Cognitive underpinnings of Speech Sound Disorders: Implications for Reading ability

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Disclosures

• Financial: I am being compensated me for today’s presentation. I am a faculty member at Emerson College and receive a salary for that job.

• Nonfinancial: I am the director of the Children’s Literacy and Speech Sound (CLaSS) Lab, faculty at Emerson College, and the immediate Past President of the Massachusetts Speech, Language, and Hearing Association

As a result of this presentation, participants will be able to:

1. identify the role of phonological representations
2. discuss the risk factors and outcomes for children with persistent speech sound disorders as well as those with dyslexia
3. discuss the SLPs role in facilitating literacy skills for children with speech sound disorder and those with dyslexia

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Children’s Literacy and Speech Sound (CLaSS) lab

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Observation from a school-based SLP:
Subgroups of SSD???

<table>
<thead>
<tr>
<th>Remediates</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literacy Problems</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Motor Deficit?</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Linguistic Deficit?</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>True phonological deficit</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

What is reading?
The Simple View of Reading
(Catts, Hogan, & Fey, 2003; Catts, Hogan, & Adlof, 2005; Gough & Tunmer, 1986; Hoover & Gough, 1989)

Reading

Word Recognition
The Simple View of Reading
(Catts, Hogan, & Fey, 2003; Catts, Hogan, & Adlof, 2005; Gough & Tunmer, 1986; Hoover & Gough, 1990)

Reading Comprehension

- Word Recognition
- Listening Comprehension

The Many Strands That Are Woven Into Skilled Reading

LANGUAGE COMPREHENSION
- Semantic (vocabulary)
- Text Processing (comprehension)

LEXICON

VALINGENTON

PHONOLOGICAL AWARENESS
- Phonology (syllables, phonemes, etc.)

DECODING (alphabetic principle, spelling-sound correspondences)

SIGHT RECOGNITION
- Familiar words


How does this apply to phonological impairments?
Who are they?

• Speech sound disorders
  • Articulation
  • Phonology

• Dyslexia
  • Word reading
  • Phonemic decoding

Speech Sound Disorders

“SSD was formerly called articulation disorder (which emphasized putative problems in the motor programming of speech) and phonological disorder (which emphasized putative problems in the cognitive representations of speech). Since each of these terms made a premature commitment to the underlying processing deficit that causes the speech production problem, the neutral and descriptive term SSD is now preferred.”

- Pennington (2006)

Speech sound disorders are characterized by a delay in the acquisition of appropriate speech sounds


Speech sound disorders can impact academic, linguistic, vocational, and socio-emotional skills in children and adolescents.


Even once the speech sound disorder has been remediated through speech therapy services


Children with speech sound disorders are the primary population treated by school-based speech language pathologists


50-70% of children with speech sound disorders require some level of special education services through the 12th grade

- Shriberg & Kwiatkowski, 1988; Shriberg & Fernald, 1980;
**Speech Sound Disorder**


- Deficits in the phonological system often result in difficulty acquiring phonological awareness (PA) skills, a necessary pre-requisite for reading success (Larrivee & Catts, 1999).

**Prevalence of SSD**

- 11-13% of children ages 5-7 years have a speech sound disorder.

- Approximately 10% of children ages 9-11 have a persistent speech sound disorder.

- Sound errors that persist past the typical age of acquisition (i.e., 8-years-old).

- 18% of 8-year-olds in the UK have unresolved speech sound errors.

- 1.4% of college freshman have persisting speech sound errors.

**Risk of Reading Difficulties**

- Typically developing
- Speech Sound Disorders only
- SSD + Language impairment

Dyslexia is...

• A language-based problem
• A phonological processing disorder
• Neurobiological in origin
• Present from birth
• Usually experienced for life

Dyslexia is...

• A spectrum disorder than can range from annoyance to severe limitation
• More common than any other kind of learning disability
• Responsive to expert, informed instruction (Moats, 2008)

Dyslexia is...

• Characterized by weaknesses in word reading, phonemic decoding, and spelling
• Surprising, because this weakness exists in the presence of normal intelligence
• Present in adults who have compensated but are poor spellers, are slow readers, and have difficulty with novel and complex phonological forms
Dyslexia is NOT...

- Characterized or diagnosed by seeing letters backwards
- Indicative of “gifted” status
- A disorder that cannot be diagnosed until 3rd grade
- A visual problem
- Responsive to colored lenses and/or eye tracking exercises

Phonological processing deficit

- This phonological processing deficit seen across a variety of languages
  - French (Sprenger-Charolles et al., 2000)
  - Greek (Porpodas, 1999)
  - German (Wimmer et al., 1999)
- Manifestation is also different across languages
  - English: word reading
  - Dutch: word reading fluency
  - German: spelling

Oral language deficits

- Phonological processing problems associated with dyslexia can impact other language skills
- Many studies show that subtle oral language deficits are present in children at risk for dyslexia before formal schooling
  (e.g., Lyttinen et al., 2008; Scarborough, 1990, 1991)
Secondary Consequences
(research committee of the IDA, Lyon et al., 2003)

- Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.

Dyslexia Summary

- Classic case is uncommon
- Impairment in phonological processing (not necessarily production)
  - Across the lifespan
- Compensated adults
  - Poor spellers
  - Poor at reading quickly
  - Still have subtle phonological processing deficits

What is phonological awareness?
PHONOLOGICAL AWARENESS
(syllables, phonemes, etc.)

DECODING (alphabetic principle, spelling-sound correspondences)

SIGHT RECOGNITION (of familiar words)


SEMANTICS & GRAMMAR (vocabulary, syntax)

TEXT PROCESSING (text structures, cohesion)

BACKGROUND KNOWLEDGE (facts, concepts, etc.)

VERBAL REASONING (problem solving, inference)

METACOGNITION (comprehension strategies)

THE MANY STRANDS THAT ARE WOVEN INTO SKILLED READING

PHONOLOGICAL AWARENESS
(identification, pronunciation, segmentation, blending)

Easier                                                                                           Harder

Rhyming                                                                                           Sentence Segmentation

Syllable Segmentation & Blending                                                                                     Identification of initial or final phonemes

Phonemic Awareness                                                                                             Manipulation of individual phonemes

Phonological Awareness Continuum

Phonological awareness

• One’s sensitivity to the sound structure of a word
• Measured by rhyming, blending, and deletion tasks
• Research supports causal link between phonological awareness and early reading
  • Good phonological awareness = good readers
  • Poor phonological awareness = poor readers
• The component of reading in which SLPs are most likely to be involved
PA & SSD – Relations over time

Preschool:
• Preschoolers with SSDs are at increased risk for deficits with phonological awareness (Anthony et al., 2011; Bird, Bishop, & Freeman, 1995; Foy & Mann, 2011; Lewis et al., 2011; Lewis & Freebairn, 1992; Peterson, Pennington, Boada, & Beards, 2000; Raitano, Pennington, Beards, & Beards, 2004; Rvachew, Ohberg, Grawburg, & Heyding, 2003)
• Atypical speech sound errors and distortions in preschool are predictive of weak PA skills (Preston & Edwards, 2010)
• This is true even when language is normal (Bird et al., 1995; Overby, Trainin, Smit, Bernthal, & Nelson, 2012; Raitano et al., 2004; Rvachew et al., 2003)
• The proportion of speech sounds in error at age 5 is related to the likelihood of persistent errors at age 8 (Roulstone et al., 2009)

School-aged:
• Children with persistent speech sound disorders (2-5th grade) have markedly weaker PA skills compared to same-age peers (Farquharson, 2012)
• Children with "residual" SSD, ages 8.5-10, exhibit cortical and subcortical differences during phonological processing tasks (Preston, Felsenfeld, Frost, Mencl, Fulbright, Grigorenko, Landi, Seki, & Pugh, 2012)
• Atypical speech sound errors in preschool are predictive of school-age PA abilities; if more than 10% of the child’s speech has atypical errors, the child is likely to have deficits in PA, reading, and spelling (Preston & Hull, 2012)

Adolescents:
• 10-14 year old children with “residual” speech sound errors (no comorbid diagnoses) have weaker phonological processing skills compared to same-aged peers (Preston & Edwards, 2003)
• Phonological processing (word reading and phonological working memory) skills have been shown to be weak even once the speech sound disorder is remitted (Farquharson, 2013; Raitano, Trainin, Pennington, Beards, & Beards, 2004)

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How do we use this information?

Early identification

Early intervention

Reduced Risk of Reading disorders

Early Intervention

• Critical because children who start out as poor readers generally continue to be poor readers

• Poor reading achievement quickly leads to a host of negative consequences

Downward Spiral of RD

Low Motivation

Negative Expectations

Limited Practice

Academic Failure
Early Indicators

• Problems in oral language and speech sound development are primary signs of risk for reading disorders
  - Nathan, Studebaker, Goulandris, & Snowling (2004); Pennington (2005); Rattano, Pennington, Tunick, Boada, and Shriberg (2004)

Early signs of risk for Dyslexia

• Family history of reading or language impairment
• Difficulty learning the letter names and sounds
• Consistent use of unusual or nondevelopmental errors
• Multisyllabic words especially difficult

Not early signs of dyslexia

• Reversing letters when writing
  • This is typical until 2nd grade

• Common errors on long words
  • annual: annaul
  • peppers: peppers
New frontiers in early identification of dyslexia

• Speech discrimination at 3-5 days old
  • Guttorm et al., 2005

• Babbling complexity in infants
  • Farquharson, Hogan, Hoffman, Green, Wang, & Green, (under review); Lambrecht-Smith et al., 2008

Resources

• International Dyslexia Association (IDA)
  • http://ida.org/

• Decoding Dyslexia
  • http://www.decodingdyslexia.net/
  • #saydyslexia

See last few slides for additional resources

PA & phonological representations

• Testing phonological awareness is a robust measure of underlying phonological representations
Phonological Representations

spoken language
written &
blocks for
Building

• How phonological information – like speech sounds – is stored in long term memory

Phonological Reps + SSD

• Underdeveloped in children with SSD (Catts & Larivee, 1999)
• May be difficult to access for children with SSD because working memory resources are limited
• May be the reason why some children with speech sound disorders experience difficulties with literacy and some do not.
How could this affect reading?

• Learning decoding skills
  • Letter sound correspondence

• Learning sight words

What is a sight word?

• The sight of the word immediately activates its pronunciation and meaning in memory
• To build sight words in memory, orthographic mapping, is required

• What is needed for orthographic mapping?

(Ehri, 2014)

Orthographic Representations

• The storage of orthographic information in long term memory
  (Apel, 2011)

• Provides information regarding how to represent spoken language in written form.
Orthographic Mappings

- Mappings from phonology to orthography occur early on in reading development.
- Parallel connections between orthography and phonology
  - Phonological awareness appears to provide extra support. (Nilsen & Bourassa, 2008)

**PONY = BOLOGNA**

**COUGH=THROUGH= ROUGH = THOUGH**
SSD and mapping

- Children with SSD often struggle to make the translation between phonology and orthography (Sutherland & Gillon, 2005).
- Long-term difficulties even after the sound is remediated (Farquharson, 2015; Felsenfeld et al.)
- How will we know if there are strong phonological representations?

SSD and Literacy

- Children with SSD were found to have poorer performance on the following tasks:
  - Phonological processing
  - Phonological learning
  - Phonological awareness
  - Word recognition
  - Letter knowledge**

** (Carroll & Snowling, 2004)

Does Working Memory play a role?
Deficits in literacy skills
(Raitano, Pennington, Tunick, Boada, & Shriberg, 2004)

Deficits in acquiring phonological awareness
(Catts & Larrivee, 1999)

Deficits in phonological representations
(Antony et al., 2011; Storkel, Maekawa, Hoover, 2010)

Baddeley Working Memory Model

Central Executive

Visual-Spatial Sketchpad

Phonological Loop
Central Executive
• Allocates attentional resources to the appropriate subsystems (i.e., phonological loop or visual-spatial sketchpad)

(Baddeley, 1992; Reisberg, 2010)

Visual Spatial Sketchpad
• Stores visually presented information, such as pictures or words

Phonological Loop
• Stores auditorily presented information, such as speech sounds

“...most involved in language processing and development” (Baddeley, 1992, p. 151)
Has a positive relationship with speech and language acquisition (Adams & Gathercole, 2000)
Phonological Loop and SSD

- 12-year old with remediated SSD had poor WM
- Speidel (1993)
- Preschoolers with low WM had more speech errors than preschoolers with high WM
- Nonword repetition
- Adams and Gathercole (1995)
- Preschoolers with SSD had poor WM
- Nonword repetition
- Munson, Edwards, & Beckman (2005)

Research Question

Are there differences in the working memory skills of school-aged children with persistent SSD and typically developing children?

Method
Participants

Persistent Speech Sound Disorder
- n = 20 (13 males)
- M age = 112.3 months
- M grade = 3.3
- GFTA M Standard Score = 80.5
- CTOPP M Standard Score = 91.6

Typically Developing
- n = 20 (10 males)
- M age = 113.3 months
- M grade = 3.3
- GFTA M Standard Score = 104.45
- CTOPP M Standard Score = 105.25

All Participants: Inclusionary Criteria

- Monolingual
- Normal hearing
- Normal vision (corrected)
- Normal non-verbal intelligence
  - Reynolds Intellectual Assessment Scales (RIAS)

Experimental Tasks
Phonological Loop Tasks

• Sentence span task
• Nonword repetition task
• Henry Task

Results & Discussion

$p < .05$
Research Question

Are there differences in the working memory skills of school-aged children with persistent SSD and typically developing children?

![Graph showing stop signal stop and go accuracy with p-values]

Stop Signal - Stop and Go Accuracy

![Graph showing stop signal response time with p-value]

Stop Signal Response Time (ms)

P-SSD TD

p=0.229
Tasks used for Analysis

- Phonological Loop
  - NWR
  - Henry Task
  - Sentence Span
Nonword Repetition

![Graph showing mean scores on NWR task.](image)

Mean Scores on NWR task

- TD: p = .858
- PSD: p = .044
- TD vs. PSD: p = .200

Henry Task

![Graph showing mean scores on Henry Task.](image)

Mean Scores on Henry Task

- Monosyllabic: TD vs. PSD: p = .006

Sentence Span Task

![Graph showing number correct.](image)

Number Correct: TD vs. PSD: p = .080

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Conclusions

Children with P-SSD appear to have deficits specific to the phonological loop of working memory. Specifically, children with P-SSD struggle with complex word structures (e.g., multisyllabic words, longer lists of words), indicating limited phonological representations as well as limited working memory.

Results Summary

- Children with persistent SSD performed poorer than peers on phonological working memory tasks...
- This relation was mediated by their nonverbal IQ scores (not vocabulary)
- It is not common place to test nonverbal IQ in children with SSD, but it may have predictive value for working memory and literacy skills

What about after dismissal?

- [Link](http://sig16perspectives.pubs.asha.org/Article.aspx?articleid=2240012)
Assessment Implications

• Test phonological awareness in all SSD evaluations
• Test PA using both expressive and receptive measures
  • (see the Comprehensive Test of Phonological Processing: 2nd Edition [CTOPP-2] for a possibility)
• Obtain material from preschool/ classroom teachers regarding decoding, phonological awareness, or spelling skills
• Screen early and often; and don’t screen “just” for speech sound production

Treatment Implications

• Include phonological awareness
• Try minimal pairs
• Include reference to orthography
• Partner with reading specialists and special educators
• Push in to the classroom
• Use curriculum based vocabulary

Clinical Implications

• Children with SSD will likely have poor phonological representations
• SLPs are on the front lines of defense for these children
  • Early SSD and language impairments put children at risk for later literacy deficits... EVEN IF the issue has remediated
• Be mindful of the warning signs and open to collaboration or consultation
Thank you!

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Suggested Assessments

- **Comprehensive Test of Phonological Processing** – 2nd Edition (CTOPP-2; Wagner, Torgesen, Rashotte, & Pearson, 2009)
  - Measures phonological processing – skills needed for word reading/decoding
  - Ages 4.0 – 24.11
  - Subtests: Elision, Blending, Sound Matching, Phoneme Isolation, Blending Nonwords, Segmenting Nonwords, Memory for Digits, Nonword Repetition, Rapid Digit Naming, Rapid Letter Naming, Rapid Color Naming, and Rapid Object Naming
- **Woodcock Reading Mastery Test – 3rd Edition** (WRMT-3; Woodcock, 2011)
  - Measures most aspects of reading – decoding and its related skills & comprehension and its related skills
  - Ages 4.6 – 79.11

Suggested Assessments (continued)

- **Reynolds Intellectual Assessment Scales – 2nd Edition** (RIAS-2; Reynolds & Kamphaus, forthcoming)
  - Measures nonverbal and verbal intelligence (provides IQ score)
  - Ages 3-94
  - Subtests: Guess What, Odd-Item Out, Verbal Reasoning, What’s Missing, Verbal Memory, Nonverbal Memory, two new speeded processing subtests
  - Measures nonverbal and verbal intelligence (provides IQ score)
  - Ages 4.0 – 85.0
  - Subtests: Verbal Knowledge, Riddles, and Matrices

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Helpful websites

• Classlab.emerson.edu
• www.facebook.com/classlabemerson
• Florida Center for Reading Research
• International Dyslexia Association
• ASHA Practice Portal for SSD
• What Dyslexia Is and Is Not
• Classroom accommodations for dyslexia
• Speech Bite
• Decoding Dyslexia
• International Literacy Association
• Use IPA on any website/ email/ document

References


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