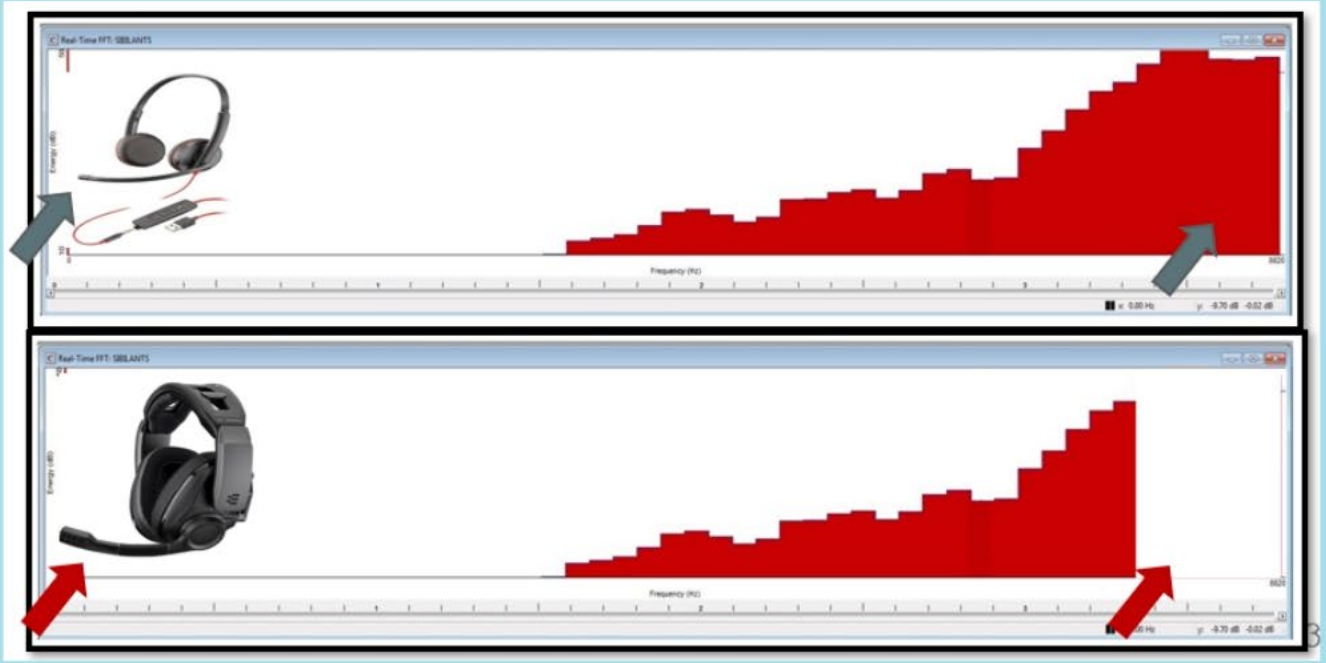
NEW DIRECTIONS: FFT SPECTRUM

CHALLENGE: Data loss for treatment of /s/

- The frequency range response of a microphone impacts the quality of the speech the clinician hears. Below is an example of an FFT spectrum showing a 9-year child's attempt to produce the fricative /s/.
- Acoustic energy for /s/ is concentrated at very high frequencies (~4000 Hz and above).

PROBLEM:

- If max frequency response of mic is 7,300 Hz, salient acoustic features of /s/ will be deleted
- Evidence: Loss of higher frequencies



DISCUSSION/CONCLUSIONS

We can help children with RSSD!

SUGGESTIONS

- Keep your cues on point
- To achieve stimulability, focus on principles of acquisition
- To generalize, focus on principles of motor learning

ADD VAB TO YOUR TREATMENT PLAN

- VAB is a viable treatment for /ɹ/ distortions.
- Free or low-cost options for VAB treatment available!
- Developing evidence for treating /s/ using VAB - stay tuned!

TELEPRACTICE is here to stay and is effective using visual acoustic biofeedback

THANK YOU!

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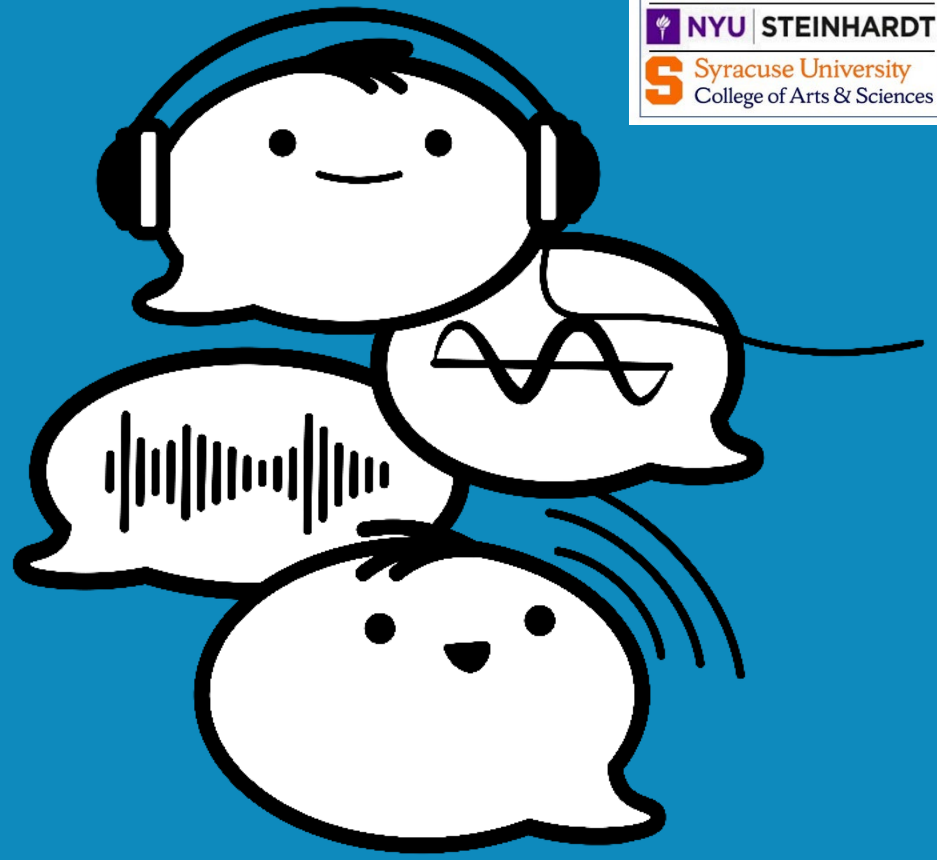

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