Dr. Joanna Christodoulou
jac765@mail.harvard.edu

The Reading Brain: Neuroscience & Assessment Implications for Hemispherectomy

Joanna A. Christodoulou
MGH Institute of Health Professions
jac765@mail.harvard.edu

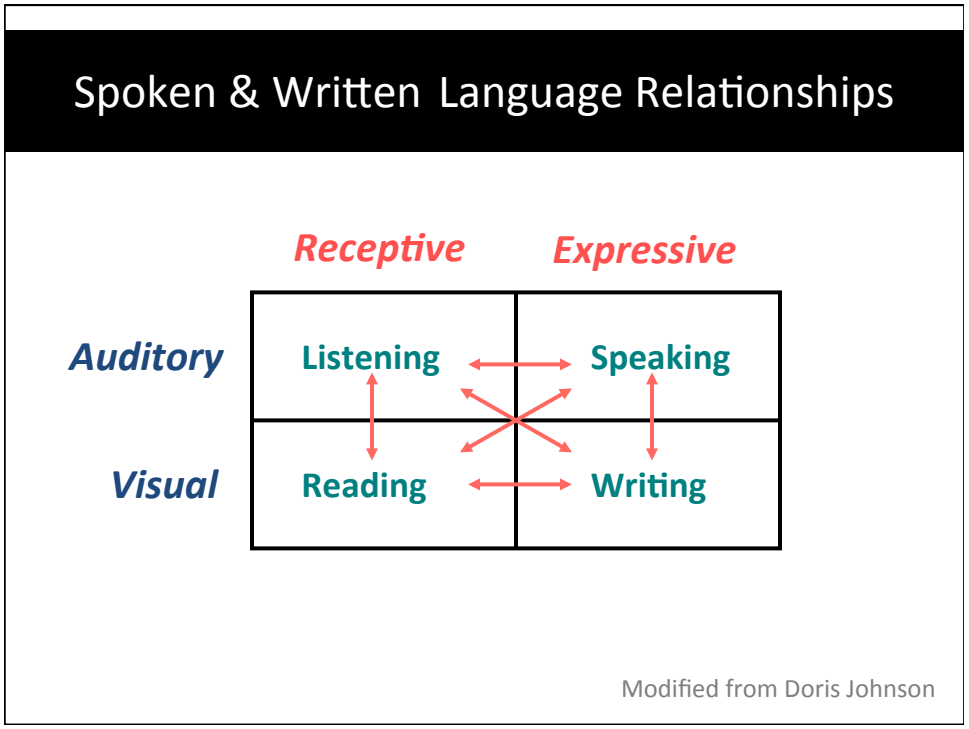
BEAM
Brain, Education & Mind

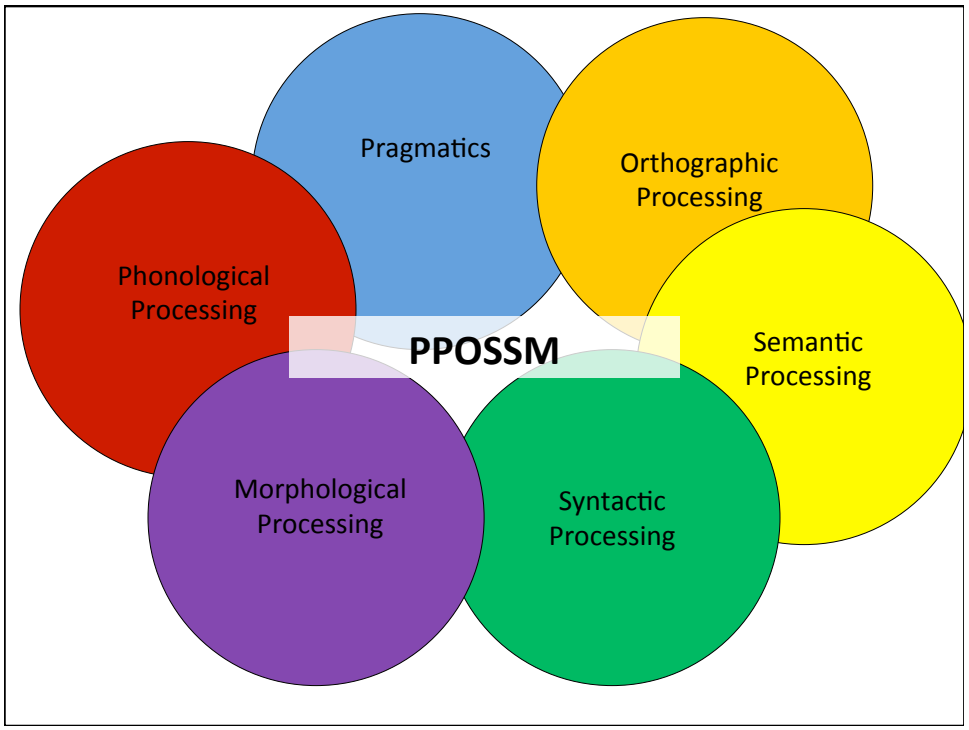
MGH INSTITUTE
OF HEALTH PROFESSIONS

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?

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

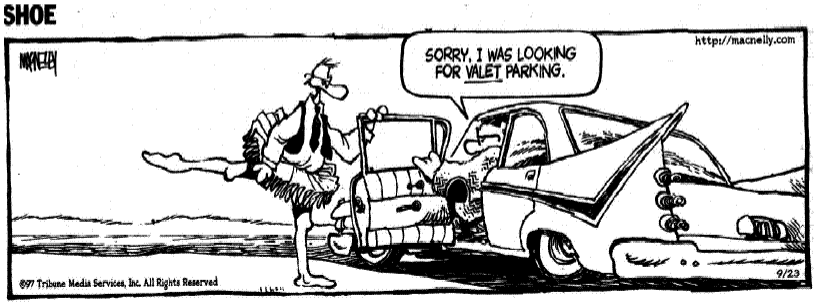




Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

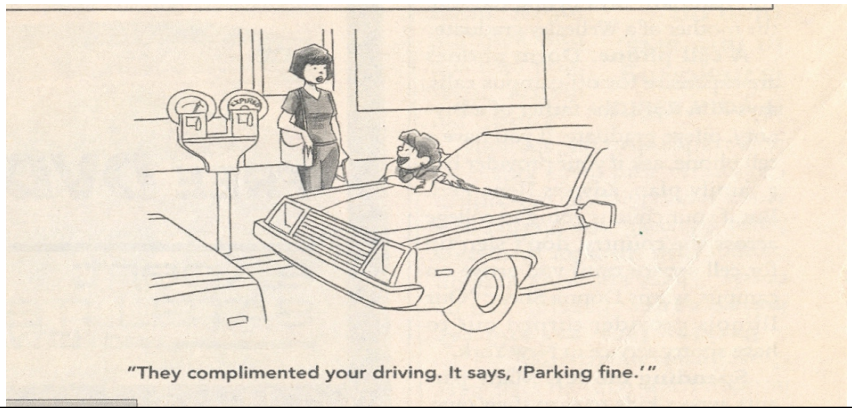
O For orthography

- 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



Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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*

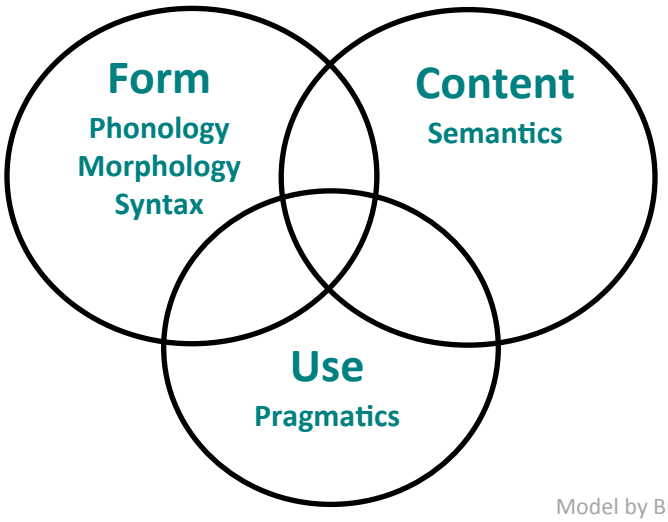
M is for Morphology

- 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

Radford, A (2006) *Grammatical Aspects of Specific Language Impairment: A Linguistic Perspective*, unpublished coursebook, University of Essex (http://courses.essex.ac.uk/lg505)

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

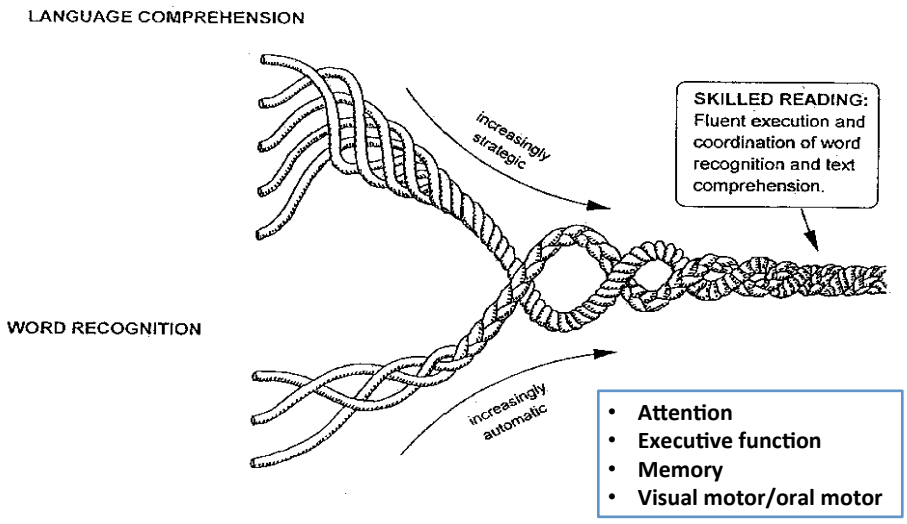
Components of Language (Receptive and Expressive)



Model by Bloom & Lahey

The Many Strands that are Woven into Skilled Reading

(Scarborough, 2001)

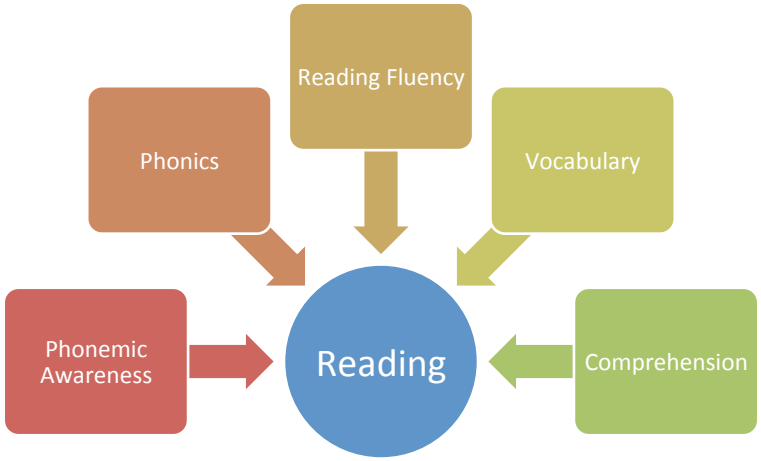


Dr. Joanna Christodoulou
jac765@mail.harvard.edu

Components of Reading

Phonemic Awareness	Phonics	Reading Fluency	Vocabulary	Comprehension
• Awareness and understanding of sounds.	• Correspondence between sounds and letters.	• Reading aloud with speed, accuracy, and proper expressions	• Knowledge of words.	• Understanding discourse and text.

National Reading Panel Findings



Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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?

The Reading Brain

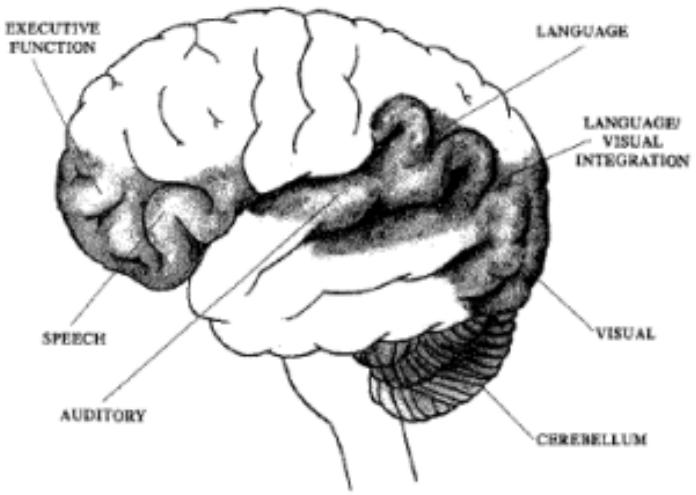
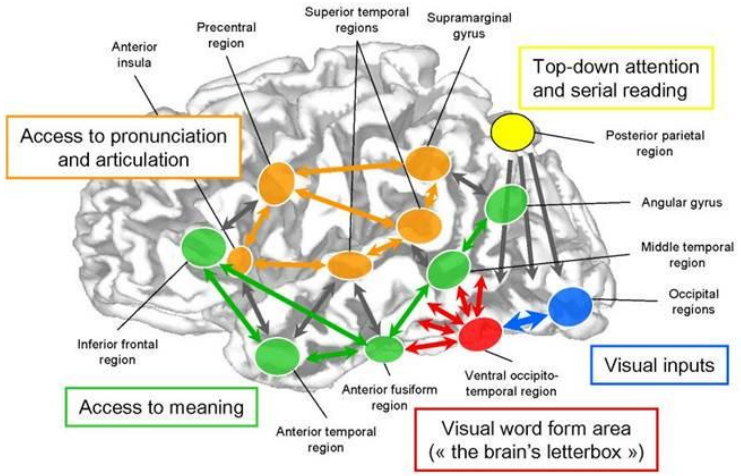


Figure 7-5: Cumulative Dyslexia Hypothesis

(Wolf, 2007)

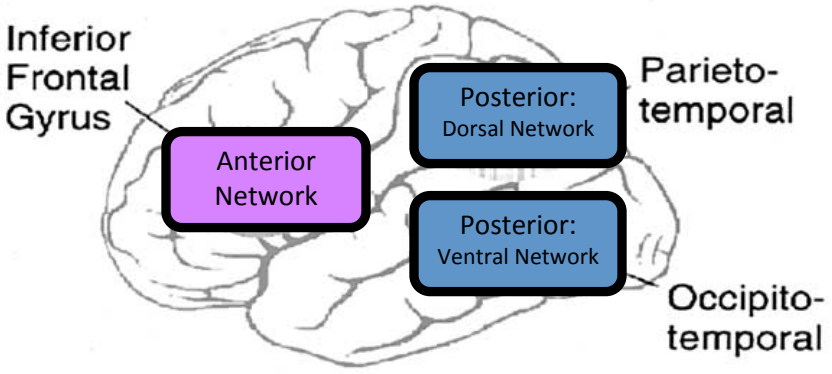
Dr. Joanna Christodoulou
jac765@mail.harvard.edu

Cortical Networks for Reading



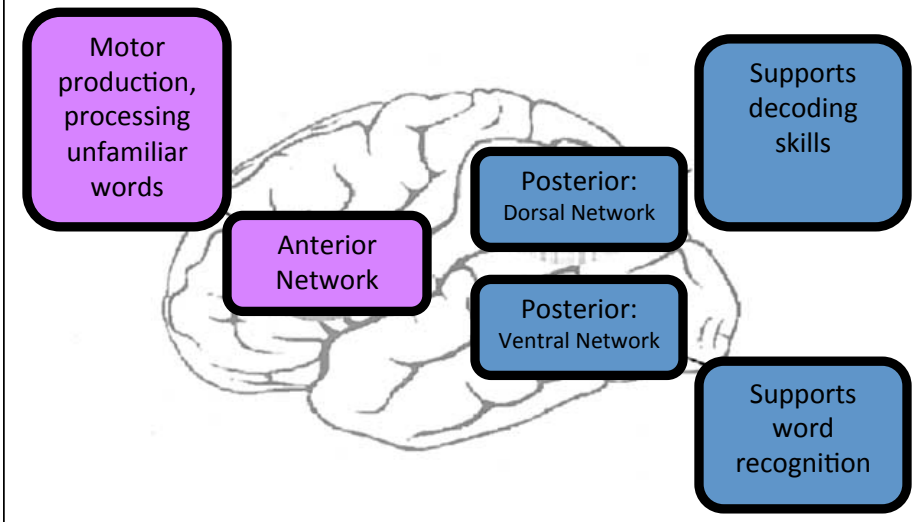
(Dehaene, 2009)

3 Core Reading Brain Networks



Dr. Joanna Christodoulou
jac765@mail.harvard.edu

3 Core Reading Brain Networks



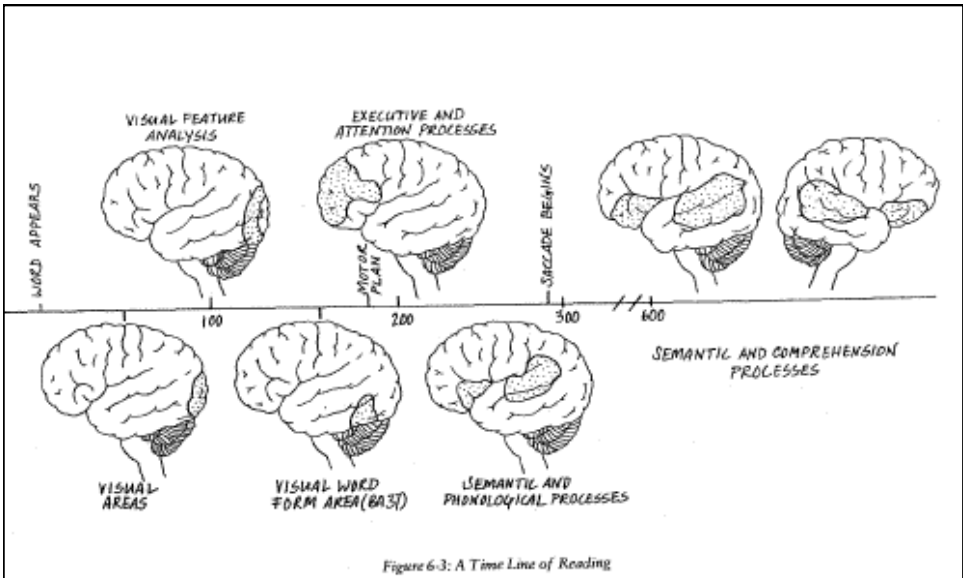


Figure 6-3: A Time Line of Reading

Wolf, M. (2007). *Proust and the Squid*. pp.145

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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?

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

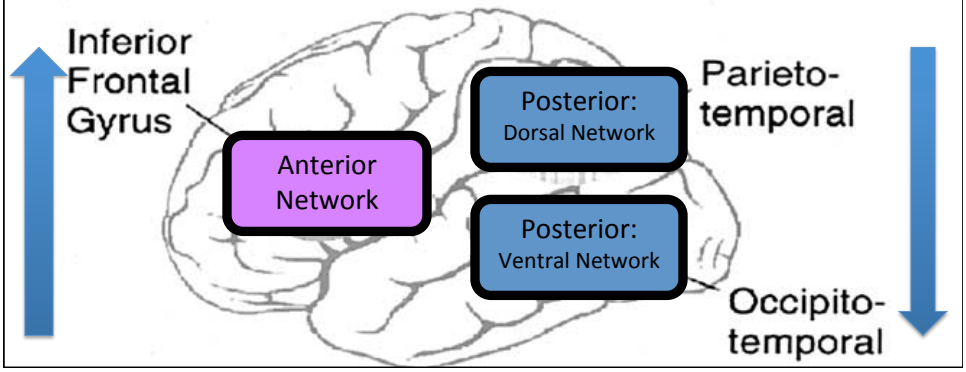
(Lyon et al., 2003)

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

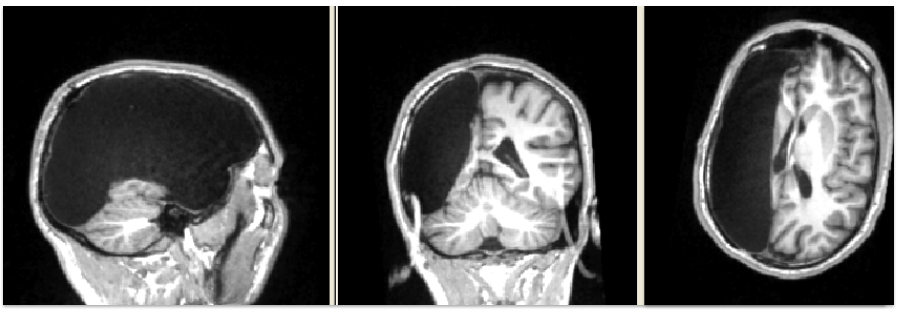
Characteristics of Developmental Dyslexia

- **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?

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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

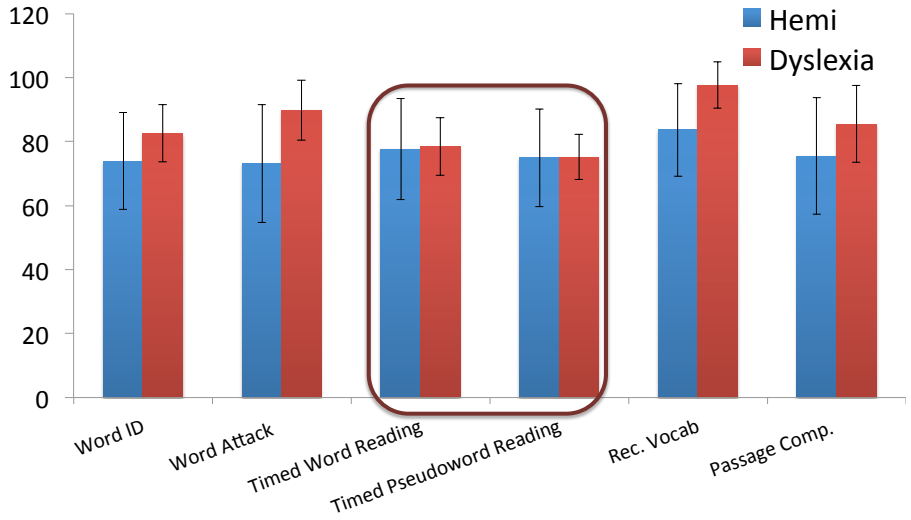
- Does the immature brain show 'equipotential', with minimal functional localization early in development, enabling healthy brain to take up functions previously the responsibility of damaged areas? (Aram, 1988; Oddy, 1993)

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 & Curtiss, 2000; Gott, 1973; Mariotti et al., 1998; Stark, Bleile, 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 (DeBode et al, 2015)

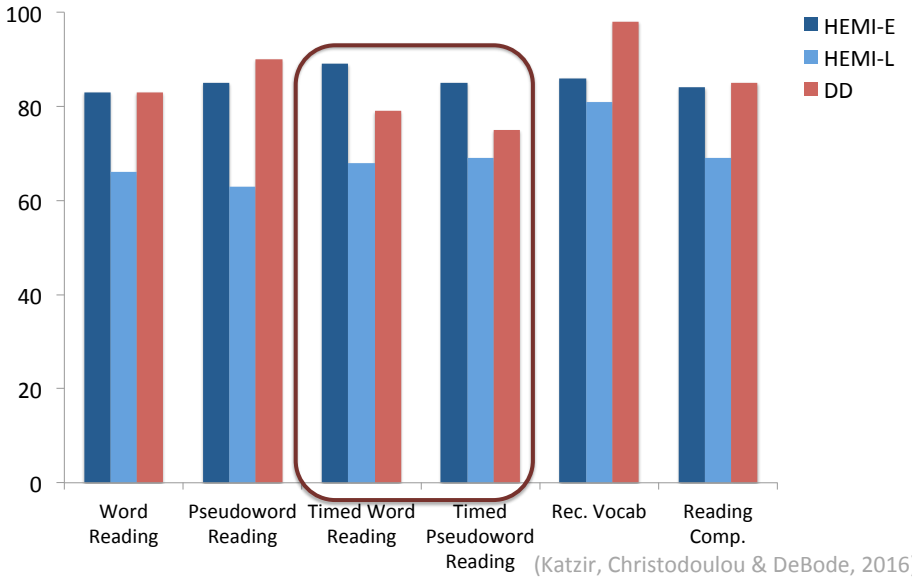
Dr. Joanna Christodoulou
jac765@mail.harvard.edu

How do readers with left hemispherectomy compare to peers with dyslexia?



(Katzir, Christodoulou & DeBode, 2016)

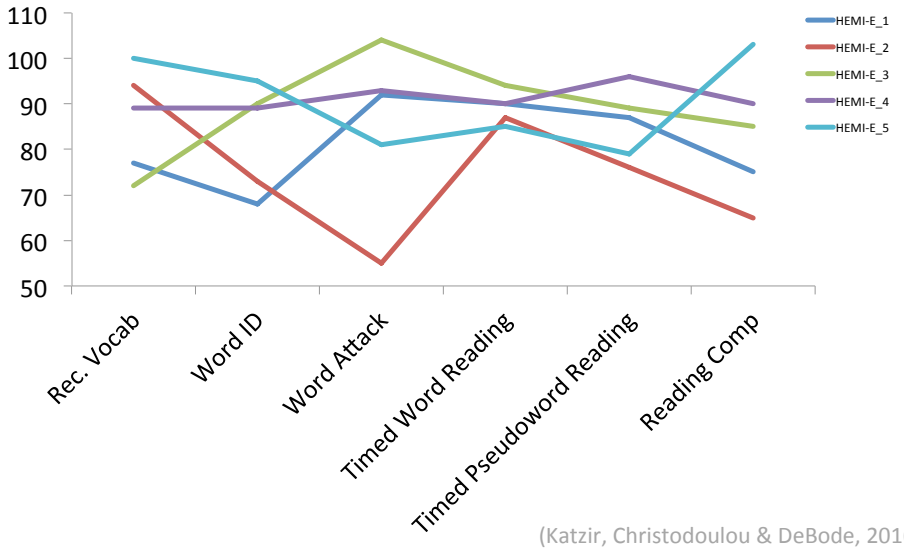
How do readers with left hemispherectomy compare to peers with dyslexia by early/late insult?



(Katzir, Christodoulou & DeBode, 2016)

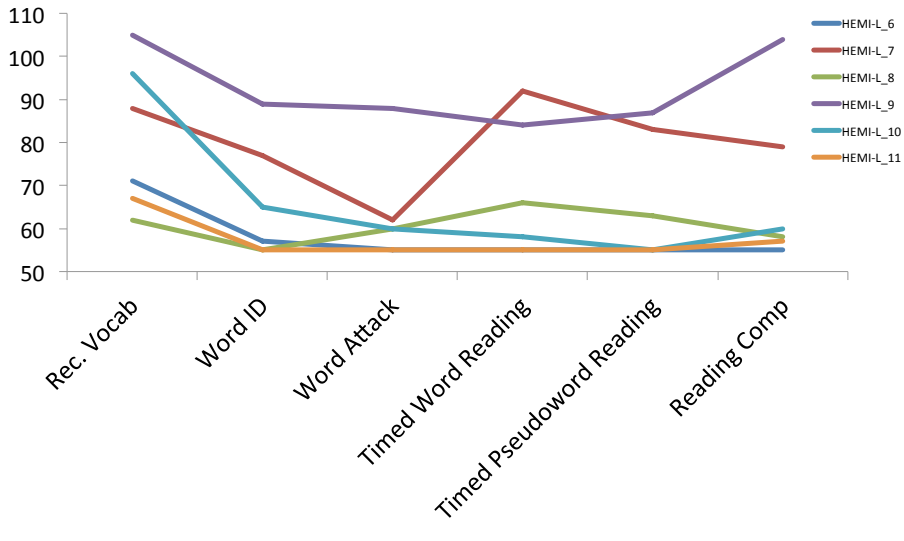
Dr. Joanna Christodoulou
jac765@mail.harvard.edu

Individual Patterns: Early Insult Cases



(Katzir, Christodoulou & DeBode, 2016)

Individual Patterns: Late Insult Cases



(Katzir, Christodoulou & DeBode, 2016)

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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?

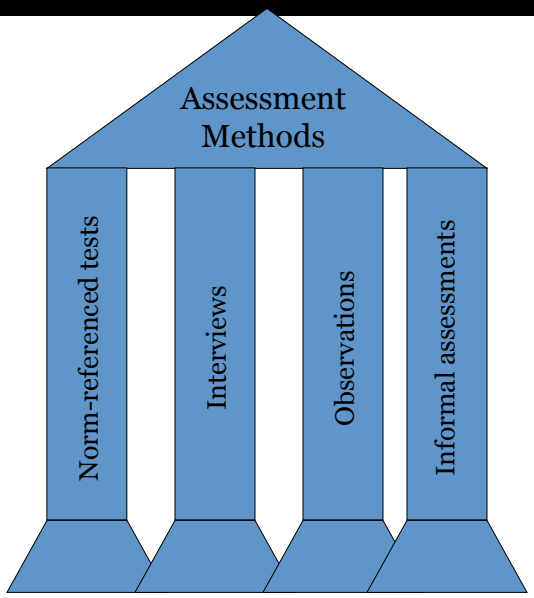
Assessment

- 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, 11th Edition

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

Clinical Perspective: "Four pillars" of assessment



Sattler

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?

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

The essentials of statistics
Types of scores

Raw Score: reflects number of items answered correctly – no comparison to norm group → Almost never useful in raw form

Standard Score: derived score reflecting how far the score lies from the norm group's mean in terms of the standard deviation → Perhaps the most widely reported, beware of potential confusion by non-professionals

Percentile rank: 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 → Useful but can be confusing:
- **NOT** the % correct
- Different intervals for different tests

Age- and Grade-Equivalents: the (sometimes hypothesized) average score of children in a particular age or grade level → Easy to understand but also **easy to misinterpret**

Assessment Components

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

Dr. Joanna Christodoulou
jac765@mail.harvard.edu

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

MGH Institute of Health Professions
A graduate school founded by Massachusetts General Hospital

BEAM
Brain, Education & Mind

Thank you

Participants and their families

Lab members

National Science Foundation #1644540

National Institute of Child Health and Human Development

Contact: jac765@mail.harvard.edu