Evidence-Based Application of Device Technology in Speech Sound Disorders: A Clinical Workshop

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ASHA 2013 Interest Disclosure Statement

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Agenda

- **Part 1: The Uses of Device Technology in the Treatment of Speech Sound Disorders**
- **Part 2: Types and Evidence of Device Technology**
- **Part 3: Clinical Workshop**
- **Part 4: Conclusion**

Part 1:

The Uses of Device Technology in the Treatment of Speech Sound Disorders

A Quick History Lesson

A proto form of traditional articulation therapy was described in Tritton (1957) (p. 60-61):

"… A boy pronounced Ghain instead of ra. A man examined his tongue, told him that the organ was sound and asked him to produce ra with his tongue in the roof of his mouth; he did so but the sound was not right. The man kept at him, now coaxing now scolding, making him put his tongue in various positions and say ra in them. When the sound was not right, he moved the tongue many times till the boy could say ra; he was then made to repeat this till the right sound became easy to him and the "thickness" disappeared."

Source: http://www.acsu.buffalo.edu/~duchan/history.html

Alexander Graham Bell:

an SLP whose inventions changed the world!

A Review: “Low tech” Approaches

The Traditional Approach

*according to **Charles Van Riper** (1984)*

- Perceptual training (ear training)
- Varying and correcting the production of the target phoneme until it is correct
- Strengthening and stabilizing correct production
- Transferring correct production to everyday communication (generalization)
- The traditional approach also uses the classic hierarchy – isolation to conversation

Phonological Approaches

- *Because phonological approaches should possess a linguistically meaningful context (i.e. be a word that means something), therapy begins at the minimally meaningful linguistic unit, **the word!***
- *This is different from traditional methods of articulation therapy*
- ***However, in practice, phonological approaches tend to focus on the motoric aspect of speech (Grunwell, 1987; Powell et al, 1998)***

***** In general, device technology most directly complements a traditional, motoric approach *****

Why Use Device Technology in Treatment?

- 91% of SLPs reported at least one case in which traditional methods of articulation therapy did not achieve the desired clinical results.

  -- Ruscello (1995)

- 28% of pre-school and school-age children make little to no measurable progress (i.e. 1.3 million kids, as per the 2010 census).

  -- Jacoby, Lee, Kummer, Levin and Creaghead (2002)

- Device technology has been shown to provide a treatment response for treatment-resistant children and treatment-naïve children.

  -- Clark, Schwarz and Blakely (1993), Shuster, Ruscello and Smith (1992); Rogers and Galgano (2011)

SLPs and Health Care Reform

- Whether we like it or not, health care will reform will radically change how we do our jobs
- Greater emphasis on efficiency in service delivery and paperwork
- Greater scrutiny, particularly with regard to selecting evidence-based approaches
- Eventually, the fee-for-service model would be in jeopardy
- This will “trickle down” to schools and private practices
- Technology will allow you to stay ahead of these reforms!

Device Technology is Generally Termed Sensory Biofeedback – What is this?

"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

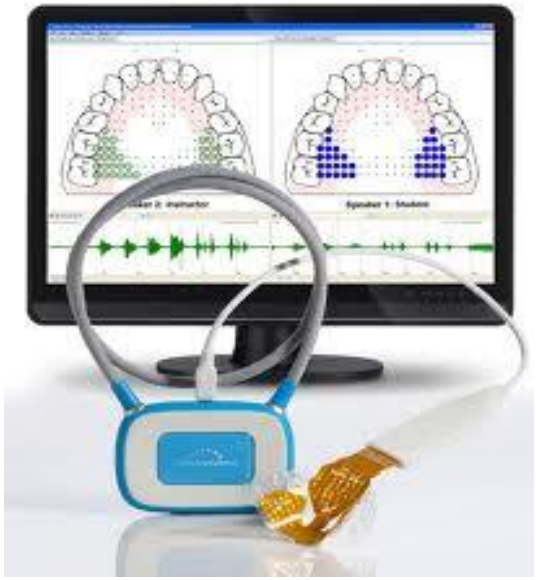
Part 2:

Types and Evidence of Device Technology

Visual Biofeedback

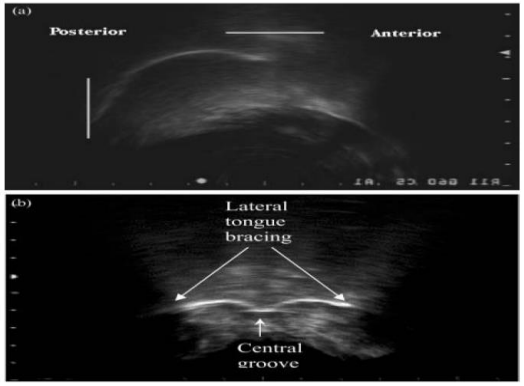
Electropalatography (EPG)

- 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)

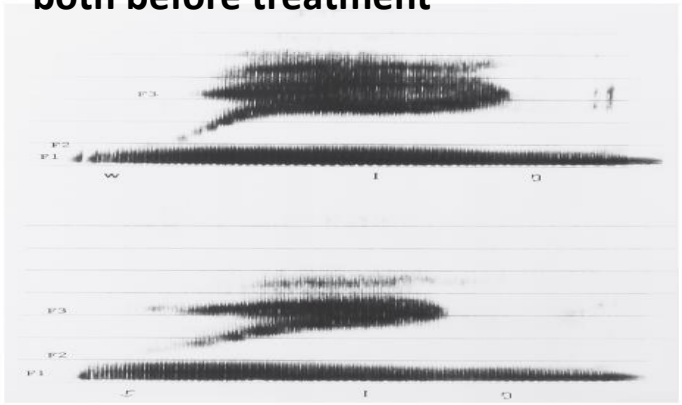
- ***Hearing Impairment:*** Bernhardt, Gick, Bacsfalvi & Ashdown (2003)

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

Spectral Biofeedback

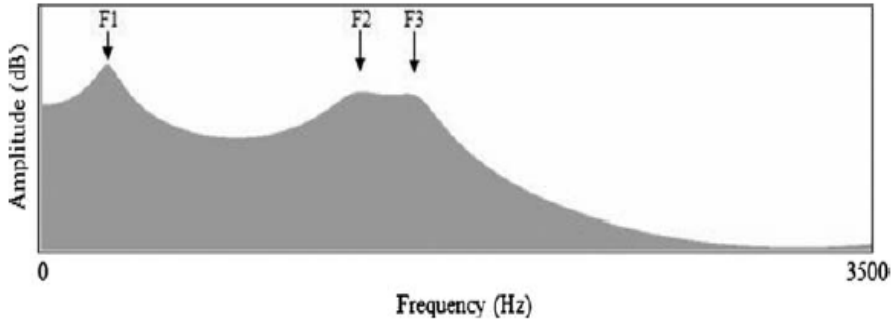
- Spectrography as a visual representation of acoustic signal of speech
- Research evidence of clinical applicability of spectral biofeedback:
  - Shuster, Ruscello & Smith (1992)
  - Shuter, Ruscello & Toth (1995)
  - McAllister Byun & Hitchcock (2012)
- Linear productive coding (LPC) spectrum allows 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)*

Tactile Biofeedback

- 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)

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

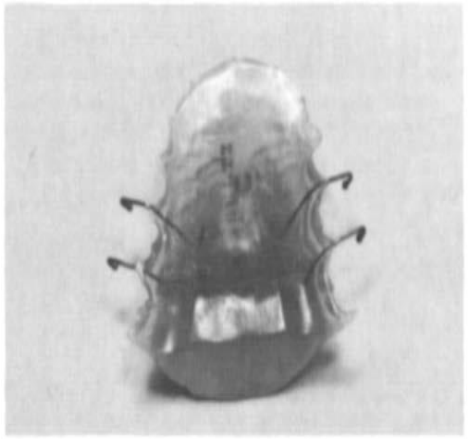
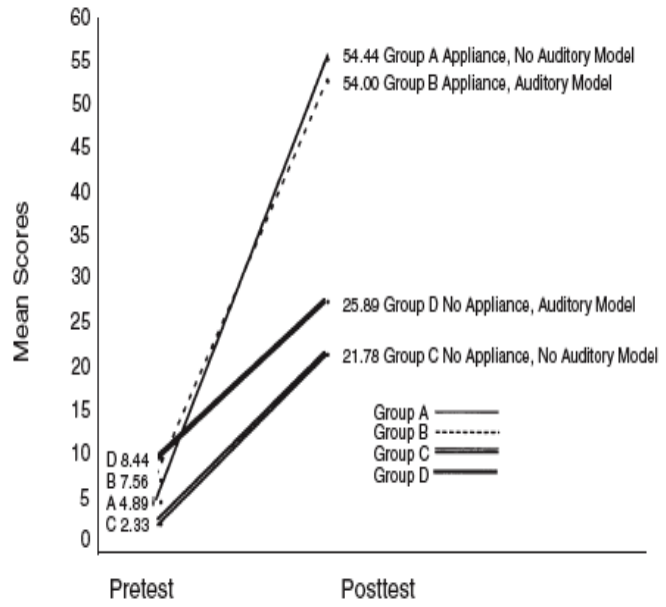


FIGURE 2. Summary of pretest and posttest means scores by groups for 60 /r/ words.



"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

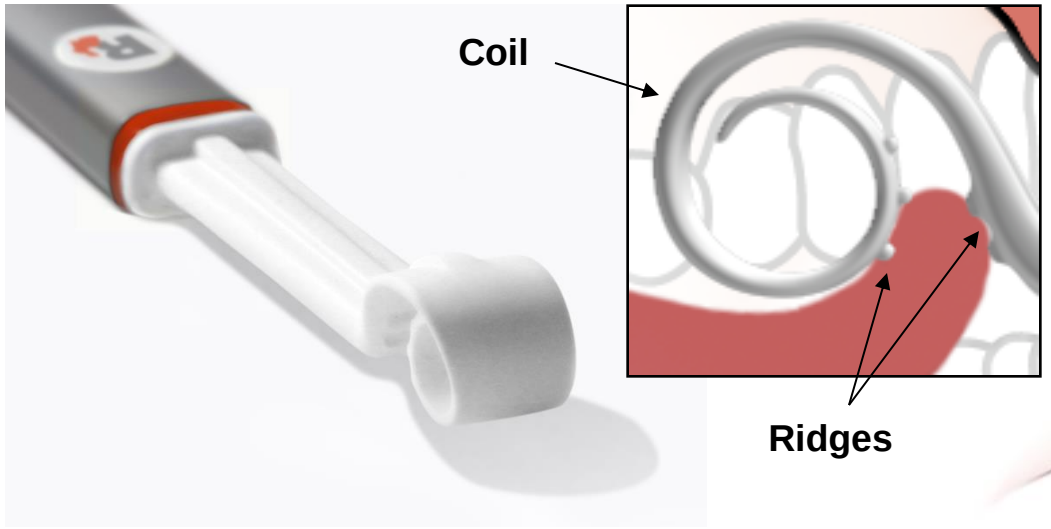
Dentistry

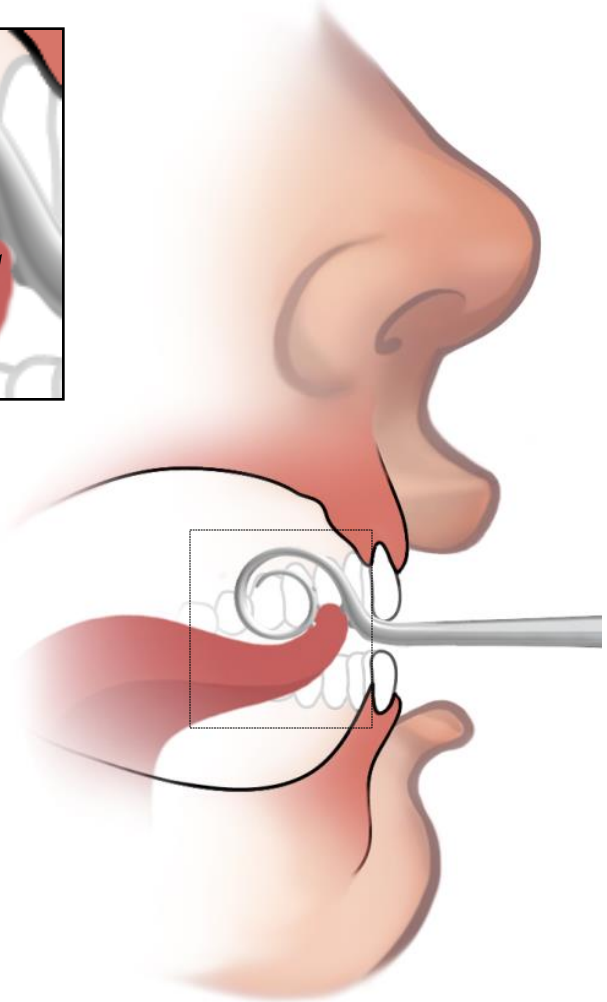
Speech Buddies use Tactile Feedback to train correct tongue placement

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

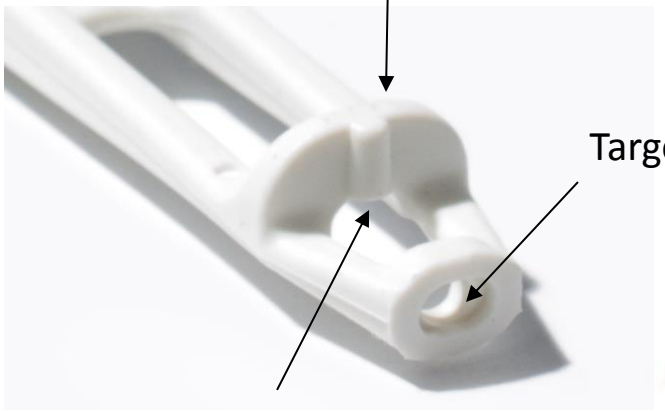




- Ridges guide initial tongue position
- Coil guides retroflection
- Easy for students to feel correct and incorrect R productions
- Works for vocalic R (bird, car) and consonantal R (rabbit, rise)

The S and SH Speech Buddies

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

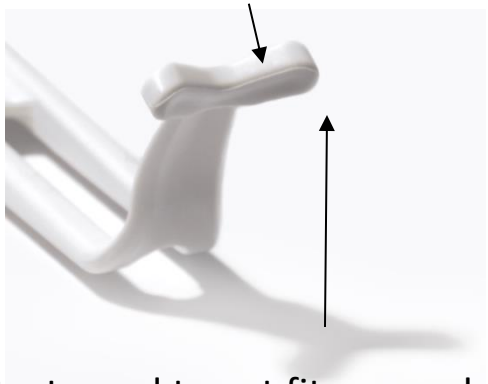


Tip design enables clear sound production

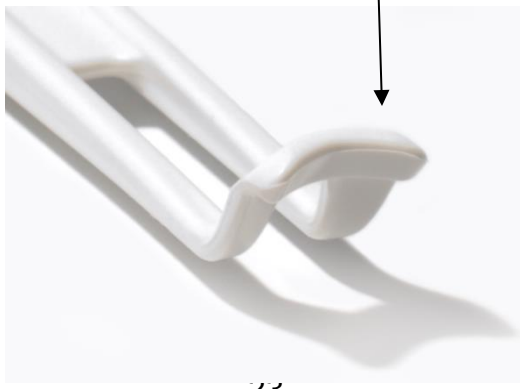
Correct tongue depth and height within mouth help fix both frontal and lateral errors

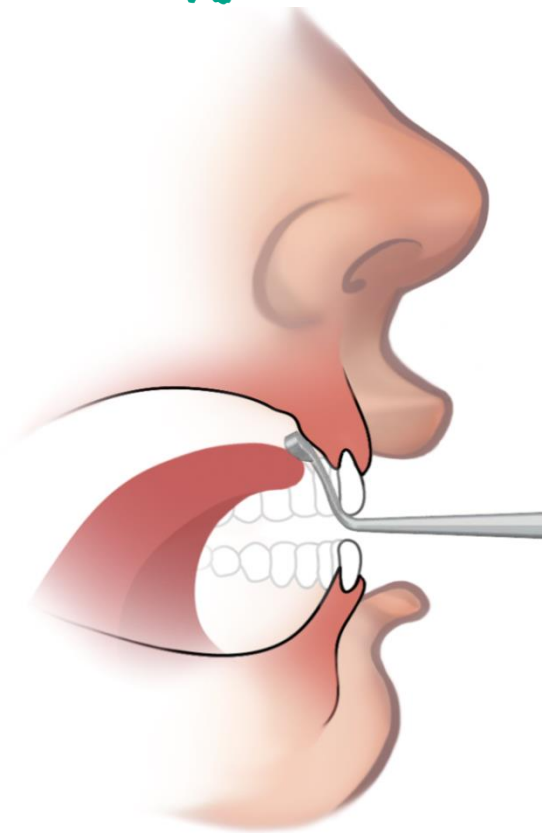
The CH and L Speech Buddies

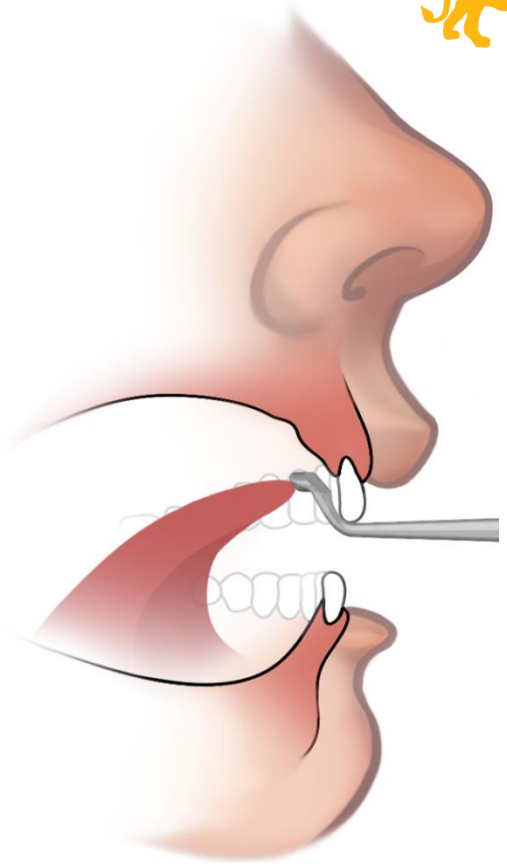
Two-pronged target cues “spreading” affrication and tongue **tip** and **blade** contact with palate



Contoured target fits around upper front teeth to enable coarticulation





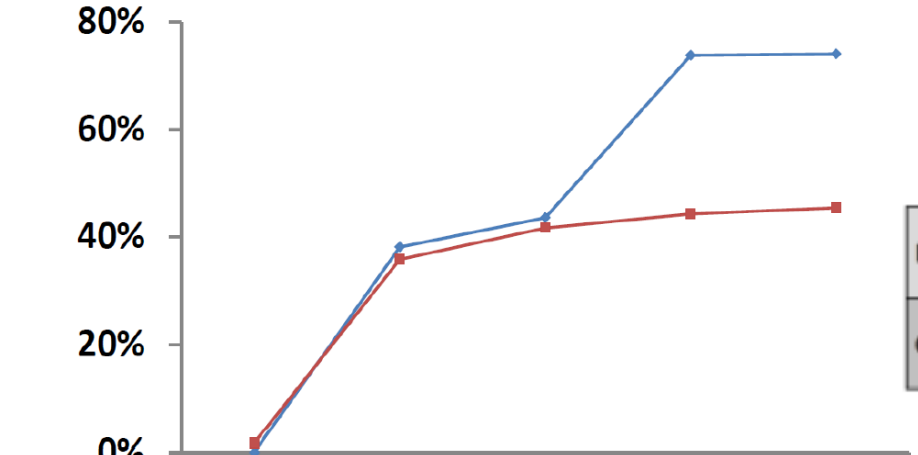


Research Studies Completed

- 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

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 ($f(3,25)=5.46$, $p=.004$)

Effectiveness Study 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

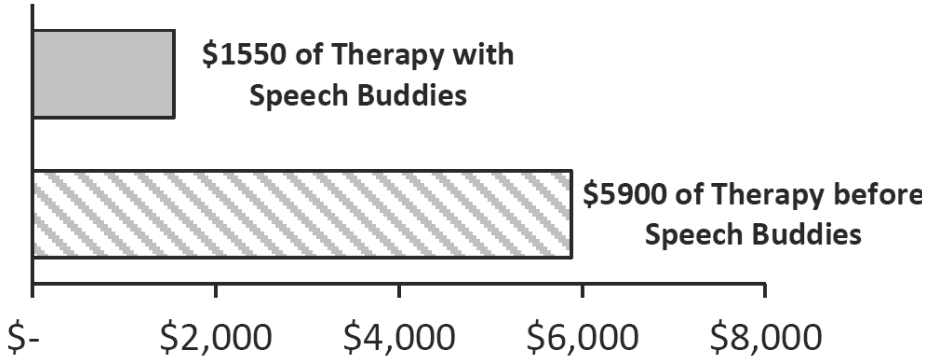
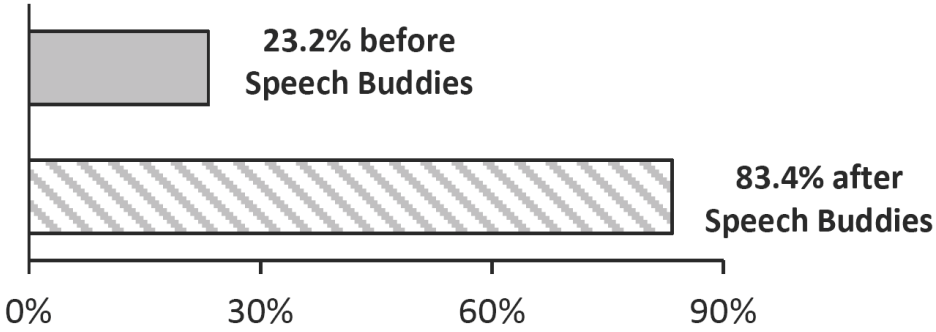


Figure 2: Average accuracy on S-CAT assessment



NYC Special Education COLLABORATIVE

speech buddies

Part 3:

Clinical Workshop

What Types of Patients can Benefit from 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

Tech-based Approaches for Tough Clinical Problems

Lateral /s/

- Lateral /s/ is manifested as the tongue tip placed on the alveolar ridge, just as in /l/

Strategies

Tactile biofeedback

- train tongue tip *down* configuration using placement cue (e.g. Speech Buddies /s/ tool) for the tongue tip and the air flow
- Use “haaa” + /s/ to maintain open vocal tract configuration during production

Lateral /s/ *continued*

EPG

- Use dual view (SLP and client) to show incorrect palatal contact during production of lateral /s/
- Highlight function of Smart Palate system allows the SLP to highlight the palatal regions to avoid during production
- Work to help client dissociate jaw and tongue movements may be necessary

Ultrasound

- Use side view to show client incorrect vs. correct placements
- Use frontal view to show tongue bracing and lateral grooving, which are often absent in lateral lispers

Spectral Feedback

- Lateral /s/ generally has a lower frequency (pitch) and amplitude (loudness) than correct /s/
- Contrast correct SLP model to client's incorrect model using these spectral parameters

/r/

- The most common persistent speech sound error in children (Shriberg & Kwiatkowski, 1982)
- 91% of clinicians reported at least one instance in which traditional treatment methods did not successfully remediate /r/ (Ruscello, 1995)

Strategies

Tactile biofeedback

- Tongue tip has greatest number of nerve endings (Zur, Genden & Urken, 2004)
- Therefore, retroflexion is typically the preferred method of training /r/ (rather than retracted or "bunched" /r/)
- Slightly adjust the position of the Speech Buddy based on client
- Don't forget about lip rounding!

/r/ *continued*

EPG

- Tongue contact with lateral portions of the palate
- However, EPG does not show image of tongue shape or movement

Ultrasound

- Side view can show dynamic movement of /r/
- Real time view gets *inside the mouth* to contrast correct vs. incorrect tongue positioning for /r/
- Posterior vocal tract constriction may also be imaged

Spectral Feedback

- Formant function provides clear model of correct vs. incorrect /r/

Lateral /sh/

- Lateral /sh/ is manifested as the tongue tip placed in various positions on the palate
- However, the depth of placement in the mouth is typically more anterior (front) than for correct /sh/

Strategies

Tactile biofeedback

- train tongue tip *down* configuration using placement cue (e.g. Speech Buddies /sh/ tool) for the tongue tip and the air flow
- Use “haaa” + /sh/ to maintain open vocal tract configuration during production

Lateral /sh/ *continued*

EPG

- A greater surface area of the palate is contacted for /sh/ than for /s/
- Use dual view (SLP and client) to show incorrect palatal contact during production of lateral /sh/ -- just as in /s/
- Highlight function of Smart Palate system allows the SLP to highlight the palatal regions to avoid during production
- Work to help client dissociate jaw and tongue movements may be necessary

Ultrasound

- Use side view to show client incorrect vs. correct placements
- Use frontal view to show tongue bracing and lateral grooving, which are often absent in lateral lispers

Spectral Feedback

- Lateral /sh/ generally has a higher frequency (pitch) and amplitude (loudness) than correct /s/
- However, pitch is the preferred target here
- Contrast correct SLP model to client's incorrect model using these spectral parameters

Using Technology To Involve Parents

- Low tech methods require greater levels of training
- Parents are not just for the later stages of therapy
- Biofeedback methods allow the parent, with minimal training, to elicit sounds
- Track progress and make sure parents are following through on assigned homework
- Apps synthesize everything a parent needs to get directly involved
- Technology makes it easier for parents and SLPs to communicate and coordinate – especially in schools!

Practical Considerations: Paying for Technology

- Any new technology requires a capital investment
- That investment can pay dividends!
- Make treatment more effective for more clients
- Stay on top of health care reform
- More effectively leverage parent involvement

Solution	Price ($ USD) for Starter Kit
Electropalatography	$2,999.00
Articulography	$67,800.00
Ultrasound	$5,000.00
Speech Buddies	$299.00

Part 4:

Conclusion

Conclusion

- Device technology is effective and efficient
  - For treatment resistant children
  - A first line treatment option for treatment-naïve children
  - Strong and growing base of evidence
- Device technology can help with your trickiest cases
  - Takes advantage of clients' natural sensory feedback system
  - Proven with a variety of treatment populations
  - Enables parent involvement and enhanced generalization
  - Supported by online software applications


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