



Joanna A. Christodoulou, Ed.D.
Assistant Professor
MGH Institute of Health Professions

**Brain Differences and Interventions
for Struggling Readers**

Brain, Education, and Mind (BEAM) Team

- **What:** Research group led by Dr. Christodoulou (Dept. of Communication Sciences and Disorders) @ MGH Institute of Health Professions
- **Where:** Located in Charlestown area of Boston
- **How:** Behavioral assessments & brain imaging
- **Why:** Study factors contributing to reading improvement in individual readers and predicting treatment efficacy for struggling readers
-  Twitter: @BEAMstudies
-  Facebook: @BEAMChristodoulou

Research Context

- **Reading disabilities** are the most commonly identified learning challenge in school-age populations
- Remediation efforts are a significant focus for **educators and clinicians**
- **Effective interventions** can help a struggling reader, whose efforts are consumed by attempts to *access* the text, to use written language as a tool for *understanding* the content
- Impact of **early** intervention is well established



Problem Space

- Individuals differ in profiles and response to treatment
- Selecting programs and predicting individual response to intervention is a major challenge
- Definitions of effective interventions are based on average gains

Education Neuroscience: Next Steps

- Measuring outcome efficacy
 - Standards for intervention efficacy
 - How many people should benefit?
 - How much should people benefit?
 - Who should benefit?
 - How should we measure these outcomes?
 - How long should results last?
 - Maintenance versus acceleration of reading skills

BEAM Team Research Themes

<p>Measuring Intervention Efficacy</p> 	<p>Identifying Compensatory Approaches & Protective Factors</p> 
--	--

Study: Evaluating Summer Intervention

- Every student experiences summer vacation
- What impact do activities during the summer have on reading outcomes?
- What do we know about summer slump for readers?

Evaluating Intervention: Summer

- Comparable gains **during the school year** for students of diverse SES backgrounds

School Year Cumulative Gains

Year	Disadvantaged, by Year	Better-Off, by Year
1	~60	~60
2	~100	~100
3	~140	~140
4	~170	~170
5	~190	~190

Alexander, Entwisle, & Olson, 2007

Evaluating Intervention: Summer

- Significant differences **during the summer** for students of diverse SES backgrounds

Summer Cumulative Gains

Year	Disadvantaged, by Year	Better-Off, by Year
1	~-10	~10
2	~-10	~20
3	~-10	~40
4	~-10	~60

Alexander, Entwisle, & Olson, 2007

Summer Slump: Evidence for Reading

- **Students from low socioeconomic backgrounds**
 - Learn less than their middle- and high-SES peers during the **summer** (Alexander, Entwisle, & Olson, 2007a; Alexander, Entwisle, & Olson, 2007b; Kim & Quinn, 2013)
- **Achievement Gap**
 - ~80% of the achievement difference between high-income and low-income students may be attributable to summer reading loss (Hayes & Grether, 1983)

Summer Slump: Evidence for Reading


- **General student population**
 - Indirect investigations of the summer lag have shown higher gains from fall to spring (academic year) than during spring to spring (full year) time periods (Borman & D'Agostino, 1996)
- **Students who are struggling readers**
 - ?

Measuring Intervention Efficacy

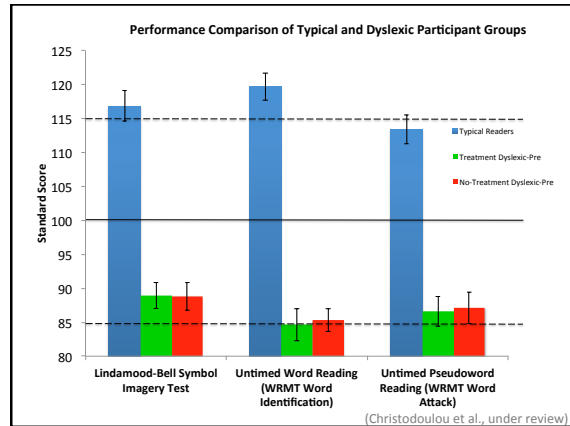
- What is the impact of intervention for young struggling readers during the summer on reading?

Summer Time Adventures in Reading & Teaching (START Study)

- 77 Students
 - Ages 6-9
 - Completing grade 1 or 2
- Recruited from community
- Reader Groups
 - Typically Developing Readers
 - Struggling Readers
 - Treatment Group
 - No-Treatment Group



(Christodoulou et al., under review)



Summer Time Adventures in Reading & Teaching (START Study)

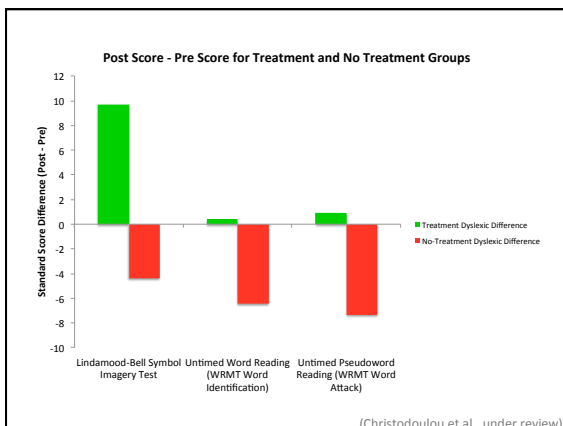
- Treatment Group
- Instruction: 4 hours x 5 days x 6 weeks
 - Minimum of 100 hours
 - Academic summer months
 - Groups of 3-5 children
 - Lindamood-Bell teaching staff
- Program: Lindamood-Bell Seeing Stars



(Christodoulou et al., under review)

Seeing Stars: Symbol Imagery for Fluency, Orthography, Sight Words, and Spelling

- Orthographic and visual processing training, and consequently phonological training
- Visualize
 - Letters
 - Syllables
 - Words
 - Connected text
 - Semantic information



Converging Evidence for Program Efficacy

- Previous research on Seeing Stars
 - School year investigations
 - Treatment groups showed relative word level benefits
 - Untimed real word reading
 - Untimed pseudoword reading

(Krafnick et al., 2010; Olulade et al., 2013)
- Current summer study
 - Treatment group showed relative word level benefits
 - Untimed real word reading (Tx no change, No-Tx decline)
 - Untimed pseudoword reading (Tx no change, No-Tx decline)

(Christodoulou et al., under review)




Study Findings

- Direct evidence for widening differences between students with reading difficulties who do and do not receive intensive summer reading instruction
- Convergence with studies of other vulnerable student populations for summer reading outcomes

(Christodoulou et al., under review)

Implications for Education: Summer Reading Intervention in Struggling Readers

- Inform our definition of a successful intervention
- Prevention of academic summer regression
- Improvement of outcomes

Summer Slump Evidence for Reading

- Implications & Next Steps
 - Closing the gap
 - Answering: For whom should we do what?
 - Maintaining Skills vs Accelerating Growth
 - Readers require sustained instructional support across early elementary grades to maintain reading gains acquired from 1st grade (Connor et al., 2013)
- Evaluate impact of intervention across SES

(Christodoulou et al., under review)

Prediction and Intervention

- Identification estimates imprecise
 - Current practices over- and under- estimate who struggles to read (Gabrieli, 2009)
- Prospects for struggling readers vary
 - (88% remained poor readers from grade 1 to 4, Juel, 1988)
- Estimates of intervention efficacy vary (Snow et al., 1998)

Can neuroprediction be informative?

- Life-Style
 - 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)
- Reading
 - Reading performance in teenagers over a 2.5 year period is robustly predicted with neuroimaging data but at chance for behavioral measures (Hoefft et al., 2010)

Predicting Reading Outcomes with Neuroimaging

- 25 children with dyslexia
- 20 typical readers
- Predict reading over time: age 14→16.5
- fMRI Rhyme task

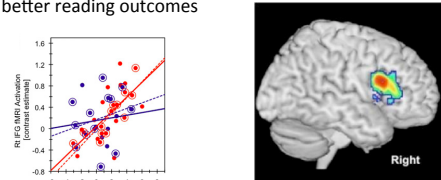
bait
gate

price
miss

(Hoefft et al., 2010)

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 Frontal Region at time 1 predicted better reading outcomes



(Hoeltt et al., 2010)

Study: Predicting response to reading intervention

- Goal
 - Can we use neuroimaging tools to improve our ability to **predict which children will benefit from which intervention?**
- Current Approach
 - Choose 1 program
 - Evaluate brain-behavior links for individuals

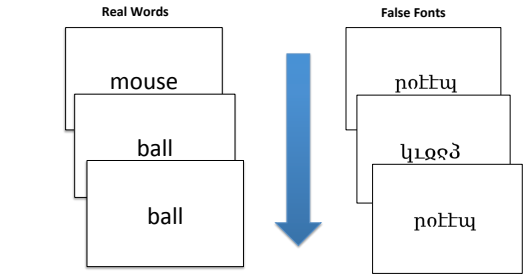


(Christodoulou et al., in prep.)

Functional Magnetic Resonance Imaging



fMRI Reading Task

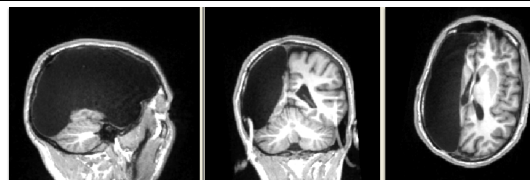


Push Button to indicate match when identical items are presented in a row

Study Findings

- Focus on the compensatory regions
 - Treatment group with dyslexia improvement in reading linked to **less** reliance on compensatory system
 - Findings contrast results from teenage readers brain systems
- Implications
 - Effective and early treatment may relieve reliance on compensatory mechanisms for reading

Study: Obligatory Compensation in Hemispherectomy



- **Prevalence:** 16-20% of all epilepsy resections in the US
- **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?

(Christodoulou et al., in prep.)

Language Lateralization

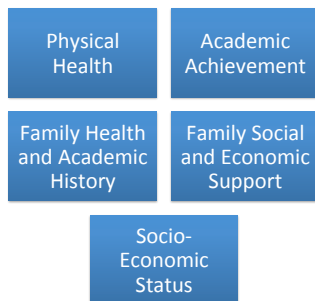
- More than half a century established that the left hemisphere is dominant for most language functions.
- Recently, there is a theoretical shift into the understanding of language as a result of interplay between the two hemispheres.
- The right hemisphere involvement is also well-documented in developmental disorders of reading, where right hemisphere recruitment is associated with compensation.

(Temple et al., 2003, Shaywitz, 2008)

Reading in the Right Hemisphere

- The isolated Right Hemisphere has potential to support reading
- Informs Compensation versus Remediation
- Informs mechanisms underlying reading

Study: Investigating factors in a socio-cultural context



(Mancilla-Martinez, Christodoulou, Shabaker, 2013)

Contributions of Early Factors

- Cumulative risk negatively impacts initial vocabulary level and interacts with language proficiency
- Individual factors can serve as risk-inducing or protective
 - Risk: single parent, limited parent English
 - Protective: multiple families in home

(Mancilla-Martinez, Christodoulou, Shabaker, 2013)

Study: Evaluating Intervention Individualization & Efficacy

- School & Research Collaboration
- Challenge:
 - Can reading progress be optimized by addressing cognitive challenges?
- Goals:
 - How do cognitive abilities relate to reading?
 - Can targeted cognitive training improve reading?



Design

- In-school intervention
 - Baseline
 - Pre-test
 - Intervention
 - Post-test
- Training content: Cognitive skills
- Participants: 51 students in 8th grade

Education Implications & Next Steps



- For interventions that are successful on average, how many children benefit? How many lose ground?
- Next steps
 - Randomized control trial to evaluate intervention efficacy
 - Exploring opportunities to enhance reading outcomes
 - Examining individualization of instructional programs
 - Integrate neuroimaging component

BEAM Team Research Contributions

Intervention and Compensation: Implications & Next Steps for Education Neuroscience

- Summers are an opportunity for intervention critical for struggling readers
- Summer intervention efficacy may present as absence of decline rather than presence of growth in reading skills
- Effective and early treatment may relieve reliance on compensatory mechanisms for reading
- The right hemisphere can support reading, with potentially unique strategies
- Understanding children's socio-cultural context enhances our characterization of risk and protective factors



-  Twitter: @BEAMstudies
-  Facebook: @BEAMChristodoulou
- Email: beamstudies@gmail.com
- Resources: <http://scholar.harvard.edu/joanna>