

Contributions of Cognitive Neuroscience to Education: Promise, Potential, Pitfalls

Joanna A. Christodoulou
Assistant Professor
Brain, Education, & Mind Team
jac765@mail.harvard.edu

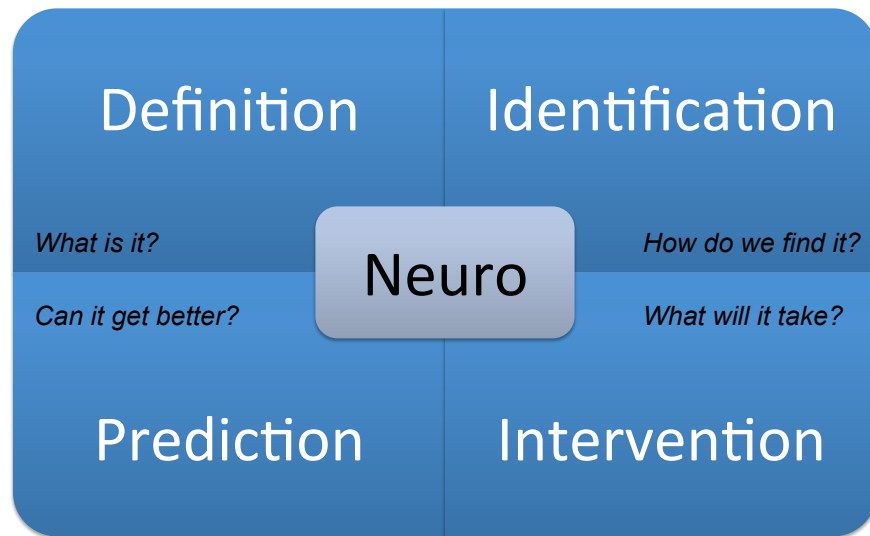


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OF HEALTH PROFESSIONS

Objectives

- Understanding the neural correlates of reading intervention
- Understanding the impact of risk factors such as socioeconomic status
- Appreciating the potential and limitations of neuroscience contributions

Potential Contributions of Neuroscience



Neuroscience Headlines

Promise

- Students with reading disabilities show functional brain differences compared to typically developing readers
- Brain imaging shows promise in predicting reading outcomes
- Effective instruction can rewire the reading brain

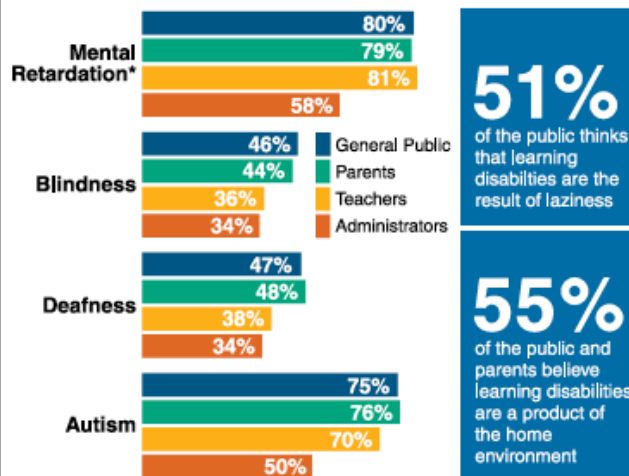
Pitfalls

- Neuroimaging data can impact perceptions of science
- Reading disabilities cannot be diagnosed through a brain scan
- The target of instruction is behavioral change, rather than brain changes
- “Brain-based” labels may be misleading

Developmental Disabilities

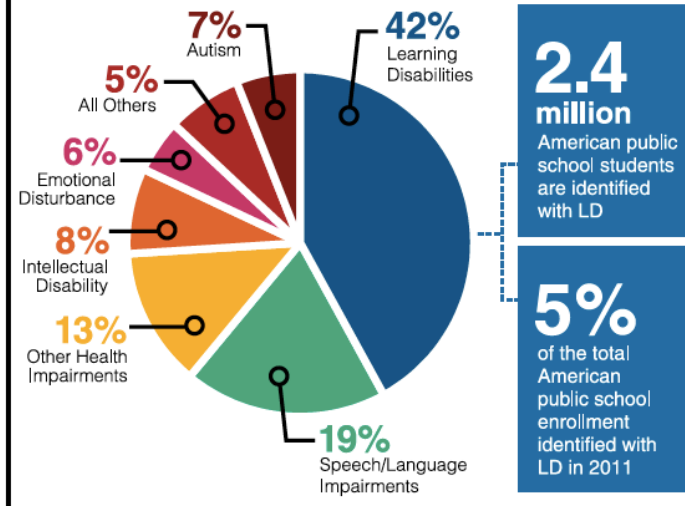
- Describe sets of abilities or characteristics that vary from the norm in the limitations they impose on independent participation and acceptance in society (Odom, Horner, & Snell, 2009)
- 17% of the school-age population (US Centers for Disease Control & Prevention)
- Students struggle to develop the skills required for success in academic settings (and beyond)
- Students face challenges in and out of the classroom, and typically across the life span

Percentage Who Think Each of the Following Are Associated With Learning Disabilities



Source: Tremaine Foundation, 2010

Special Education Students: 2011 By Disability Category



Source: IDEA Part B Child Count, Ages 6–21. Does not include Developmental Delay category (allowable to age 9).

Resources on LD Perception

- Cortiella, C. & Horowitz, S.H. (2014) The state of learning disabilities: Facts, trends, and emerging issues. New York: National Center for Learning Disabilities. <http://www.nclid.org>
- Implicit Bias Tests: <https://implicit.harvard.edu/implicit/>

Neuroscience Headlines

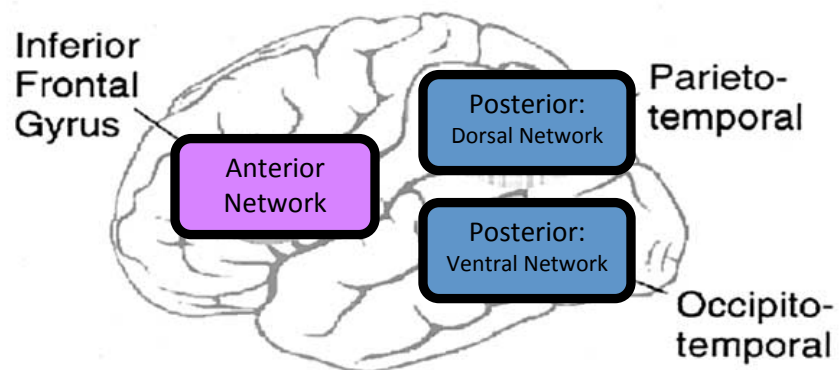
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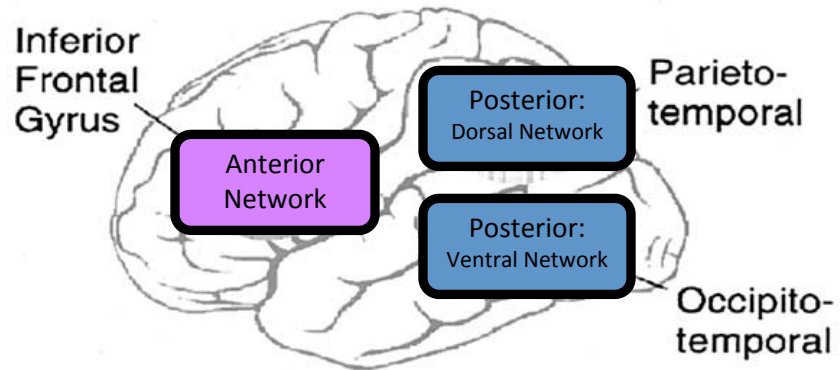
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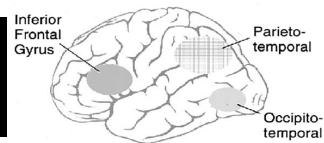
Core Reading Brain Networks



Core Reading Brain Networks



Reading Brain Networks



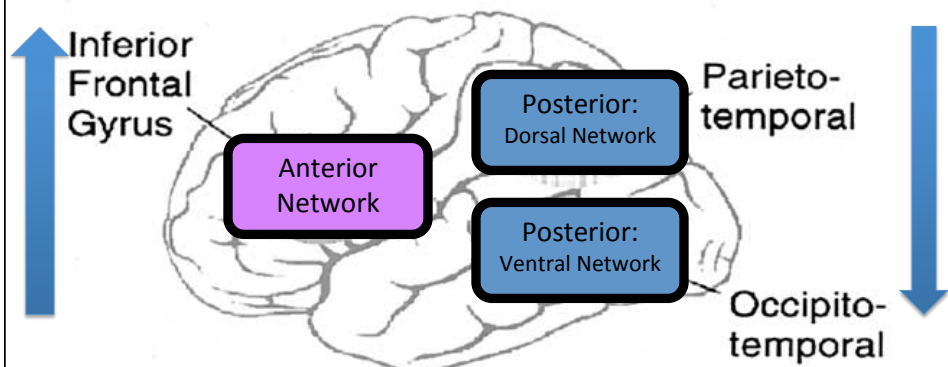
- **Anterior**
 - Motor production
 - Processing of low-frequency exception words and nonwords
- **Posterior – Dorsal**
 - Efficient word reading & phonological processing
- **Posterior – Ventral**
 - *Automatic* recognition of printed words

(Cohen et al., 2000; Fiez et al., 1998; Shaywitz et al., 2002)

Characteristics of Developmental Dyslexia

- **Anterior *hyper*activation**
- **Posterior *hypo*activations**
- Recruitment of **right hemisphere** homologous regions

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



Compensatory Systems in Dyslexia

- Left and right hemisphere anterior regions
- Right hemisphere posterior regions
- Activations in right hemisphere negatively correlated with reading skills
- **Accurate, but not automatic, word reading**

(Shaywitz et al., 2002)

Defining Dyslexia

- Neurobiological in origin
- Difficulties in accurate and/or fluent word recognition and by poor spelling and decoding abilities
- Deficit in the phonological component of language
- Unexpected in relation to other cognitive abilities and the provision of effective classroom instruction
- Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge
- Exclusion of cultural, educational, environmental, or other disabilities
- **NOT ADMISSIBLE: brain data**

(Lyon et al., 2003)

ADHD and RD

TABLE 1
Epidemiological Data

<i>Author</i>	<i>Cases</i>	<i>RD in ADHD</i>	<i>ADHD in RD</i>
August & Garfinkel, 1990	115 boys ADHD	39%	
Dykman & Ackerman, 1991	182 ADHD	45%	
Semrud-Clikeman et al., 1992	60 ADHD	38%	
Ginger et al., 1992	140 RD		39%
Willcutt & Pennington, 2000	209 RD		42% in males 18% in females
Mayes et al., 2000	86 ADHD	26%	
Loo et al., 2004	407 ADHD	18-23%	
Gayan et al., 2005	505 RD		36%
Wisniewska et al., 2007	28 ADHD	18%	

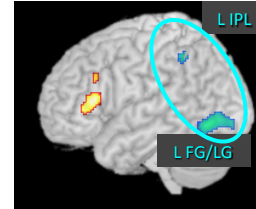
ADHD = attention deficit hyperactivity disorder; RD = reading disorder.

(Germano et al., 2010)

Dyslexia: Specific Activations vs. Developmental Differences

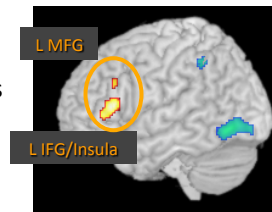
- Posterior network activations specific to dyslexia

- Dyslexic Group < Typical Age-Matched Readers
- Dyslexic Group < Typical Reading-Matched Readers



- Frontal network activations not unique to dyslexia

- Dyslexic Group = Typical Reading-Matched Readers
- Dyslexic Group > Typical Age-Matched Readers

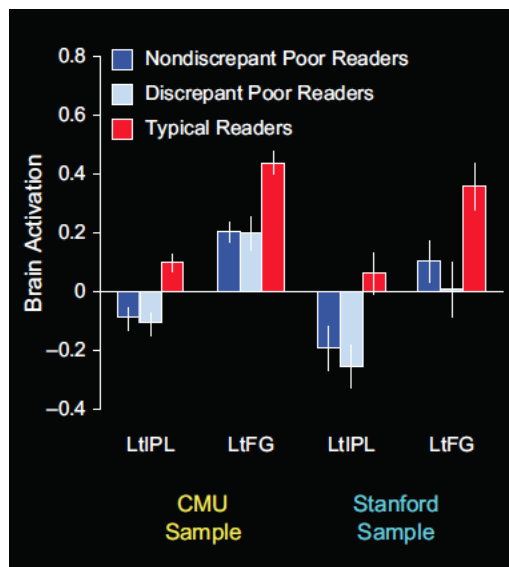


(Hoefl et al., 2007)

Dyslexia and IQ

Regardless of IQ,
poor readers have
similar kinds of
reading difficulties in
relation to
phonological
processing

(Tanaka et al., 2011)



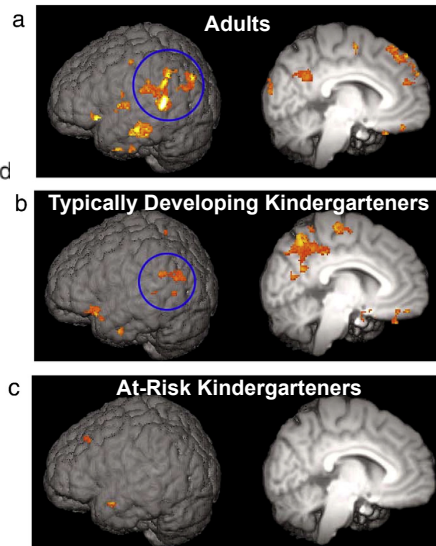
Intervention: Brain & Behavior Changes

- Brain networks recruited for reading are adaptable during development and modifiable in struggling readers
- Plasticity of the reading brain across reader ages

Differences in Emerging Reading Systems



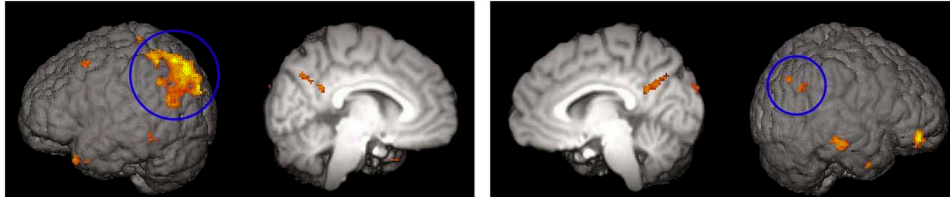
- Typically Developing Readers
 - initial recruitment and subsequent disengagement of right hemisphere
- At-Risk Developing Readers
 - compensatory recruitment of frontal regions



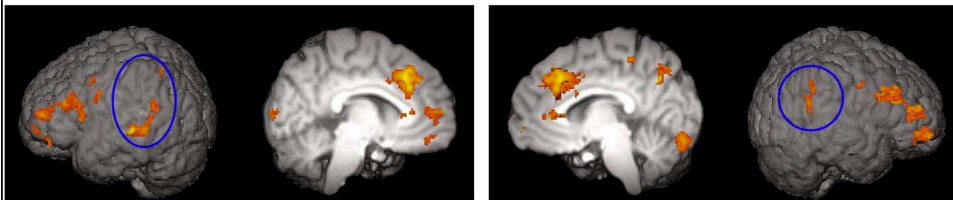
(Yamada et al., 2011)

Differences in Emerging Reading Systems

Typically Developing Kindergarten Readers after 3 months



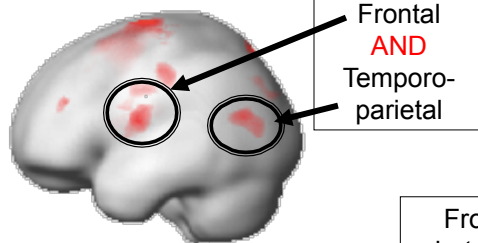
At-Risk Kindergarten Readers after 3 months



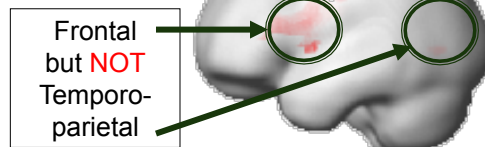
(Yamada et al., 2011)

Phonologically-Based Intervention

Control



Dyslexic



Example:

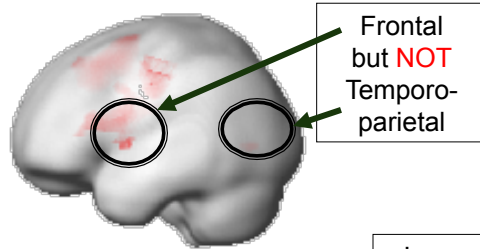
B D = Rhyme

B K = Do Not Rhyme

Temple et al. (2003) PNAS

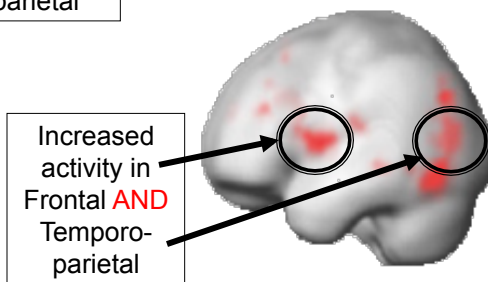
Neural effects of intervention in dyslexic children

Pre-Intervention



After training, metabolic brain activity in dyslexics more closely resembles that of normal readers.

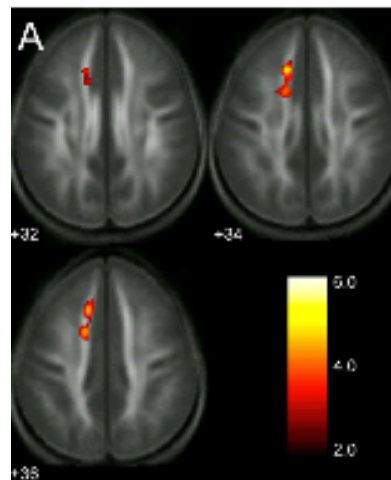
Post-Intervention



Temple et al. (2003) PNAS

Intervention Changes Brain Connections

- Diffusion tensor imaging (DTI)
- 8- to 10-year-old poor readers
- Change in white matter, suggesting an increase in myelination
- Correlated with improvement in phonological decoding ability
- (Keller & Just, 2009)

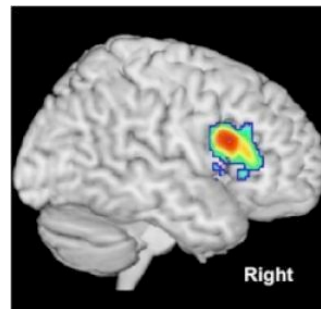
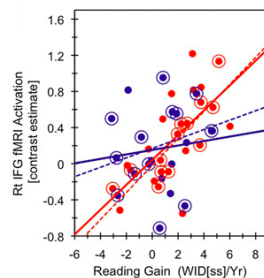


Can neuroprediction be informative?

- Life-Style
 - Predict positive affect with reactivity to reward and recent life stress (Nikolova et al., 2012)
 - Predict weight loss program outcomes with fMRI reactivity to food images (Murdaugh et al., 2012)
- Aging
 - Predict cognitive functioning in older adults based on white matter structure (Meier et al. 2012)
- Treatments
 - Predict treatment response for depression and anxiety (Hernández-Ribas, 2012; Doehrmann et al., 2013)
 - Predict outcomes following head trauma (Bernick et al, 2012)

Predicting Reading Outcomes with Neuroimaging

- Neuroimaging (70-90%) vs. Behavioral (@ chance, 50%)
 - Greater activation at time 1 in the right frontal region predicted reading improvement 2.5 years later
- More activation of Right IFG at time 1 predicted better reading outcomes



(Hoefl et al., 2010, PNAS)

Reading Development & Disabilities

Definitions & Labels



Identification



Intervention



Classroom

Clinic



Lab

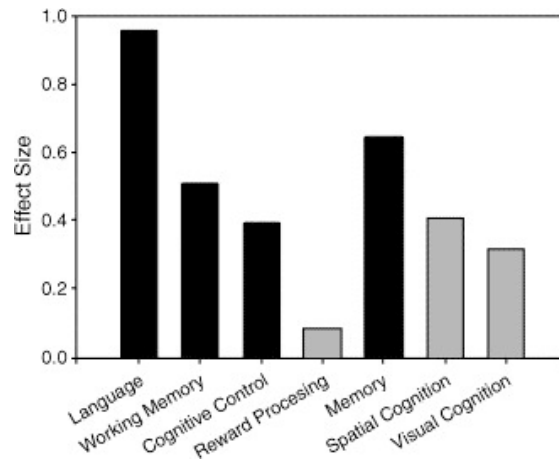
Socioeconomic Status (SES)

“An individual's access to **economic and social resources**, as well as the benefits and **social standing** that come from these resources; often measured by **educational attainment, income, and/or occupation.**”

- Strong predictor of academic achievement and cognitive skill in childhood & throughout life (Bradley & Corwyn, 2002)
 - “Achievement gap” grows with age (Lee & Burkam, 2002)
- Disproportionate effect on language and literacy skills (Noble et al., 2005; Noble et al., 2012)
- Low-income students have a disproportionately higher rate of RD diagnosis (Shifrer et al., 2010; Fluss et al., 2009)

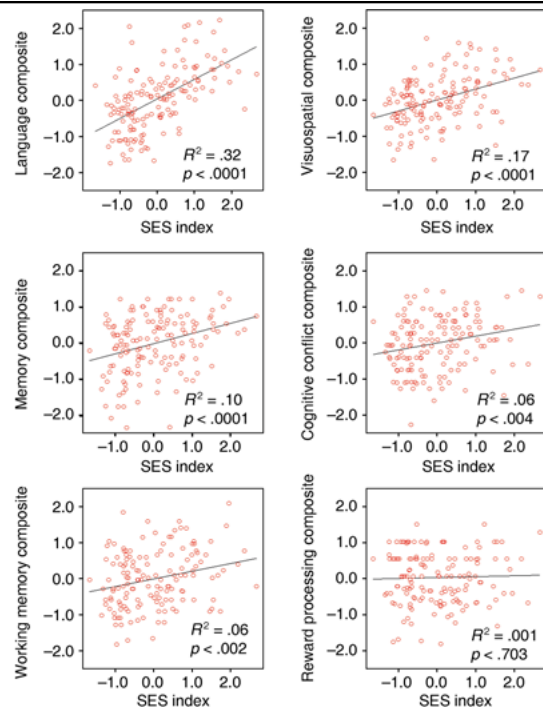
(Romeo, Christodoulou, et al., in prep.)

Childhood poverty: Specific associations with neurocognitive development



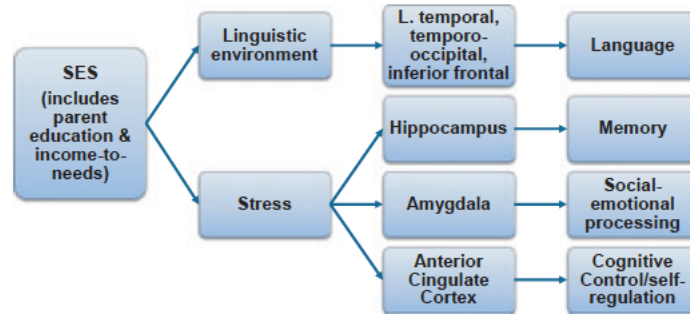
Farah et al., 2006

- SES accounts for variance in all neurocognitive composites except reward processing
- SES accounts for statistically more variance in the language composite than in all other composites



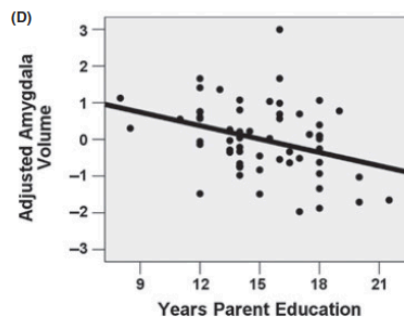
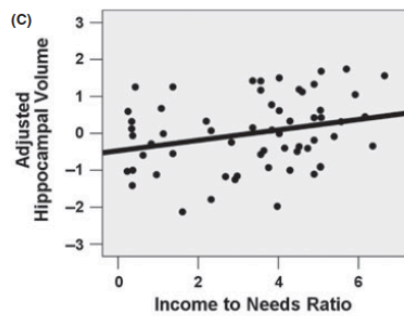
Noble et al., 2007

Hypothesized mechanisms of SES influence



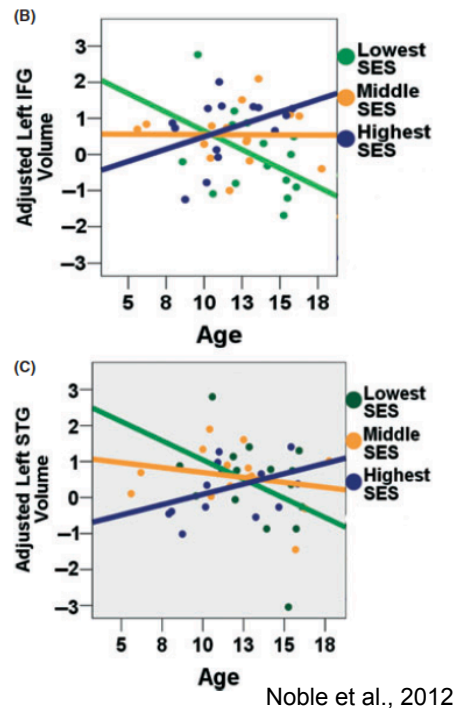
Noble et al., 2012

- Family SES predicts child hippocampus and brain volumes in
 - Hippocampus (memory)
 - Amygdala (socio-emotional processing)
- Stress linked to dev'l of these areas
 - Larger amygdala linked to more stressful environments (less parent education, nurturing)
 - Smaller hippocampus linked to more stress



Noble et al., 2012

- Higher SES associated with protracted pruning, so prolonged plasticity
 - Linked to increased IQ
 - Disparities increase with age



Contributions of Neuroscience

- Brain imaging **can** currently:
 - Continue to inform our understanding of brain plasticity in response to intervention
 - Reveal mechanisms underlying behavioral trajectories
 - Demonstrate brain correlates for behavioral changes
- Brain imaging **has the potential to**:
 - Anticipate who will benefit from which intervention
 - Identify behavioral and brain characteristics predicting response to intervention

Myths & Misconceptions

Neuro-myths

- Brain pictures show what brain areas do reading.
- Dyslexia is caused by brain problems.
- Brain regions are dedicated to specific tasks.

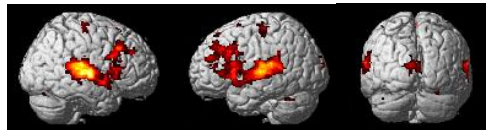
Behavior-myths

- Children with reading disabilities really are just stupid, lazy, or oppositional.
- The trademark of dyslexia is seeing letters reversed, rotated, or backwards.
- Dyslexia goes away with proper remediation.

fMRI Images & Brain Activation

Brain pictures show what brain areas do reading.

- What do the colored areas of brain images show us?

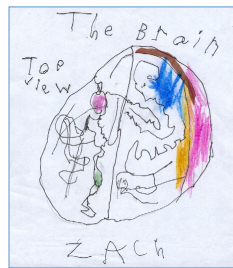


- Choice A. brain activations
- Choice B. blood flow
- Choice C. activation of neurons
- Choice D. radioactivity in the brain
- Choice E. statistical map

fMRI Images & Brain Activation

Brain pictures show what brain areas do reading.

- Zach versus Sam
- Statistics



Hole-Y Readers

Dyslexia is caused by brain problems.

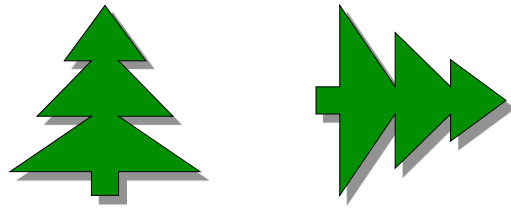
- An individual with dyslexia has ____ brain differences compared to unimpaired readers.
 - A. no
 - B. many
 - C. strange



Brains and Trees

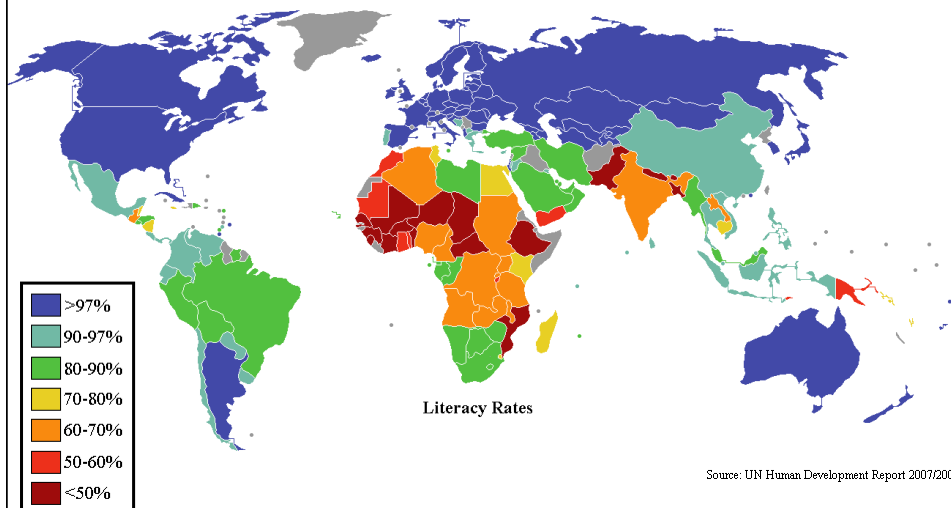
- Does a falling tree make a sound if no one hears it?

- OR



- Does dyslexia exist in non-literate cultures?

Literacy Worldwide



Words in the brain

Brain regions are dedicated to specific tasks.

- Live reading brain
- Brain networks are:
 - Distributed
 - Parallel
 - Heterarchical
 - Modular
 - Dynamic

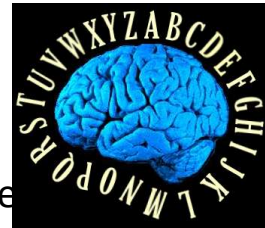


(Rose & Meyers, 2000)

Locus of Attribution for Dyslexia

Children with reading disabilities really are just stupid, lazy, or oppositional.

- Specific learning disability
- “Neurobiological in origin”
- Difficulties in accurate and/or fluent word, spelling, decoding abilities
- Phonological core deficit
- Secondary manifestations



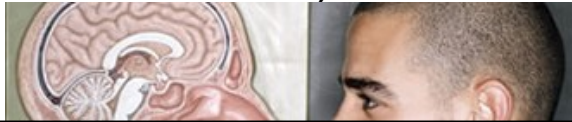
(Lyon, Shaywitz, & Shaywitz, 2003)

Dyslexia's Orientation

Readers with dyslexia see letters backwards.

True or False?

- Children with dyslexia have not been shown to misorder or reverse letters in words differently than younger unimpaired children (Treiman, 1997)
- Some research shows more letter reversals in children from 7–10 years with dyslexia
- Bottom Line: Sometimes, some cases



Dyslexia's Disappearing Act?

*With proper remediation efforts,
dyslexia goes away.*

- “Dyslexia is first reliably diagnosed in primary school (Learning Disabilities Statistics Sheet, 1997)
- *most children* with dyslexia exhibit deficient reading skills throughout adolescence (Felton, 1998; Lyon, 1995)
- most continue to manifest these difficulties throughout adulthood (Felton, Naylor, & Wood, 1990; Vogel & Adelman, 1992).” (Grigorenko, 2001)

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