Residual Speech Sound Disorders: Linguistic and Motoric Considerations

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Outline

- Residual Speech Sound Disorders
- Linguistic Considerations
  - Perception
  - Phonological awareness
  - Intervention Strategies
- Motor considerations
  - Achieving a motor target: the case for biofeedback
  - Integration of motor targets into movement
Residual speech sound disorders

- Children whose speech errors persist past the age of ~9 years

- May include children with a history of speech delay, or children whose speech was developing normally but who failed to achieve correct production of one or a few sounds
Residual speech sound disorders

- Typically involve distortion/substitution errors on “late-8” sounds /r, l, s, z, ʃ, θ, ð/ and /ʃ, þ/
  - If the child has a history of CAS, we may see
    - Occasional vowel errors
    - Sequencing errors (e.g., clusters, DDK)
    - Consonant omissions
    - More errors on multisyllabic words
    - Deletion of weak syllables
    - Excess/equal stress
    - Monopitch/monoloudness
    - Slower rate
Developmental trajectories

Percent Speech Sounds Correct

- Typical
- Speech Sound Errors
- Speech Delay
- Childhood Apraxia of speech

Axes:
- Y-axis: 20, 30, 40, 50, 60, 70, 80, 90, 100
- X-axis: 2 yrs, 3 yrs, 4 yrs, 5 yrs, 6 yrs, 7 yrs, 8 yrs, 9 yrs
LINGUISTIC CONSIDERATIONS: PHONOLOGICAL AWARENESS & PERCEPTION
Phonological Awareness

- A meta-linguistic skill
- The awareness of the sound structure of words, and the ability to manipulate sounds
- Good indicator of reading/spelling skills
- Performance on these tasks often lower in children with residual SSDs (Preston & Edwards, 2007)
Phonological Awareness

- Examples of phonological awareness tasks for children with residual SSD
  - Spoonerisms
  - Elision (deletion) of phonemes in clusters, multisyllabic words
  - Phoneme Reversals
Differences in Speech Perception

- Children with residual SSD have difficulty recognizing errors in their own speech and in others’ (Shuster, 1998)

- Proposed differences in phonological representations

- Neurobiological differences have recently been observed
Neurobiology of speech processing

Haskins Research

- 17 children (14 male) with residual speech errors
- 17 children (14 male) with typical speech

- Ages 8;6 – 10;10
Haskins Research: Group means

<table>
<thead>
<tr>
<th></th>
<th>Typical Speech</th>
<th>Residual Error</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>9;10</td>
<td>9;7</td>
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<tr>
<td>PPVT-III</td>
<td>114</td>
<td>113</td>
</tr>
<tr>
<td>WJ Oral Expression</td>
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<td>115</td>
</tr>
<tr>
<td>WASI Verbal IQ</td>
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<tr>
<td>CTOPP Elision</td>
<td>11.5</td>
<td>8.4*</td>
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</table>
Functional MRI

A Child’s First MRI
Perception of Print and Speech

- Child sees (printed) or hears (spoken) words or pseudowords
- “Press a button if the word matches the picture on the screen”
- Child is *not* talking, just listening/reading
Functional MRI Task

dreak
/dreɪn/
dream
dress

time
fMRI Group Comparison: Speech

Bilateral superior/inferior parietal lobule and left precentral gyrus

Left superior temporal gyrus and cuneus

Left insula

Residual SSD group shows greater activation in each of these (purple) regions
fMRI Group Comparison: Speech

- Left globus pallidus
- Left middle temporal gyrus/
  superior temporal sulcus
- Bilateral fusiform,
  Right lingual gyrus,
- Left temporal pole
What do brain differences mean?

- Speech perception circuits may be over-relying on dorsal perception systems, less on ventral systems
  - Less efficient processing?
  - More effortful processing?
A model of speech perception
(Hickok, Houde, & Rong 2011)
fMRI Group Comparison: Print

Anterior cingulate

Right superior temporal gyrus/superior temporal sulcus

Bilateral fusiform
Differences in print processing do NOT necessarily replicate the dyslexia circuit, but they do suggest processing of phonological information is disrupted.
Implications

- Behavioral and neurobiological measures suggest differences in how phonological information is perceived/processed for children with residual speech sound disorders
  - Differences in processing spoken and written phonological material
- Treatments should not ignore perception and phonological awareness
Implications

- Incorporating perceptual training and phonological awareness training in speech therapy
  - Sharpen perceptual boundaries related to sounds in error
  - Heighten awareness of sound structure of words
Perceptual Training

• SAILS (Rvachew, 1994): Detect correct/incorrect productions from other speakers

• Record client’s own productions, replay, contrast correct/incorrect attempts
Phonological Awareness Training

- With older children, consider incorporating phonemic awareness training with target sounds
  - Sound substitution training
  - Segmenting and blending
  - Say It and Move It
  - Elision
  - Pig Latin
  - Spoonerisms
PA Intervention: Phoneme Manipulation

- **Speech goal**: Initial /s/
- **PA goal**: Phoneme Manipulation

- **Substituting phonemes**
  - e.g., when studying animals, play a game where all animal names begin with /s/
    - zibra → sibra
    - hippopotamus → sippopotamus
    - giraffe → siraffe
PA Intervention: Segmenting & Blending

• **Say it and Move it** (Blachman et al., 2000)
  ◦ Begin with chips, teach the concept of 1 chip = 1 sound
  ◦ Start simple (CV or VC), phonetically regular words
  ◦ Add letters
PA Intervention: School-age children

- **Speech Goal**: Initial /r/
- **PA Goal**: Segmenting & Blending

Say It and Move It with nonwords
Say It and Move It: With Nonwords

r

sh

eee

a

n

b
PA Intervention: School-age Children

- **Speech Goal**: Postvocalic /r/
- **PA Goal**: Sound manipulation

- **Pig Latin**
  - Car /kar/ → /ar - ke/
  - Farm /farm/ → /arm – fe/
  - Steer /stir/ → /ir – ste/
PA Intervention: School-age Children

- **Speech Goal:** Initial /s/
- **PA Goal:** Sound manipulation

- Spoonerisms (exchange onsets of word pair)
  - Sad day \(\rightarrow\) dad say
  - Sick boy \(\rightarrow\) bick soy
  - Yellow sock \(\rightarrow\) sellow yock
MOTORIC CONSIDERATIONS
Motoric Considerations

- I do not view motor involvement in speech as being completely distinct from perception and awareness of speech.

- There are too many feed-forward and feed-back mechanisms in the brain for perception and production to be entirely distinct.
Motoric differences

- Clearly, there are differences in children with residual SSD with establishing or executing a motor plan for specific phonemes such as /r, l, s, z/

- Children with residual SSD also tend to be slower and/or less accurate than typically speaking children on diadochokinetic tasks
  - Dworkin, 1980; McNutt, 1977; Preston & Edwards, 2009
Implications?

- We need to teach new motor target (e.g., tongue configuration) but also should consider how this interacts with movement.
Achieving a motor target: Biofeedback

- **Biofeedback**: “The use of instrumentation to make covert physiological processes more overt; it also includes electronic options for shaping appropriate responses” (Huang, Wolf & He, 2006)

- Studies using electropalatography and spectrograms to achieve accurate speech have been successful in several cases of residual SSD
Achieving a motor target: Biofeedback

- Recently, ultrasound has been used in case studies to provide a visual display of tongue configuration/positioning during production of speech sounds (e.g., Adler-Bock et al., 2007; Bernhardt et al., 2003, 2005, 2008)
Achieving a motor target: Biofeedback

- Ultrasound may be a useful biofeedback tool for correcting certain errors on lingual phonemes
  - Liquids /r, l/
  - Lateralized sibilants
  - Velar-alveolar contrasts
  - Vowels
Ultrasound biofeedback

- Ongoing study of treatment of residual SSD (Haskins/Southern Connecticut State University)
- Includes several children with well-documented histories of CAS
- Focusing on establishing a motor plan for a sound, then generalizing this to various words and prosodic contexts
- 60 minute sessions, twice per week.
  - 30 mins using ultrasound
  - 15 mins “traditional” therapy (artic, PML)
  - 10 minutes data collection
Ultrasound biofeedback

- Multiple baseline across behaviors single subject design
- Work on up to 2 treatment targets per session
- Discontinue after reaching 80% accuracy two sessions in a row (as judged by 2 listeners)
Ultrasound biofeedback

- Need to allow for individual variation
- Examples of different /r/ configurations
Results: 10 yr old male (history of CAS)

Accuracy /re/

Accuracy /gr/
Audio example

U002_9-29-11_probe GR.wav

U002_11-28_probe GR.wav
Results: 10 yr old male (history of CAS)

Accuracy /ar/

Accuracy /or/

Session 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Accuracy /or/
Results: 12 yr old male (CAS)

Accuracy /fl/

Accuracy /ar/
Results: 12 yr old male (CAS)

Accuracy /Skr/

Accuracy /or/

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Accuracy /Skr/
Results: 16 yr old male (still in treatment)

Accuracy /ru/

Accuracy /lr/
13 year old male (CAS, dysarthria, VPI)

/ar/

/kl/
/kl/ clusters

/k/ and /l/ isolation, clusters
Integration of motor targets into connected speech

- Once a motor target has been established, how can we facilitate carryover/mastery?

- Think of how a motor plan for /r/ fits into the context of “real” speech
  - Once a static posture is achieved, vary respiratory/phonotory/aerodynamic demands
  - Target movement, not just static postures
  - Pragmatic contexts
Integration of motor targets into connected speech: Our strategy

- Use principles designed to facilitate motor learning (cf. Dynamic Temporal and Tactile Cueing)
- Practice the target with:
  - Varied rate (fast-slow)
  - Varied loudness (loud-soft)
  - Varied intonation (rising-falling)
Video example: Rising intonation
Video Example: Slow
Integration of motor targets into connected speech: Our strategy

- Practice the target with various pragmatic demands
  - Imitatively
  - In response to questions
  - As requests, questions, commands, comments

- We do not rely 100% on biofeedback
  - 20 mins per session involve tabletop “tradiational” treatment
Advantages and Disadvantages of Ultrasound Biofeedback

+ More accurate, informed diagnoses based on motor movements
+ Instructions for tongue movements can be explicit
+ Children can understand what is expected and learn to self-cue

- Requires good cognitive skills and focused attention
- Not a magic pill
- Access, cost, training related to technology
- More research needed
Summary

- Linguistic (perceptual/awareness) and motoric skills must be considered in “artic therapy”
- Integrate articulatory gesture into phonological awareness activities, varying pragmatic contexts
- In addition to achieving the target articulatory gesture, integrate this gestural pattern into movement sequences while varying rate, stress, intonation
- Ultrasound biofeedback might be an approach that is on the horizon
Acknowledgements

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Questions?