Treating Speech Sound Disorders With Tactile Biofeedback: A Clinical Review

Gordy Rogers, M.S. CCC-SLP, Chief Scientific Officer
Articulate Technologies, Inc.

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ASHA 2012 Interest Disclosure Statement

Your speaker is co-founder and Chief Scientific Officer of Articulate Technologies, Inc., the company that has developed, manufactures and markets Speech Buddies ®. Your speaker holds an equity stake in Articulate Technologies, Inc. and is paid by the company on a part-time basis.

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Agenda

- Part 1: What is Biofeedback? Does it Work?
- Part 2: Tactile Biofeedback: Rationale and Evidence-Based Practice
- Part 3: Tactile Biofeedback in Clinical Practice
- Part 4: Conclusion

Part 1:

What is Biofeedback?

Does it Work?

What is Biofeedback?

"Biofeedback is a means of supplying an individual with information that is not normally available at a conscious level"

– Shuster, Ruscello & Toth (1995)

Two main scientific rationales underpinning biofeedback in speech treatment:

1. Biofeedback accesses a sensory modality other than the one necessarily involved in a physiological process (e.g. a visual interface for an auditory target)
2. An ***external*** focus (e.g. a tactile cue) better facilitates the retention of a skill

– McAllister Byun & Hitchcock (2012)

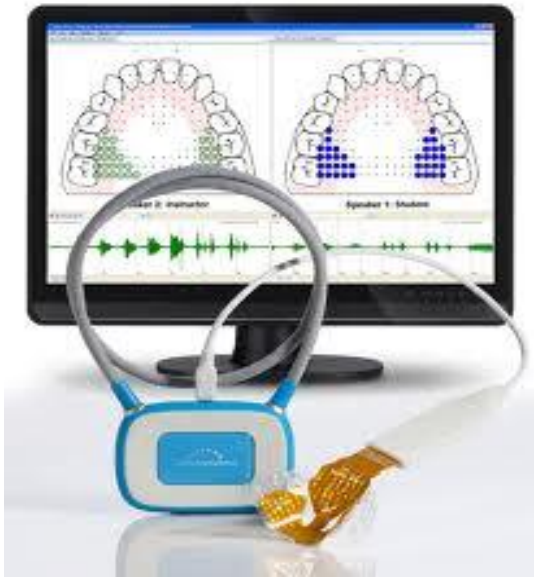
Hypotheses:

- Biofeedback makes clients more aware of a physiological process, such as a speech production, in order to help bring about change of that process
- Increased awareness of both the error patterns and the correct model of production not only facilitate correct production but enhance clients' ability to ***self-correct*** or ***generalize*** therapy gains

Visual Biofeedback

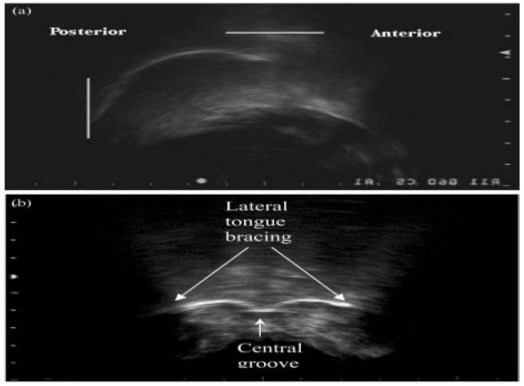
Electropalatography (EPG)

- Electrodes, placed on a dental retainer, correspond to specific palatal places of articulation
- The retainer is then attached via a USB cable to a computer application that visually displays the contact the client is making during speech production
- Enables real-time model of a client's speech production patterns
- The therapist can also provide a model of correct production to contrast with client's incorrect production



Ultrasound

- An ultrasound transducer is placed under the chin
- Much like a fetal ultrasound, a two-dimensional image is transmitted to an associated computer application
- Images require a short period of learning to interpret
- Enables real-time model of a client's speech production patterns
- The therapist can also provide a model of correct production to contrast with client's incorrect production



Does Visual Biofeedback Work?

Electropalatography (EPG)

- ***Apraxia of Speech:*** Lundeborg & McAllister (2007); McAuliffe & Ward (2006); Schmidt (2007)

- ***Cleft Palate:*** Bernhardt, Bacsfalvi, Gick, Radanov, & Williams (2005); Gibbon, Ellis, & Crampin (2004); Gibbon, Smeaton-Ewins, & Crampin (2005); ; Schmidt (2007)

- ***Hearing Impairment:*** Bernhardt, Gick, Bacsfalvi, & Ashdown (2003); Dagenais, Critz-Crosby, Fletcher, & McCutcheon (1994); Martin, Hirson, Herman, Thomas, & Pring (2007); Schmidt (2007)

- ***Down Syndrome and Cerebral Palsy:*** Cleland, Wood, Hardcastle, & Wishart (2009); Wood, Wishart, Hardcastle, Cleland, & Timmins (2009); (Gibbon & Wood, 2003)

Ultrasound

- ***Residual /r/ errors in adolescents*:** Adler-Bock, Bernhardt, Gick & Bacsfalvi (2007)

- ***Accent Modification:*** Bernhardt, Bacsfalvi & Wilson (2008)

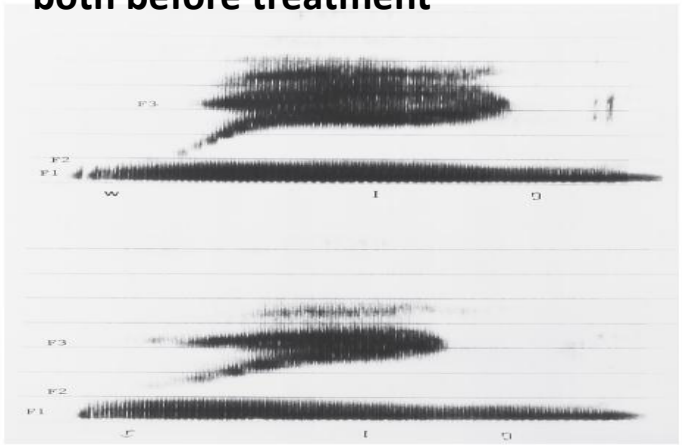
- ***Hearing Impairment:*** Bernhardt, Gick, Bacsfalvi & Ashdown (2003)

- ***Adults with Down Syndrome and Other Speech Impairments:*** *Fawcett, Bernhardt & Bacsfalvi (2008)*

Spectral Biofeedback

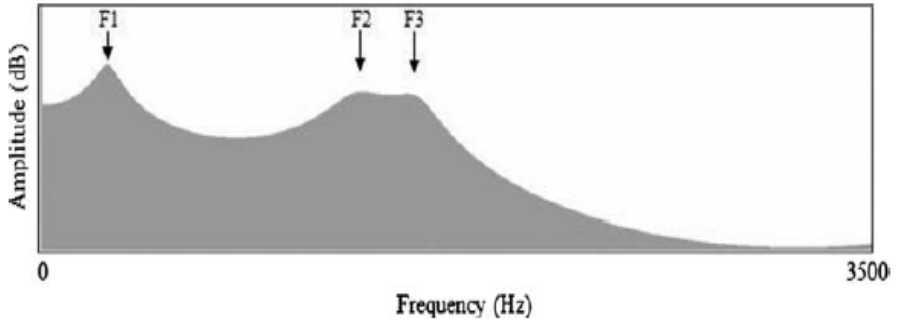
- Spectrography as a visual representation of acoustic signal of speech
- Research evidence of clinical applicability of spectral biofeedback:
  - Shuster, Ruscello & Smith (1992)
  - Shuter, Ruscello & Toth (1995)
  - McAllister Byun & Hitchcock (2012)
- Linear productive coding (LPC) spectrum allows client to match clinician's model of correct target sound

Spectrograms of "wing" and "ring" both before treatment



Source*: Shuster, Ruscello & Smith (1992)*

Linear productive coding (LPC) spectrum for American English /r/ in normal adult female



Source*: McAllister Byun & Hitchcock (2012)*

Part 2:

Tactile Biofeedback: Rationale and Evidence-Based Practice

The Tactile Biofeedback Methodology

- What is the Tactile Biofeedback Methodology?
  - Auditory, visual and now…tactile learning
  - Tactile Feedback within the mouth trains correct tongue placement and coordination
- Why tactile biofeedback works:
  - Integrating the sense of feeling greatly expedites learning
  - Enhances muscle motor memory
  - Emphasizes coordination and placement NOT strength
  - Endorsed by research and clinical leaders
- SLPs use tactile feedback already!
  - Coffee stirrers, tongue depressors, peanut butter

Gick & Derrick (2009)

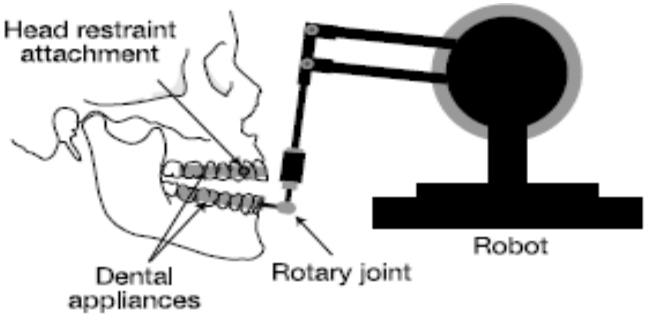
- **Aim:** Test whether normal speakers use tactile information during speech perception
- **Method:** Inaudible, slight air puffs using an air compressor were delivered on the right hand and neck of subjects during perception of voiced vs. voiceless stops
- **Results:** Subjects were significantly more likely to perceive a sound as aspirated even when the target was not a voiceless (and aspirated) stop (e.g. /p/)

Conclusion: Auditory speech perception naturally includes a tactile component in addition to a well documented visual component (McGurk & MacDonald, 1976)

Tremblay, Shiller & Ostry (2003)

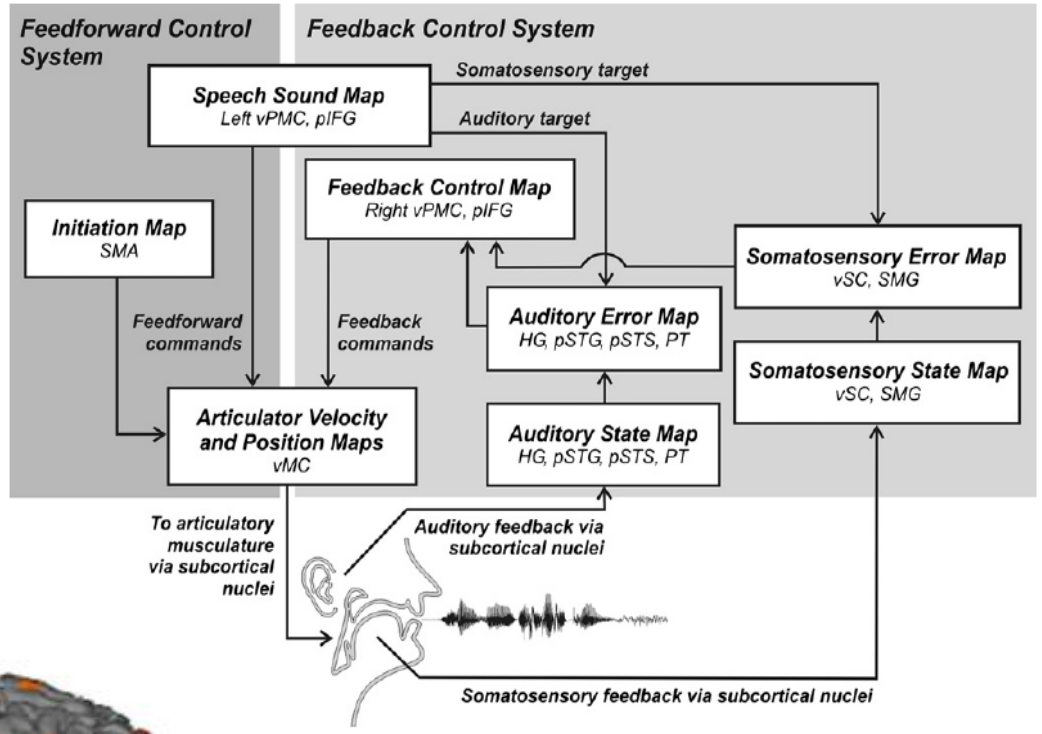
- **Aim:** To establish somatosensory (i.e. tactile) input independent of auditory input during speech production
- **Method:**
  - Apply force to the jaws of subjects during three separate tasks: speech production, silent speech, non-speech movements
  - Assess whether subjects adjust for these somatosensory changes when the auditory input is unchanged
- **Results:** Subjects systematically altered jaw movements even when the acoustic target has been achieved

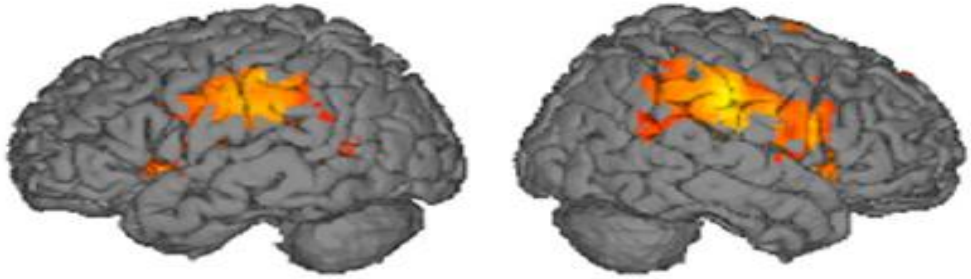
<u>Conclusion</u>: Somatosensory targets affecting specific vocal tract configurations are distinct goals in speech production



DIVA: Guenther & Vladusich (2010)

- Leading psycholinguistic model of speech acquisition and production
- Includes complementary somatosensory and auditory feedback loops
- fMRI studies show significant activation in the area of the supramarginal gyrus (left and right lobes), consistent with DIVA
- Consistent with other studies (e.g. Ghosh *et al*, 2010 with sibilants) suggesting distinct auditory and somatosensory goals





Implications of this basic research

- Disordered speech may result from one or more impaired components of the somatosensory feedback system
- Therapy methodologies should likewise explicitly target the somatosensory component of speech acquisition and production
- The time is ripe for more treatment studies to test this in a variety of treatment populations

Clark, Schwarz & Blakeley (1993)

Research

The Removable R-Appliance as a Practice Device to Facilitate Correct Production of /r/

Charlene E. Clark
Oregon Health Sciences University, Portland
Ilsa E. Schwarz
University of Oregon, Eugene
Robert W. Blakeley
Oregon Health Sciences University, Portland

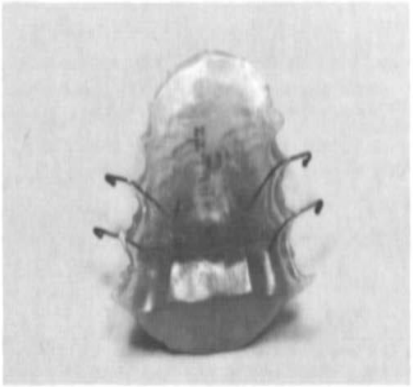
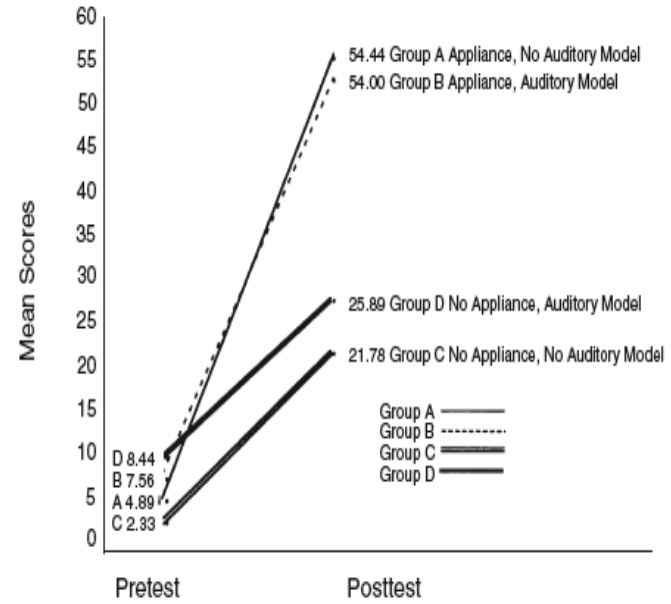


FIGURE 2. Summary of pretest and posttest means scores by groups for 60 /r/ words.



"subjects who received the appliance demonstrated ability to produce the target sound within the initial 30 minute appliance placement…."

"very little time was needed in learning "how" to produce /r/."

But, the authors cited significant drawbacks to this appliance (cost, invasiveness)

Ruscello (1995): Tactile Biofeedback review

- A review of the use of speech appliances in treatment
  - **Altschuler (1961):** A modified tongue depressor placed 30 mm into the oral cavity, used to prevent alveolar contact that causes lateral lisping
  - **Mowrer (1970):** A plastic plate placed under the tongue to create tongue configuration conducive to correct production of /r/
  - **Leonti, Blakeley & Louis (1975):** A prosthetic device specially fitted along the maxillary arch to facilitate correct /r/
  - **Shriberg (1980):** A bite stick in the form of a wooden dowel, used in conjunction with a traditional, phonetic-based verbal placement cues
- In general, most tool embodiments were shown to be promising in small scale studies
- However, devices were never adopted because of usability, manufacturability, and cost limitations

Optimizing Tactile Biofeedback for Clinicians

- Significant improvements needed:
  - Precise control of tongue placement for a wide variety of sounds
  - Easy to use & professional
  - Specially engineered for the needs of SLPs

Articulation Therapy

- Other medical therapy specialties have successfully incorporated medical devices into practice

Physical Therapy

Audiology

Dysphagia

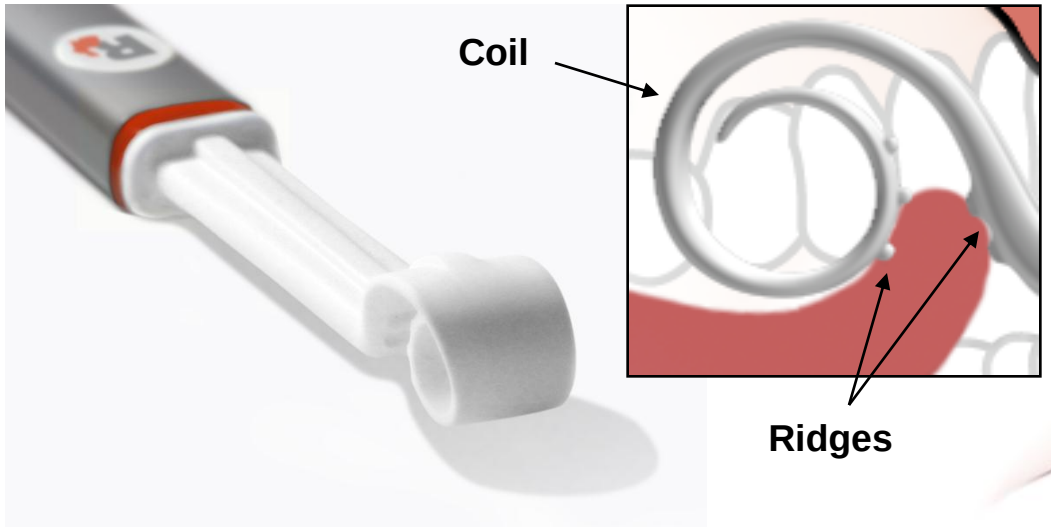
Dentistry

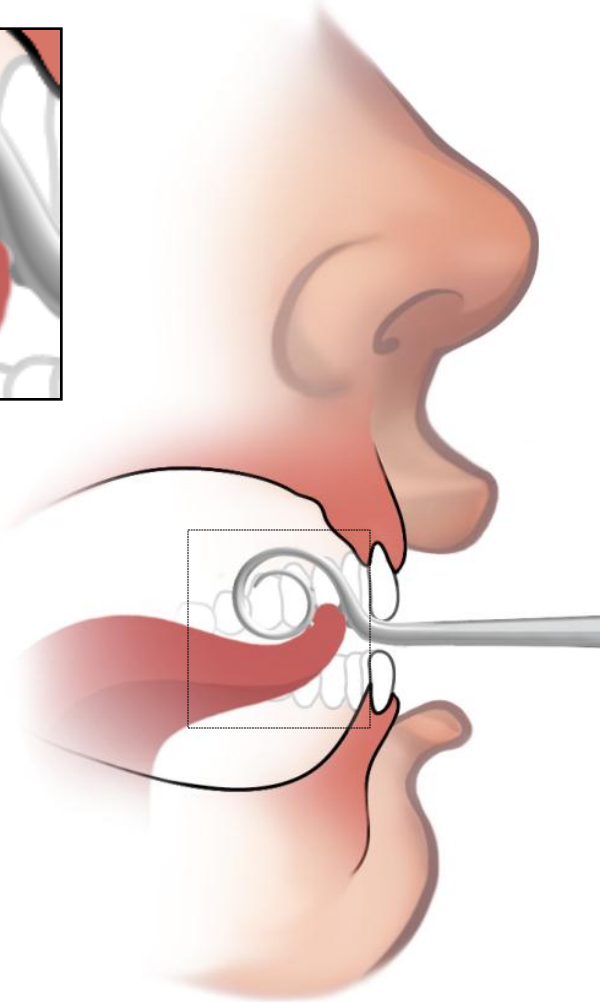
Speech Buddies use Tactile Feedback to train correct tongue placement

Speech Buddies – the optimal solution for Tactile Feedback

- Handheld tools that get inside the mouth during speech
- Teach correct and consistent tongue placement
- Target the hardest to learn sounds: R, L, CH, S, SH
- Minimally impede co-articulation and airflow
- FDA listed
- Supported by Speech Buddies University online training program

The R Speech Buddy



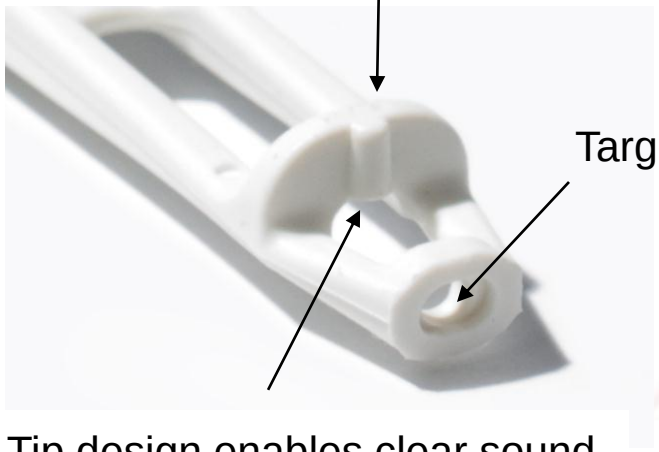


- Ridges guide initial tongue position
- Coil guides retroflection
- Easy for students to feel correct and incorrect R productions
- Works for vocalic R (bird, car) and consonantal R (rabbit, rise)

How to Use the Rabbit Buddy - Video

The S and SH Speech Buddies

Dental stop and centering ridge are placed on upper dentition and ensure correct placement



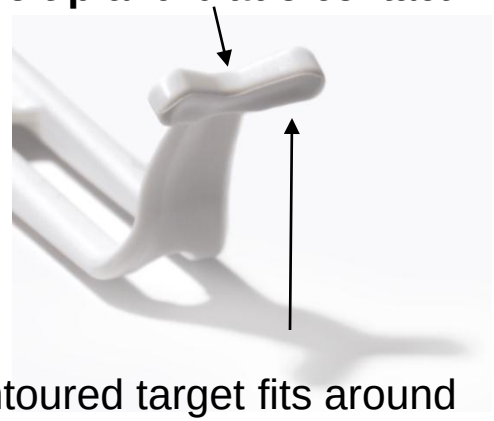
Tip design enables clear sound production

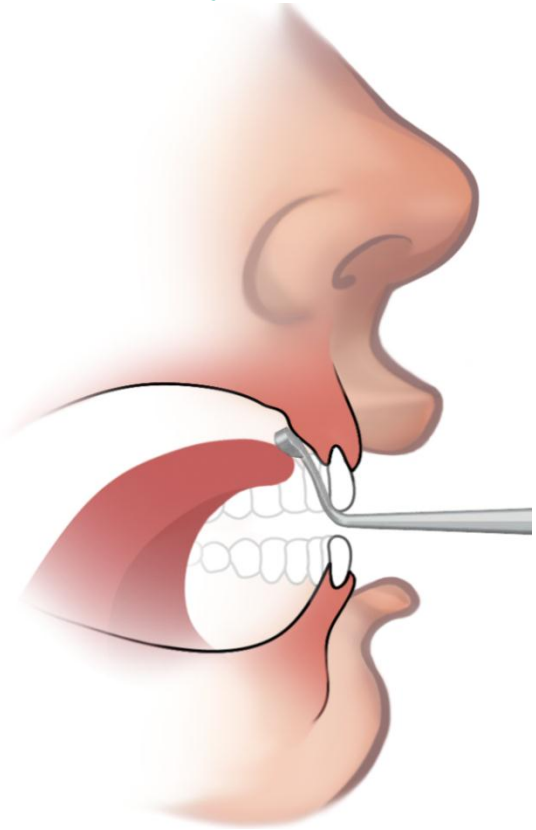
Correct tongue depth and height within mouth help fix both frontal and lateral errors

Videos

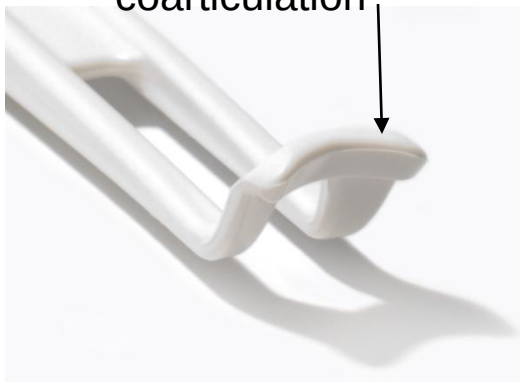
The CH and L Speech Buddies

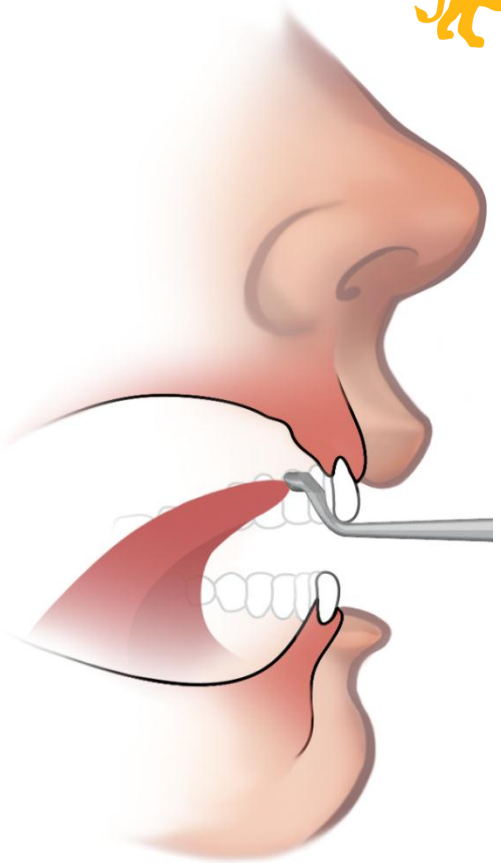
Two-pronged target cues “spreading” affrication and tongue **tip** and **blade** contact with palate





Contoured target fits around upper front teeth to enable coarticulation





Research Studies Completed

- INTACT trial: randomized, controlled, single blind efficacy study
  - Faster and more consistent gains – statistically significant result
  - Poster session ASHA 2011, currently in journal submission process
- Effectiveness study in school-based therapy (ASHA 2012)
  - Studies mass adoption in NYC charter schools, Poster session 2012
  - Superior gains in nearly 1/5 the number of therapy hours
- R treatment techniques (ASHA 2010)
  - Significantly faster treatment time vs. industry standards
  - 90% accuracy achieved in eight 30 minute sessions
- Parent-driven therapy (ASHA 2011)
  - Significantly faster treatment time vs. industry standards
  - Provides evidence that parents can be an effective therapy adjunct
  - 98% accuracy after 8 hours of parent-led intervention

Efficacy Trial for /S/: Study Design

- IRB Approved, Controlled, Single-Blind, Randomized Efficacy Study
- Inclusion Criteria
  - 20 Subjects Aged 5:0 - 8:11
  - Randomized group assignment:10 control,10 experimental
  - /s/ distortion – less than 20% accuracy at baseline, lateral or frontal
  - No history of congenital or acquired neurological, structural, or physiological deficits
  - Hearing and language function within normal limits
  - Less than10 hrs. of therapy (all enrolled had none)
- Method

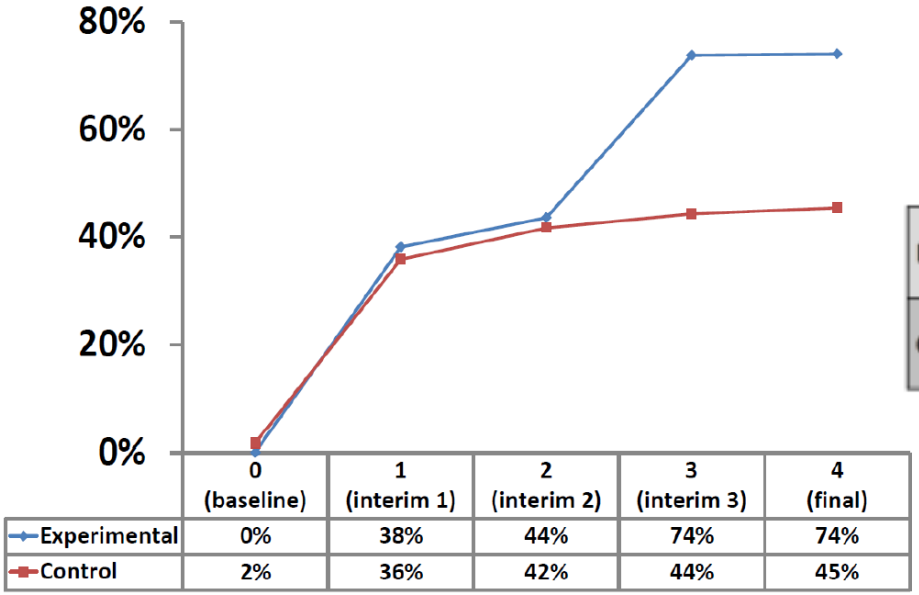
– Baseline Evaluation:
  - 50 word test battery by a blinded Ph.D. evaluator

– Eight therapy sessions
  - 45 stimulus items, approximately 25 minutes each
  - Stimulus included: “warm-up” in isolation and syllables, therapy training with /s/ in all word positions and in diverse phonemic contexts
  - Experimental group used Speech Buddies every other cue

– Final evaluation:
  - 50 word test battery by blinded Ph.D. evaluators

INTACT Study Results

Mean Percentage Accuracy vs. Timepoint



	0 (baseline)	1 (interim 1)	2 (interim 2)	3 (interim 3)	4 (final)
Experimental	0%	38%	44%	74%	74%
Control	2%	36%	42%	44%	45%

	Response	No Response
Experimental Group	87.5%	12.5%
Control Group	42.8%	57.1%

Response profile using Van-Riper's 70-80% accuracy threshold

- Results show that the Speech Buddies group learned faster and more consistently than control group
- Speech Buddy group showed a statistically significant ($p<.05$) treatment response whereas the control group did not
- One way repeated measures ANCOVA analysis ($f(3,25)=5.46$, $p=.004$)

Speech Buddies in NYC Charter Schools

Methods and Population:

- Five SLP's in five schools used Speech Buddies as needed during the 2011-2012 school year
- Accuracy of production was assessed at baseline and at the end of the school year, using the Secord Contextual Articulation Test (S-CAT)
- Inclusion: Individualized Education Plan (IEP) phoneme goals or less than 15% accuracy S-CAT probe
- Subjects: Ages 4:11 to 16:0, n=12 , 77% received group therapy; 69% also had IEP language goals; 42% represented residual, treatment-resistant errors in older students

Results: Superior gains with nearly 1/5 articulation therapy hours

- S-CAT accuracy improved from 23.3% to 83.4%
- Cohort Pre Speech Buddies: 139.9 total hours therapy (83.7 hrs articulation) = $5900
- Cohort With Speech Buddies: 25.2 total hours therapy (17.9 hrs articulation) = $1550

Figure 1: Average therapy cost per student

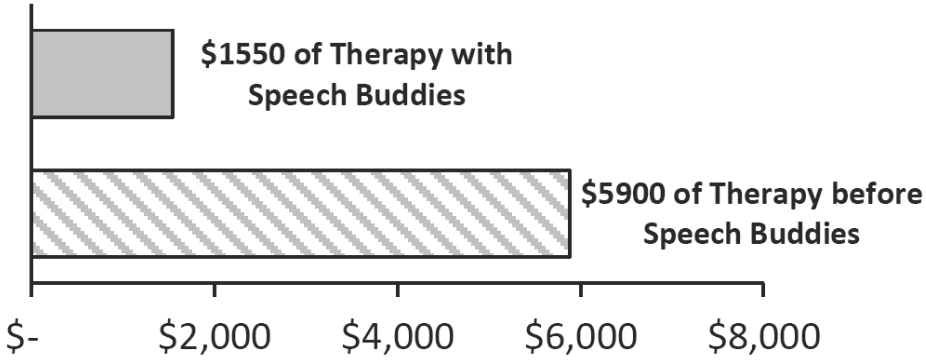
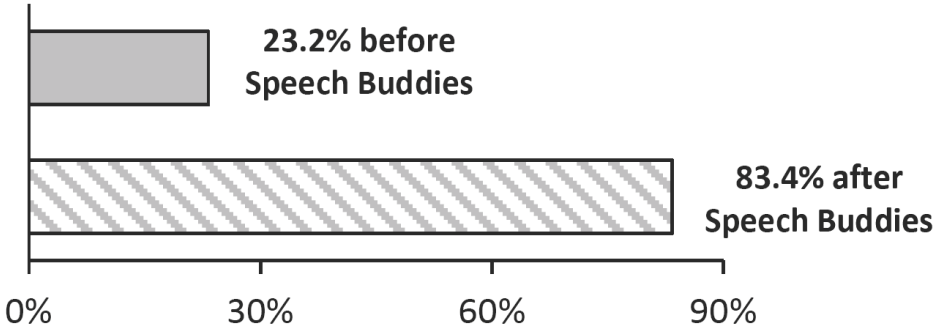


Figure 2: Average accuracy on S-CAT assessment

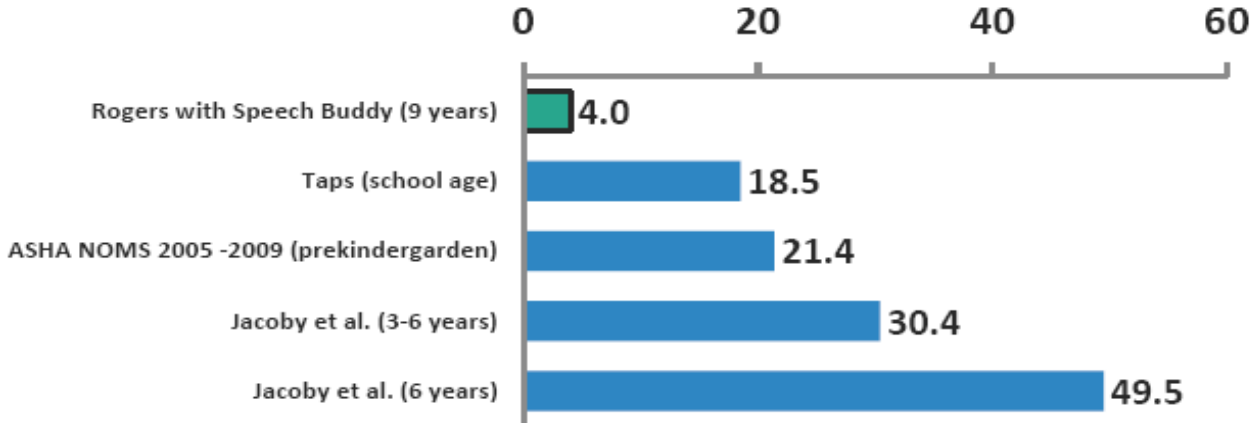


NYC Special Education COLLABORATIVE

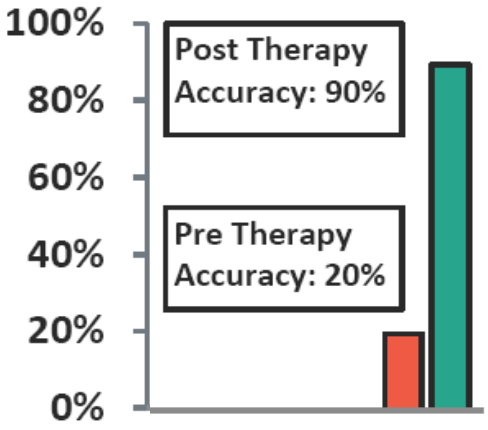
speech buddies

R Case Study: Reduced treatment time vs. Industry Norms
(Presented at ASHA, 2010)

Treatment time in Hours vs. Industry Norms



90% accuracy after 4 hours

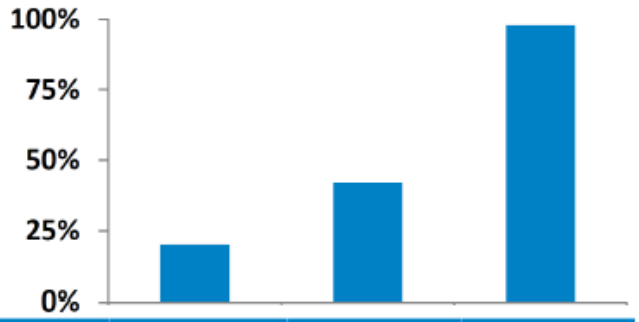


- 90% accuracy achieved in eight 30 minute sessions
- 1/4 to 1/8 treatment time vs. industry norms
- Study design basics:
  - Mild to moderate articulation disorder, age 9
  - Pre and Post treatment test of 50 stimulus items
  - 8 therapy sessions each with 55 stimulus items
    - Warm up cues (6): R Speech Buddy used for every cue
    - Remaining cues (49): Every other cue in 1st session; every 8th cue for 8th session

Parent Driven Case Study:

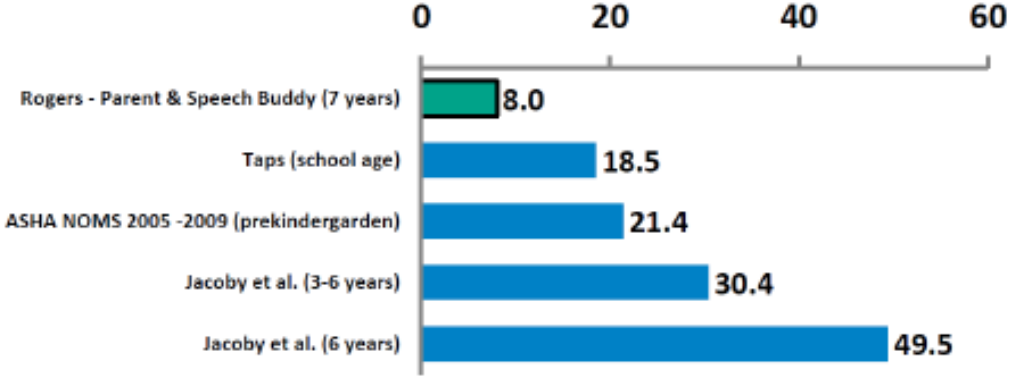
Parents using Speech Buddies are an effective therapy adjunct
Presented at ASHA, 2011

Remediation after 8 Hours



Time point	Baseline	4 Hours	8 Hours
Accuracy	20%	42%	98%
Items Correct	30	42	147
Items Tested	150	100	150

Treatment Time vs. Industry Norms



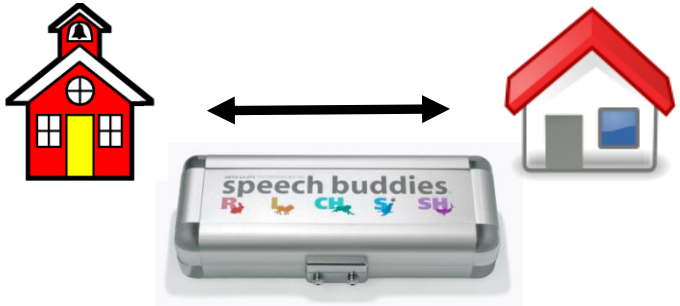
- 98% accuracy achieved in 8 hours of parent intervention and 1.5 hours of SLP acting as a consulting clinician (over 12 weeks)
- Study design basics:
  - Mild to moderate articulation disorder, /s/, age 7:4
  - Assessments performed pre-treatment, midpoint and post treatment
  - 32 parent therapy blocks each with 40 stimulus items
    - Items used traditional hierarchy of complexity
    - Specific instructions of when to use and when not to use the Speech Buddy

Part 3:

Tactile Biofeedback in Clinical Practice

How do I use Tactile Biofeedback?

- Speech Buddies are designed to be used by SLPs, parents and students
- Parent involvement enhances learning process and your results.
- Scenarios of use:
  1. In therapy and at home (preferred)
  2. In therapy only
  3. At home only



- Individual or group therapy
- Can be a powerful solution for residual errors

What types of patients can benefit from Tactile Biofeedback?

Observed benefit:

- Speech and articulation disorders of all severities
  - No known cause
  - Hearing impairment
  - Autism spectrum disorder or other cognitive disorder
- Apraxia of speech (developmental or acquired)
- Accent modification / English language learning
- Post surgery cleft palate

Benefit under evaluation:

- Speech and articulation disorders tied to neuromuscular weakness, cerebral palsy, paralysis, and Down Syndrome

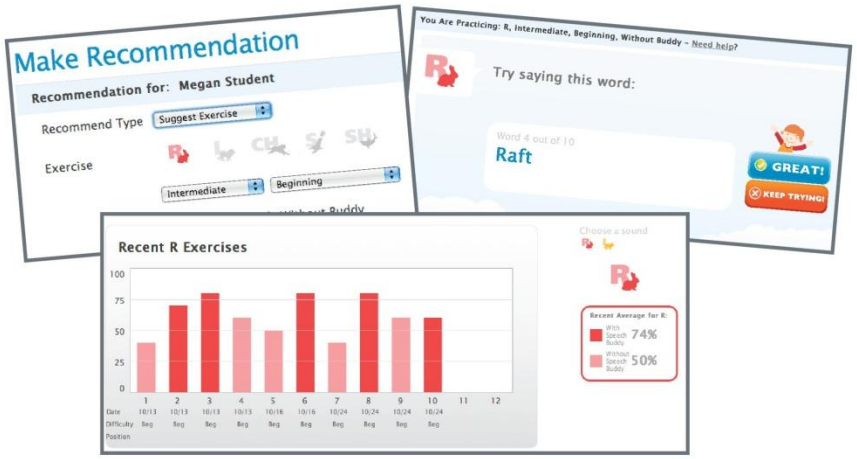
Not recommended:

- Language disorders, stuttering, voice disorders, nonverbal

Speech Buddies University: Your new partner

- Speech Buddies University is an online social speech therapy platform!

speech buddies UNIVERSITY



- Customize lesson plans
- Assign homework to meet your students' needs and level
- Monitor students' progress online with easy to read dashboard
- Connect with parents
- Completely free and designed for you!

Sample practice schedule

Follow Your Practice Schedule

Practice 10 minutes a day, 3 times a week at Speech Buddies University Online.

Week	Level	Positon	Exercise
1-2	Beginner	N/A	Practice R sound in simple syllables using Speech Buddy every time
3-4	Intermediate	Initial	Practice simple words that start with R sounds using Speech Buddy every other exercise
5-8	Intermediate	Middle & End	Practice more complex words that start with R sounds using Speech Buddy every other exercise
9-10	Advanced	N/A	Practice R sound in simple sentences using the Speech Buddy only if needed
11-12	Advanced	N/A	Practice R sound in normal conversation using the Speech Buddy only if needed

Part 4:

Conclusion

Conclusions:

- Tactile biofeedback has a strong and growing evidence base for generating significantly reduced treatment durations:
  - Treatment resistant children
  - A first line treatment option for younger children
- Tactile biofeedback has been perfected in research over years, and now can be immediately incorporated into clinical practice:
  - Cost-effective as compared to visual biofeedback
  - Takes advantage of natural somatosensory feedback system
  - Proven in real life clinic and school deployments
  - Enables parent involvement and enhanced generalization
  - Supported by online software applications


ARTICULATE TECHNOLOGIES INC
speech buddies
R L CH S SH
Q & A

Cleaning Details

- Recommended for single student use
- Several cleaning options:
  - Clean with mild soap like fork or knife
  - Submerge in 70% isopropyl alcohol: 2 minutes
  - Submerge in 4% bleach solution or use bleach germicidal wipes: 2 minutes
- Not dishwasher safe

Manufacturing Details

- Made in USA at FDA registered medical device manufacturing facility
- California Medical Device Manufacturing License
- Inspected and audited quality and manufacturing processes
- All vendors located in USA, key vendors are ISO9001 certified

Material Details

- All vendors located in USA
- Plastics and colorants selected for oral use
- Speech Buddies incorporate a USP Class 6 material, the highest class available for medical devices
- Final product tested to the highest standards for cytotoxicity as per FDA and ISO 10993-1 biocompatibility guidance