The Reading Brain: Neuroscience & Assessment Implications for Hemispherectomy

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Topics

• What skills underlie reading ability?

• How does the brain support reading?

• What do we know about struggling readers and the reading brain?

• What skills and abilities are important to measure during assessment?
Spoken & Written Language Relationships

Modified from Doris Johnson
P is for Phonology

• Phonology: the rules governing the sounds of language

• Examples: rhyming, matching sounds, blending sounds, recalling words

P is for Pragmatics

• Pragmatics: the rules governing the use of language and communication
  – Using language for different purposes: greeting, requesting, informing
  – Changing language according to listener needs/situation: speaking to a baby vs adult, offering background information
  – Following rules for conversations/storytelling: turn taking, facial expressions/eye contact, staying on topic

www.asha.org/public/speech/development/Pragmatics
O For orthography

- Orthography: the rules governing the written symbols of a language
- Examples: recognizing and using spelling patterns, matching letters and sounds

TAE CAT

S for Semantics

- Semantics: the rules governing the meaning of words
- Examples: antonyms, synonyms, multiple meanings
### S is for Syntax

- **Syntax**: the rules governing the organization of language (e.g., into sentences)

- **Examples**: sequence and organization, noun-verb agreement, pronoun use

  “Truly wonderful, the mind of a child is.”
  *Yoda, *Attack of the Clones*

  “Judge me by my size, do you?”
  *Yoda, *The Empire Strikes Back*

### M is for Morphology

- **Morphology**: the rules governing the use of morphemes (smallest units of meaning)

- **Examples**
  - My dad *drink* tea (= ’My dad *drinks* tea’)
  - Somebody coming (= ’Somebody’s coming’)
  - Can I finish game? (= ’the game’)
  - Julie wanted eat his breakfast (= ’to eat’)
  - *Firemans* live over here (= ’Firemen’)
  - *Me* don’t want those

Components of Language (Receptive and Expressive)

- **Form**
  - Phonology
  - Morphology
  - Syntax

- **Content**
  - Semantics

- **Use**
  - Pragmatics

Model by Bloom & Lahey

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The Many Strands that are Woven into Skilled Reading (Scarborough, 2001)

**Language Comprehension**

**Word Recognition**

**Skilled Reading:** Fluent execution and coordination of word recognition and text comprehension.

- Attention
- Executive function
- Memory
- Visual motor/oral motor
Components of Reading

- **Phonemic Awareness**
  - Awareness and understanding of sounds.

- **Phonics**
  - Correspondence between sounds and letters.

- **Reading Fluency**
  - Reading aloud with speed, accuracy, and proper expressions.

- **Vocabulary**
  - Knowledge of words.

- **Comprehension**
  - Understanding discourse and text.

National Reading Panel Findings

- **Phonics**
- **Vocabulary**
- **Phonemic Awareness**
- **Reading Fluency**
- **Comprehension**
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The Reading Brain

(Wolf, 2007)
Over the past few decades, cognitive neuroscience research has focused on identifying these individual regions of interest in the brain that correspond to the many stages of word reading. Although many regions have been uncovered, however, one region in particular seems especially suited for the task of processing orthographic stimuli. (Dehaene, 2009)
3 Core Reading Brain Networks

Motor production, processing unfamiliar words
Anterior Network

Posterior: Dorsal Network

Posterior: Ventral Network

Supports decoding skills

Supports word recognition

## Topics

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## Dyslexia: The most common reading disability

- **What is the basis?** Neurobiological in origin
- **What are the main features?** Difficulties in accurate and/or fluent word recognition and by poor spelling and decoding abilities
- **Why?** Difficulty with the sounds of language (phonology)
- **What else?** Average or higher cognitive skills
- **What else?** Reading comprehension challenges, reduced reading experience
- **What else can contribute to reading issues?** Exclusion of cultural, educational, environmental, or other disabilities
- **Can you tell from a brain scan?** No

(Lyon et al., 2003)
Characteristics of Developmental Dyslexia

- Relatively more activation in the frontal/anterior system
- Relatively less activation in back/posterior systems
- Activation of similar regions in the right hemisphere

(Brunswick, 1999; Paulesu et al., 2001; Rumsey et al., 1992, 1997; Shaywitz et al., 1998, 2002; Simos, Breier, Fletcher, Bergman, & Papanicolaou, 2000; Shaywitz et al., 2002; Simos, Papanicolaou, et al., 2000)

Studying Obligatory Compensation in Hemispherectomy

- Plasticity: Ultimate opportunity to study re-organization of the remaining hemisphere for its "maximum potential"
- Study: Given the compensatory role of the right hemisphere for reading, what potential does it offer in isolation for supporting reading and related skills?
Early plasticity vs. Early vulnerability
(Hessen et al., 2007)

• Are specific cerebral functions (e.g., speech, memory) ‘innately specialized’ to particular brain regions, with limited potential for reorganization or transfer, resulting in poor outcome?

Or

• Does the immature brain show ‘equipotential’, with minimal functional localization early in development, enabling healthy brain to take up functions previously the responsibility of damaged areas?
  (Aram, 1988; Oddy, 1993)

Language with Half a Brain

• Most studies don’t look in-depth into the language and reading profile
  – Typically rely on tests of aphasia or intelligence
    (Loddenkempe et al., 2003)

• RH potential to:
  – Sustain ability: Following left hemispherectomy in childhood, everyday receptive and productive language functions are often spared, provided the right hemisphere is relatively intact
    (de Bode & Curtin, 2000; Gott, 1973; Madden et al., 1998; Stark, Brandt, Freeman, & Vining, 1995; Vargha-Khadem et al., 1991)

  – Improve ability: Improved language ability post-operation in 15 yr old girl, operative age 12
    (Loddenkempe et al., 2003)

  – Phonological skills and vocabulary skills are predictive of reading outcomes
    (de Bode et al, 2015)
How do readers with left hemispherectomy compare to peers with dyslexia?

(Katzir, Christodoulou & DeBode, 2016)

How do readers with left hemispherectomy compare to peers with dyslexia by early/late insult?

(Katzir, Christodoulou & DeBode, 2016)
Individual Patterns: Early Insult Cases

(Katzir, Christodoulou & DeBode, 2016)

Individual Patterns: Late Insult Cases

(Katzir, Christodoulou & DeBode, 2016)
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Assessment

- Assessment = Testing?
- Testing consists of administering a particular set of questions to an individual or group of individuals to obtain a score. That score is the end product of testing.
- A test is only one of several assessment techniques or procedures for gathering information.
- Assessment combines data from multiple sources
  - observations
  - parent reports
  - tests – standardized and non-standardized
  - professional judgment

Assessment in Special and Inclusive Education, 6th Edition
Clinical Perspective: “Four pillars” of assessment

Assessment Methods

- Norm-referenced tests
- Interviews
- Observations
- Informal assessments

Importance of Qualitative Observations

- What problem-solving strategies are used?
- Persistence, flexibility, and frustration tolerance: how easily does a student give up and when?
- Testing limits: can a student go beyond the “ceiling”?
- Does a multiple-choice format change performance?
- Difference on expressive vs. receptive tasks?
- Do errors appear to be inattentive/impulsive?
- How effortful and/or stressful are certain tests?
- What tasks elicit enthusiasm and enjoyment? Withdrawal or reluctance?
- How consistent is performance within each test?
### The essentials of statistics

**Types of scores**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw Score</strong></td>
<td>Reflects number of items answered correctly – no comparison to norm group</td>
</tr>
<tr>
<td><strong>Standard Score</strong></td>
<td>Derived score reflecting how far the score lies from the norm group’s mean in terms of the standard deviation</td>
</tr>
<tr>
<td><strong>Percentile rank</strong></td>
<td>Derived score reflecting individual’s position relative to norm group; tells what percentage of people in the relevant part of the norm group performed more poorly than the individual</td>
</tr>
<tr>
<td><strong>Age- and Grade-Equivalents</strong></td>
<td>The (sometimes hypothesized) average score of children in a particular age or grade level</td>
</tr>
</tbody>
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- **Almost never useful in raw form**
- **Perhaps the most widely reported, beware of potential confusion by non-professionals**
- **Useful but can be confusing:**  
  - NOT the % correct  
  - Different intervals for different tests  
- **Easy to understand but also easy to misinterpret**

### Assessment Components

- General cognitive abilities (IQ)  
  - Including Working Memory, Processing Speed, Executive Functions
- Phonological Processing
- Rapid Automated Naming
- Oral Language  
  - Vocabulary  
  - Language use and understanding
- Word Reading and Pseudoword Reading
- Reading Comprehension
Headlines

- Reading abilities should be understood in the context of cognitive and language skills
- Reading abilities involve
  - Component skills: phonology, rapid naming
  - Outcome skills: word reading, comprehension, writing
- Phonology (and rapid naming) skills predict reading outcomes

Acknowledgements

Thank you
Participants and their families
Lab members
National Science Foundation #1644540
National Institute of Child Health and Human Development

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