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Learning for SUCCESS
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The Texas Center for Learning Disabilities (TCLD) investigates the classification, neurobiology, early intervention, and remediation of learning disabilities.

Enhancing Reading Outcomes: RTI and the Brain

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Disclosures

- 1. Co-Author of Texas Primary Reading Inventory (Paul F. Brookes)
- 2. Co-Author of Learning Disabilities: From identification to Intervention
- 3. Research supported by NICHD grant, P50 HD052117, Texas Center for Learning Disabilities
- 4. Father of 2 “grown” children

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Dyslexia, Reading, and and Neural Plasticity

- Reading is not a natural process and is not constructed as a result of simple exposure to language or words (Liberman)
- Good reading instruction is always brain-based and involved in the development of reading proficiency and in dyslexia, a word level reading problem
- The process of learning to read *rewrites* the organization of the brain (Eden), which varies depending on the structure and transparency of the language (Zigler)
- **What is the relation of reading instruction and brain structure and function?**
- **Compensatory or normalizing changes?**

New Alternatives: Instructional Models of LD

- Universal screening and serial curriculum-based assessments of learning in relation to instruction
- Dynamic recursive model that continually corrects status model errors
- As one criterion, student may be LD if they do not respond to instruction that works with most students (i.e., unexpected underachievement) (IDEA 2004)
- May identify a unique subgroup of underachievers that reflects an underlying classification that can be validated Implemented with a multi- tiered intervention model that integrates general and special ed
- School-wide change- not just enhanced pre-referral services

Linking Prevention and Remediation: A 3-Tier Model

If progress is inadequate, move to next level.

Tier 1: Primary Intervention

Enhanced general education classroom instruction for all students.

Tier 2: Secondary Intervention

More intense intervention in general education, usually in small groups.

Tier 3: Tertiary Intervention .

Intervention increases in intensity and duration. Child could be considered for special education

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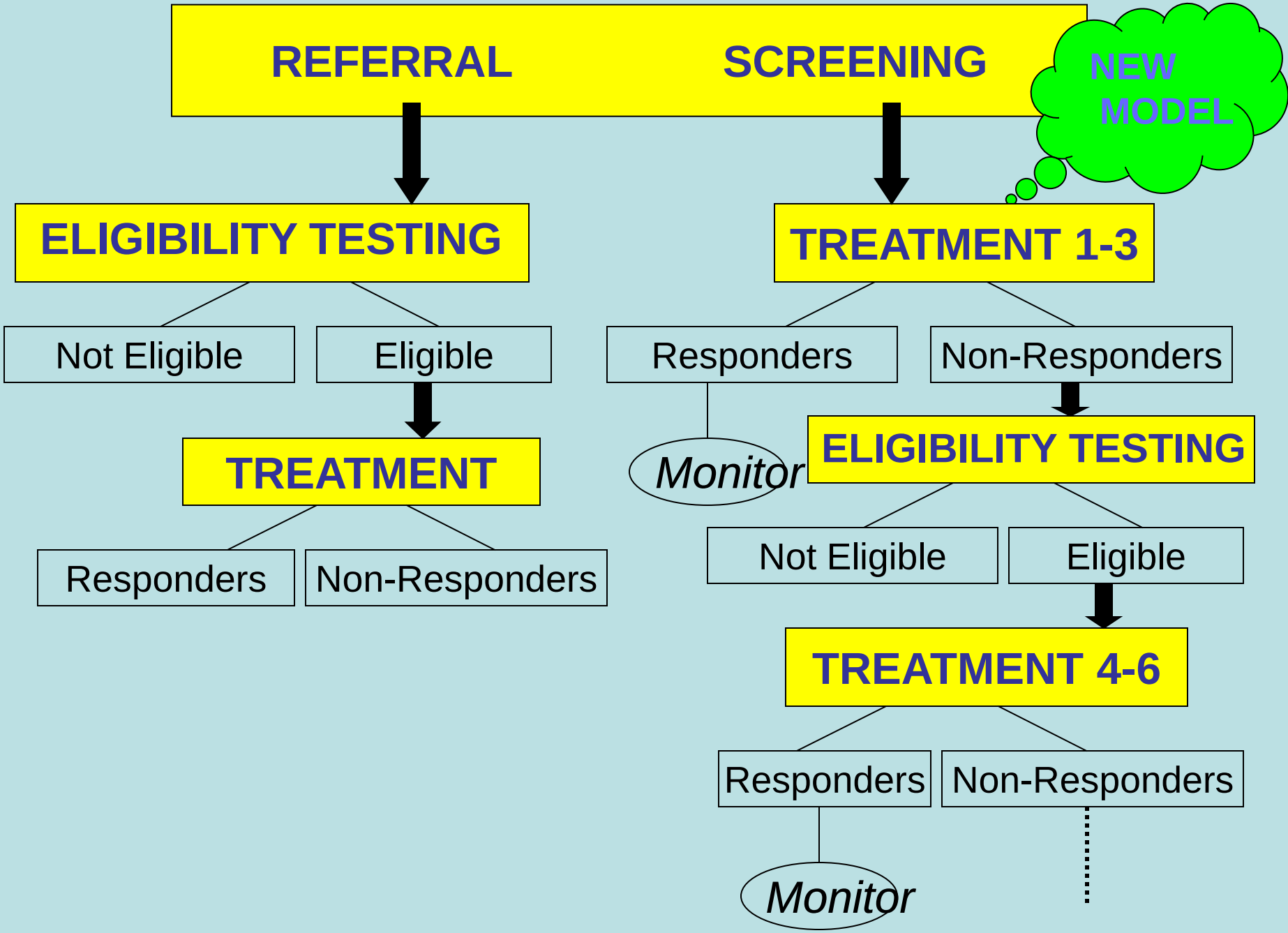
REFERRAL
SCREENING
NEW MODEL
ELIGIBILITY TESTING
TREATMENT 1-3
Not Eligible
Eligible
Responders
Non-Responders
TREATMENT
Monitor
ELIGIBILITY TESTING
Responders
Non-Responders
Not Eligible
Eligible
TREATMENT 4-6
Responders
Non-Responders
Monitor

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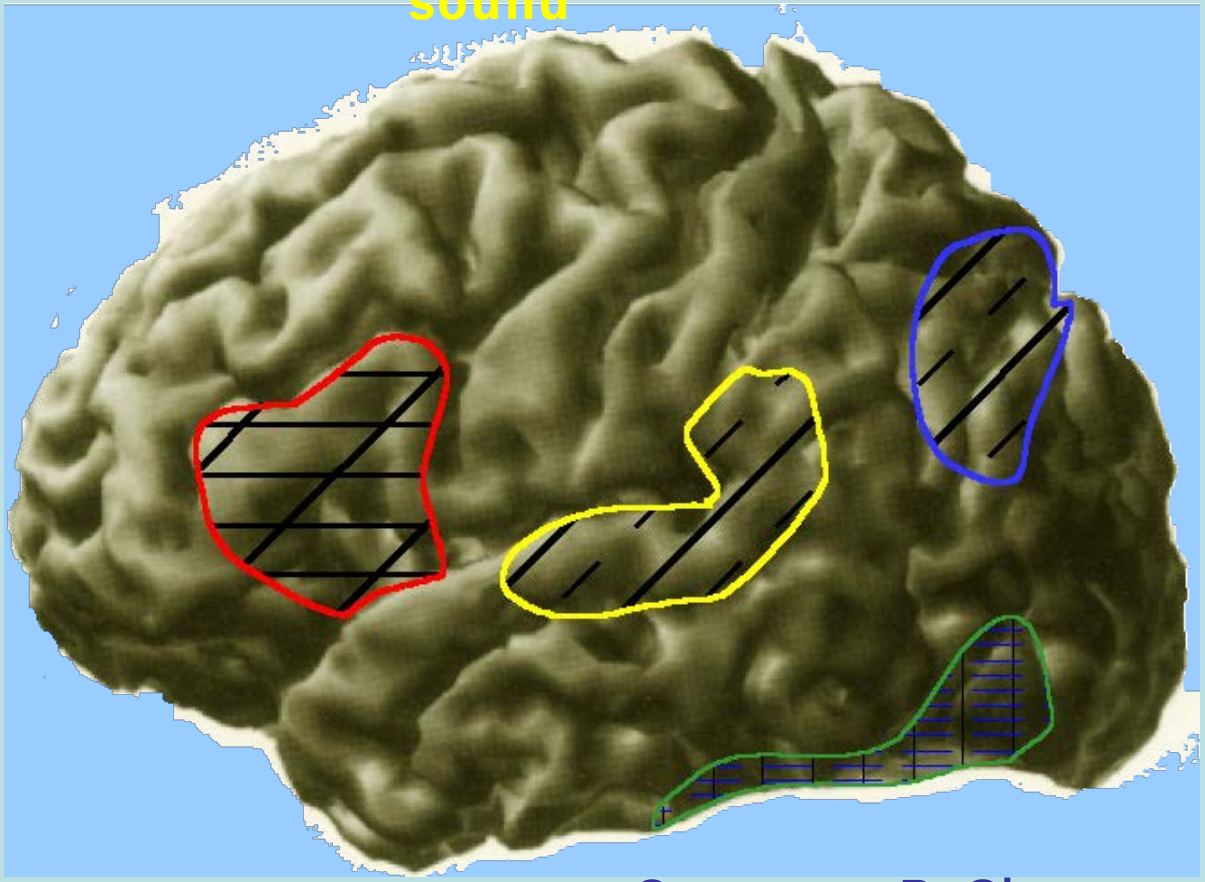
Functional and Structural Neuroimaging

Children's Learning Institute, U of Texas Health Science Center- Houston (A.C. Papanicolaou, P.G. Simos, Jenifer Juranek, Roozbeh Rezaie)

A Model for the Brain Circuit for Reading (Component Processes)

Phonological processing: correspondence between letter and sound

Phonological processing: articulatory mapping



Relay station; Cross-modal integration

Graphemic analysis; word forms/ orthograph patterns

Courtesy P. Simos

Brain Structure: Overview

- Brains of children with LD are visibly normal
- Postmortem studies: Cortical ectopias and microdysgenesis (anomalies of cell migration) bilaterally, but more in the left perisylvian region; thalamus, lateral geniculate, cerebellum
- Structural neuroimaging studies were not dramatic, but new generation emerging
- Small, heterogeneous sample- results not persuasive

Distribution of Cortical Ectopias (Rosen)

Left

Right

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Structural MRI

- Voxel-Based Morphometry (size of different brain regions through counts of voxels in anatomically defined regions)
- Diffusion Tensor Imaging (integrity and connectivity based on diffusivity of water molecules)
- Both methods now highly sophisticated, semi-automated, with increasing precise and rapid acquisition: New studies emerging

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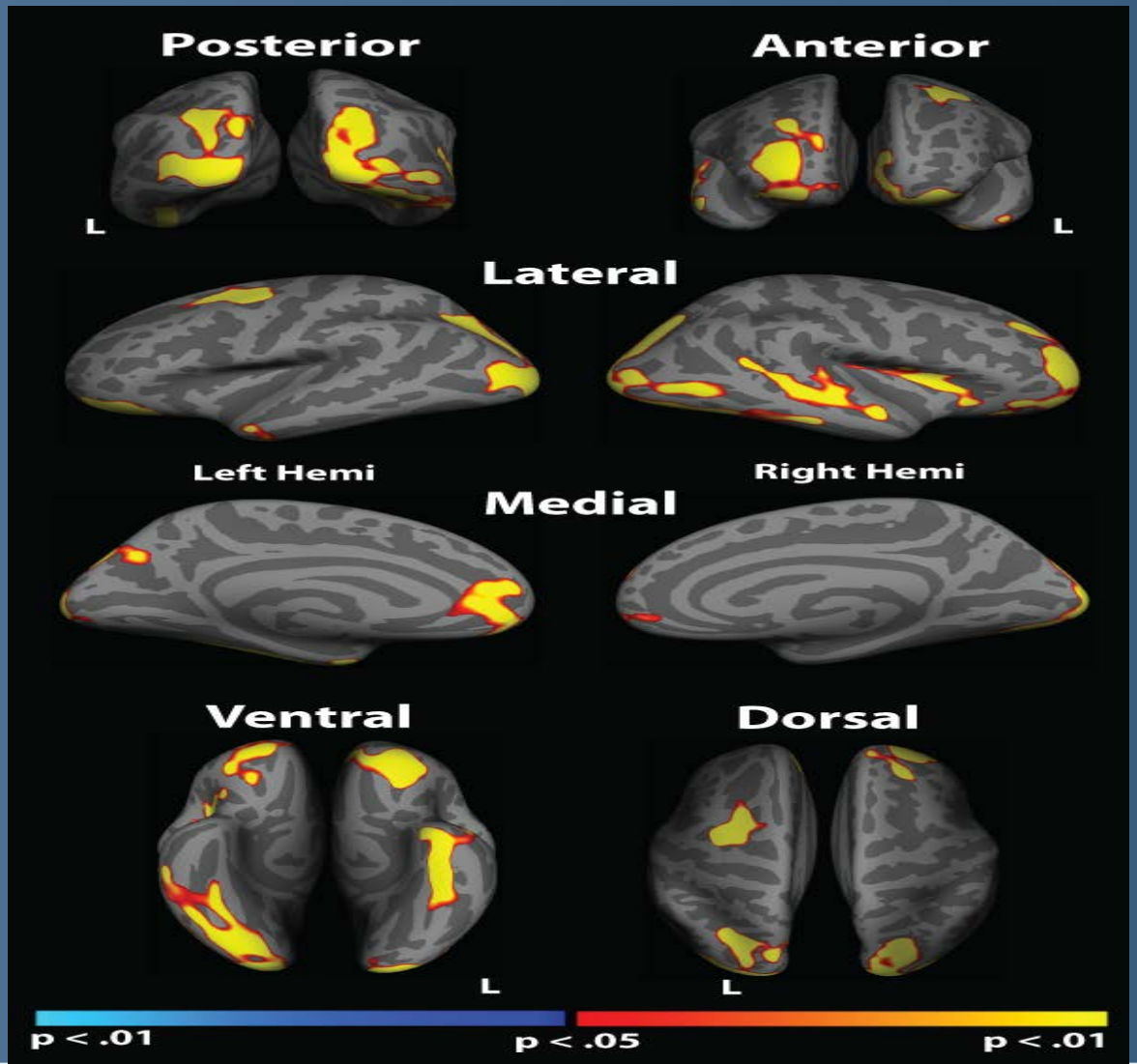
Differences in Cortical Thickness at Baseline (Typical > Dyslexic; Freesurfer) in Adolescents



Fernandez et al. Cerebellum (Adolescents)

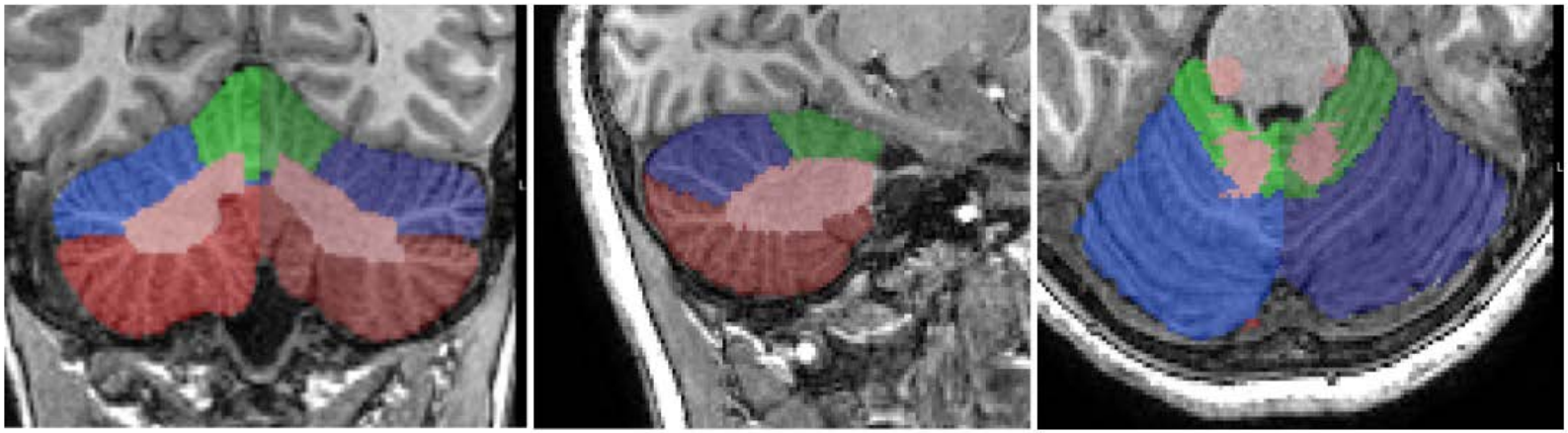
Figure 1a-c

Parcellation Units

1a: Coronal plane

1b: Sagittal plane

1c: Axial plane



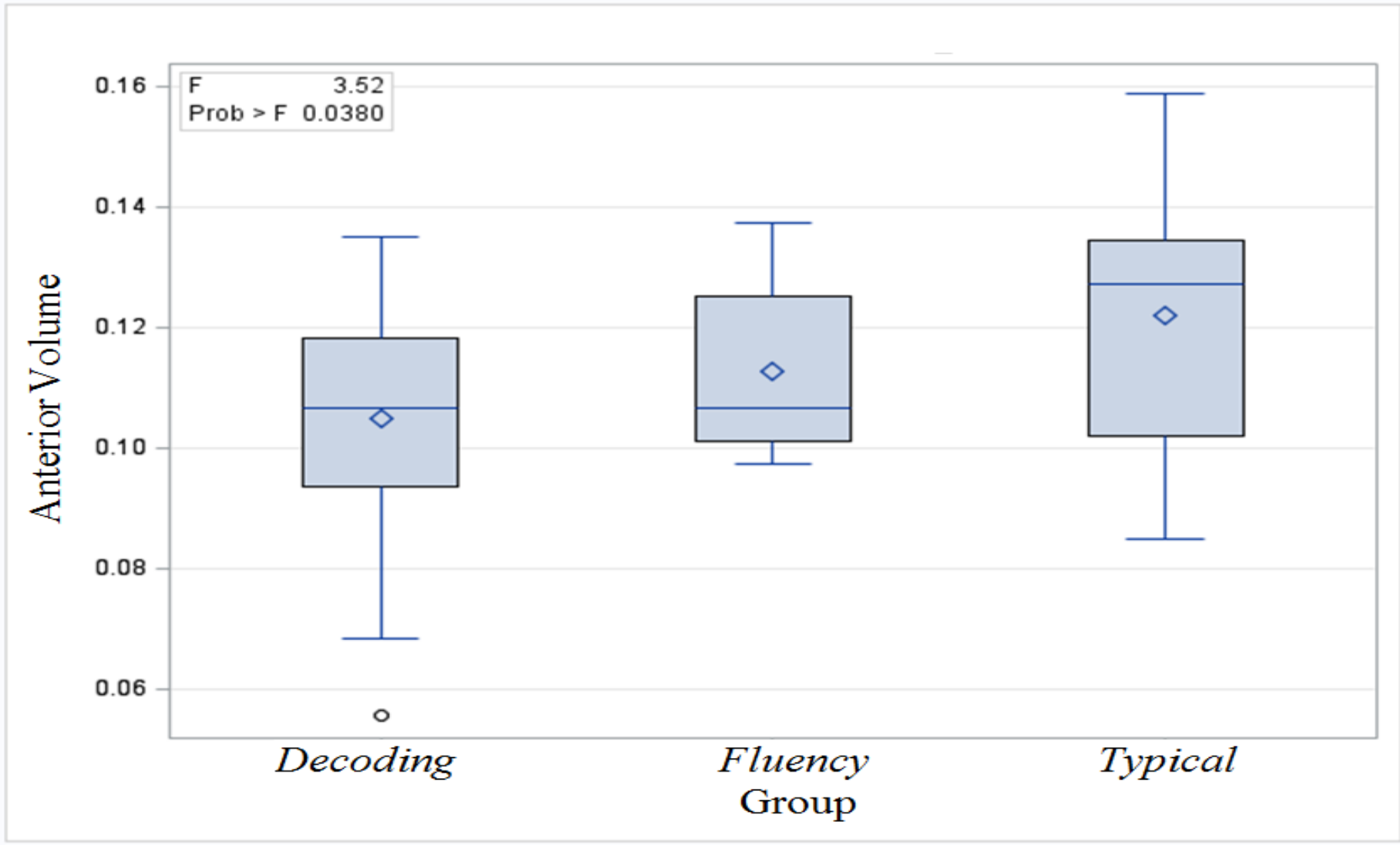
Anterior Lobe

Posterior/Superior Lobe

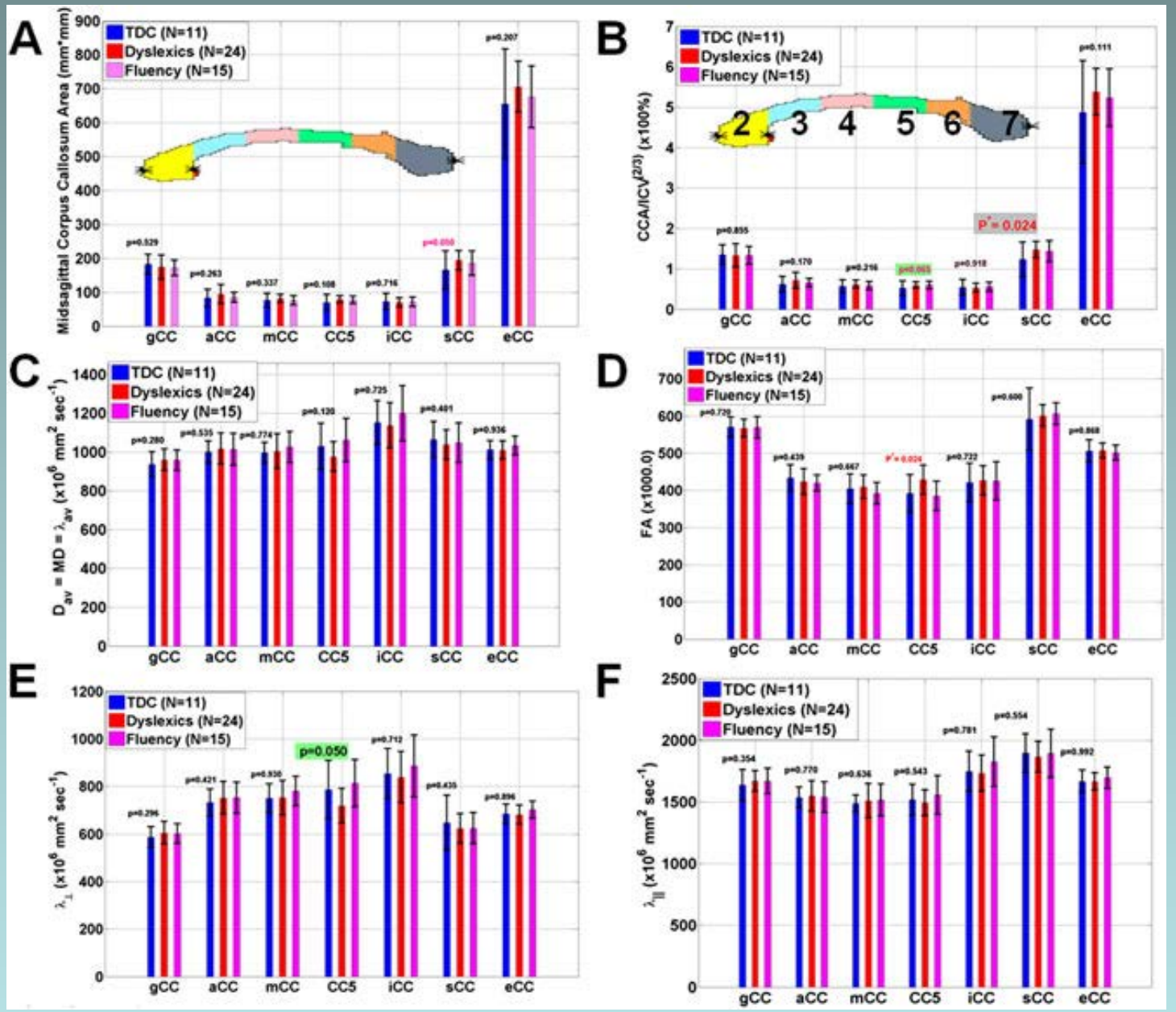
Posterior/Inferior Lobe

Corpus Medullare

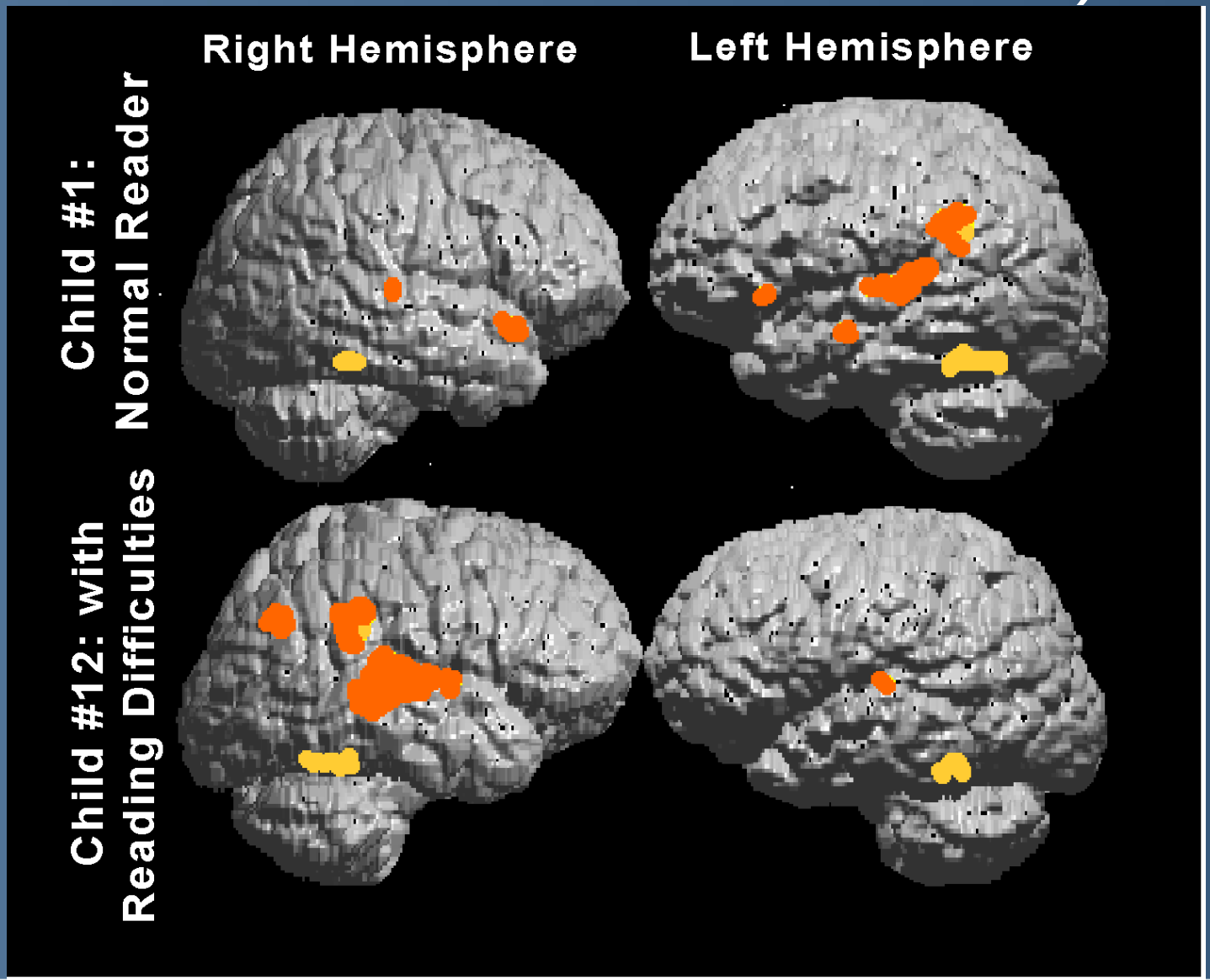
Differences in Anterior Cerebellum Volumes by Group



Hasan et al., NMR Biomedicine, 2012



Brain Function in Dyslexia (Simos et al., 2001; Pseudowords)



Neural Response to Intensive Intervention

Does the pattern of brain activation change in response to intervention?

8 children with severe dyslexia

8 week intense phonologically- based intervention (2 hours a day= up to 80 hours of instruction)

Simos et al., *Neurology*, 2002

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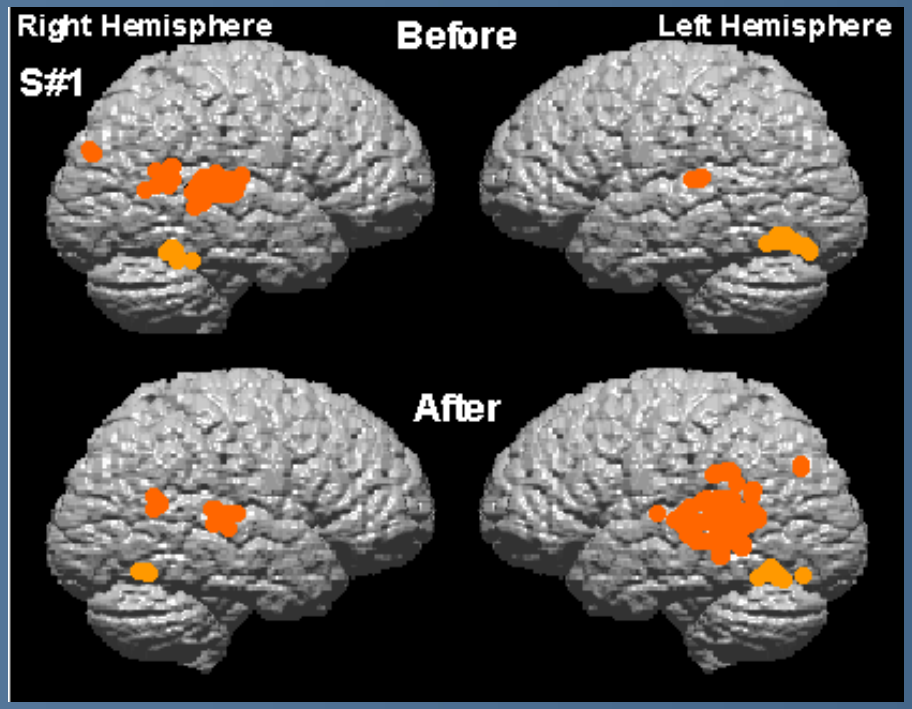
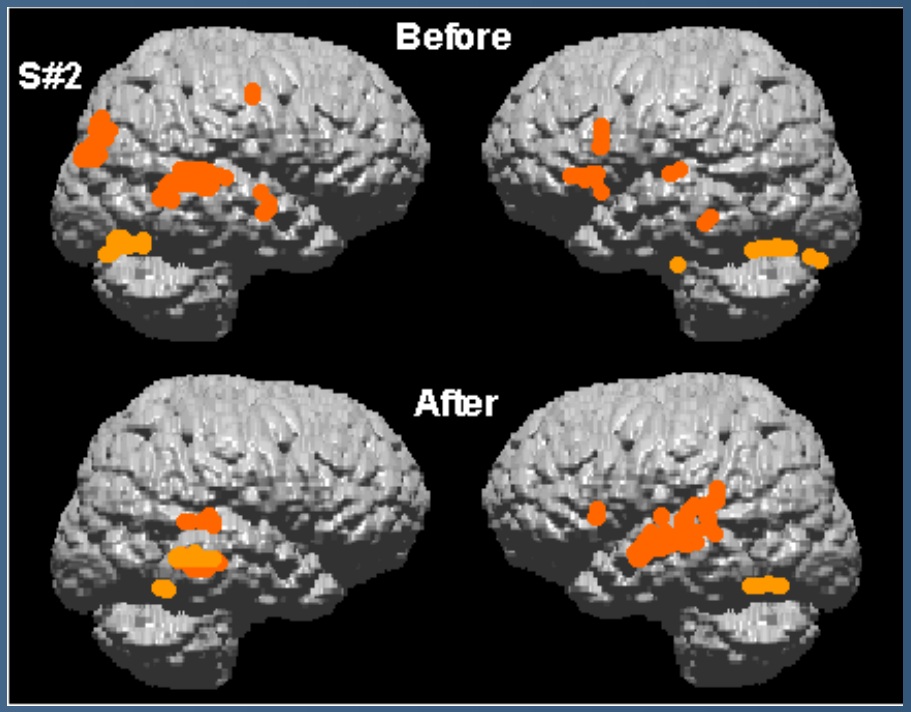
Neural response to intervention; (Pseudoword Task; Simos et al., 2002)





Demographic Information

Child	Gender	Age (years/mo)	WJ-III pre (%)	WJ-III post (%)	IQ	Medication
1	M	15	13	55	103	Adderall
2	M	10	2	59	95	Ritalin
3	M	10	2	38	110	Ritalin
4	F	8	3	55	105	Ritalin
5	F	7	2	50	110	Ritalin
6	M	7	18	60	101	__
7	M	11	1	38	98	Ritalin
8	M	17	1	45	102	__

Early Development of Reading Skills: A Cognitive Neuroscience Approach (Jack M. Fletcher – PI)

Grade 1 Multi-tiered Intervention

Patricia Mathes and Carolyn Denton **Early Reading Intervention (Mathes et al., RRQ, 2005; Denton et al., 2006, JLD)**

A. Papanicolaou, P. Simos: **Brain Activation Patterns (Simos et al., Neuropsychology, 2005; 2007; JLD, 2007)**

The Core Sample

Children – two Grade 1 cohorts sampled across 2 years (2001- 2002)

- 300 At-Risk Readers - assigned randomly to intervention in Grade 1 (2 small group tutorial, one Enhanced Classroom Intervention); all programs in each school
- 100 Low Risk Readers

Teachers

- 6 Intervention Teachers; 30 General Education 1st-grade Teachers

Schools

- 6 elementary schools in a large urban school district

Comparison of Pullout Interventions

- **40 minutes, 5 days per week, for 30 weeks**
- **1:3 teacher-student ratio**
- **Taught by certified teachers: school employees supervised and trained by our group**
- **Supplemented enhanced classroom instruction**

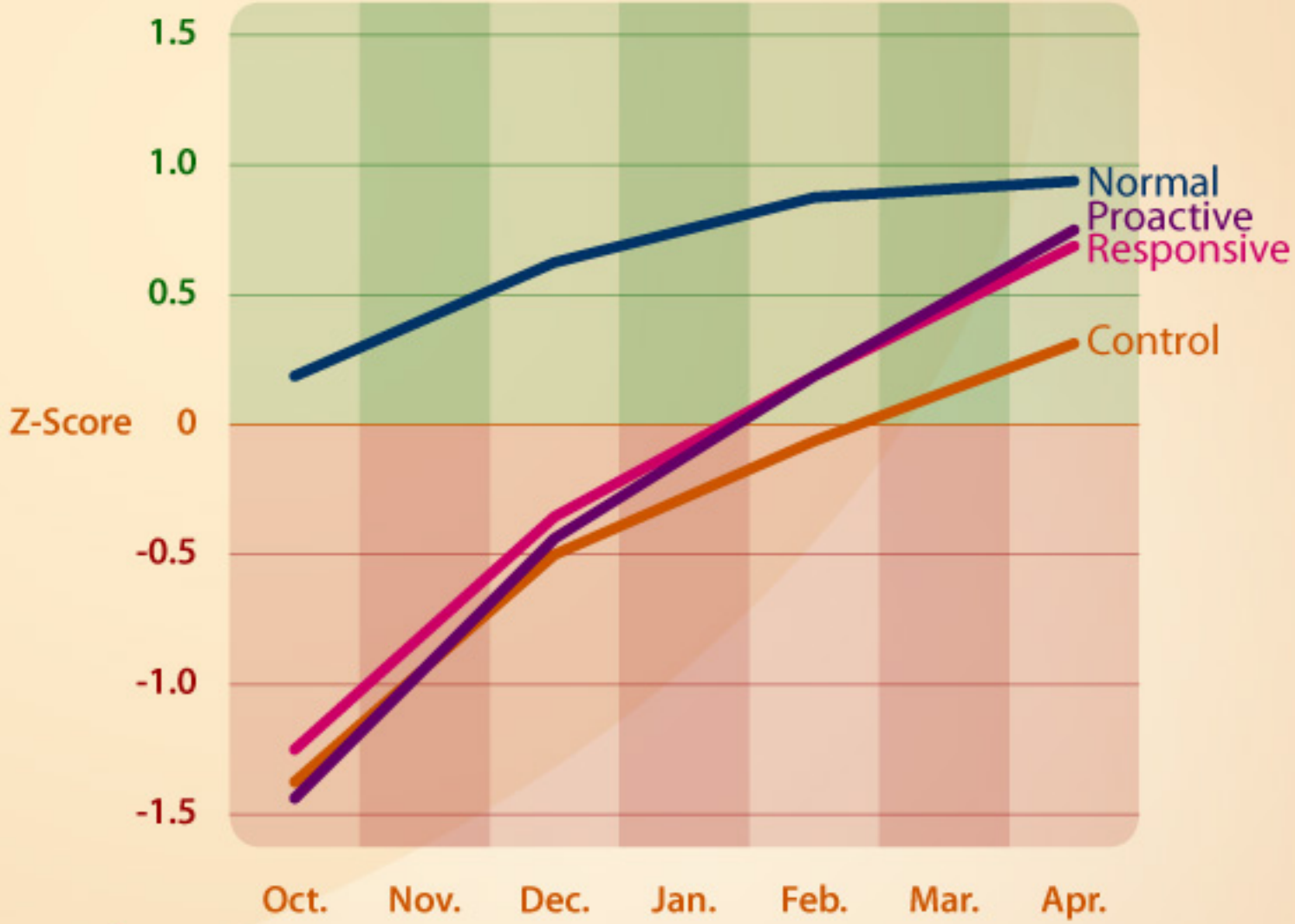
Intervention 1 (Proactive; Mathes)

- Explicit, manualized instruction in the alphabetic principle, with fluency emphasis
- Integrates decoding, fluency, and comprehension strategies.
- 100% decodable text
- Carefully constructed scope and sequence designed to prevent possible confusions.
- Every activity taught to 100% mastery everyday.

Intervention 2 (Responsive; Denton)

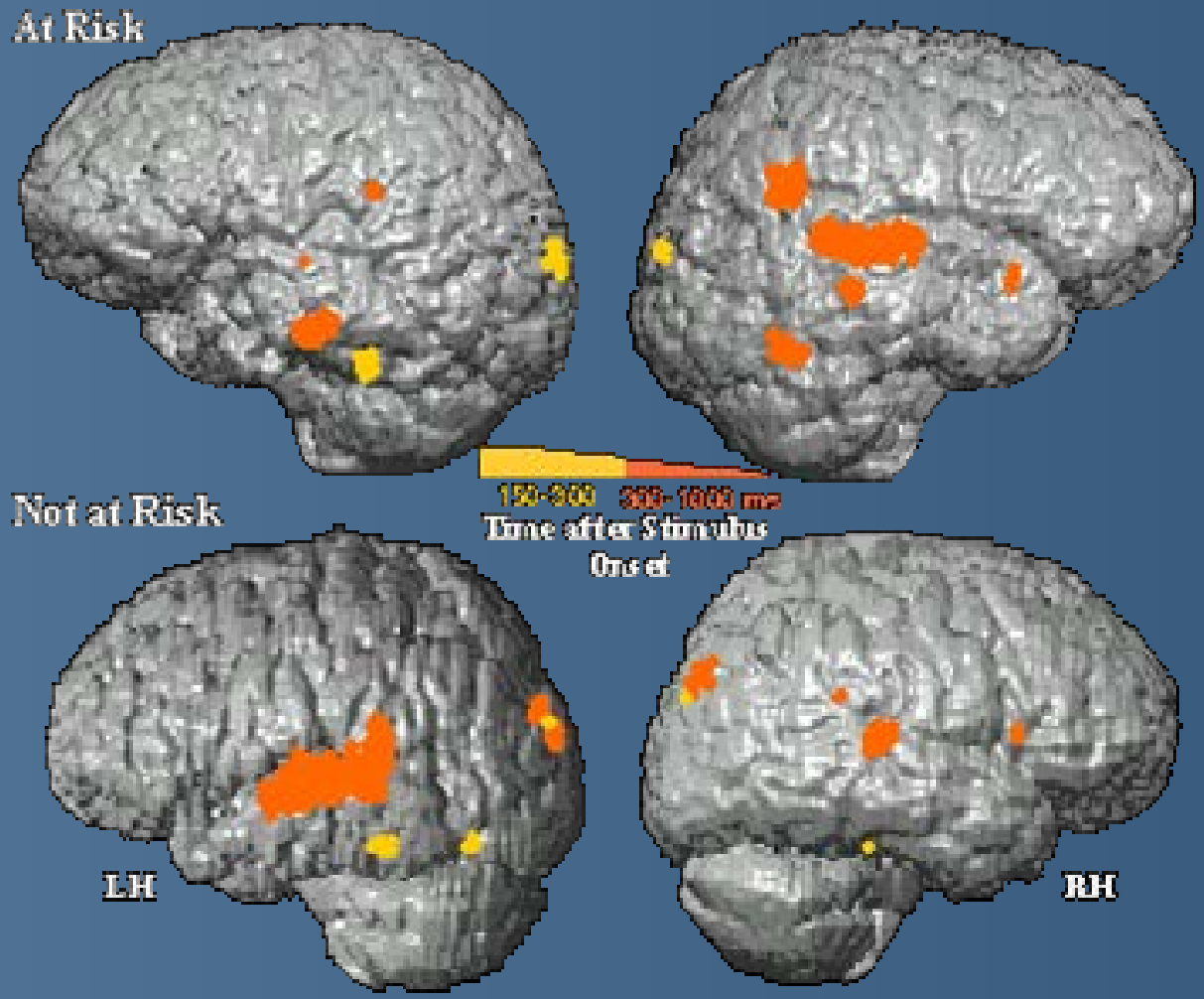
- Explicit instruction in synthetic phonics and in analogy phonics
- Teaches decoding, using the alphabetic principle, fluency, and comprehension strategies in the context of reading and writing
- No pre-determined scope and sequence (activity book, not manual)
- Teachers respond to student needs as they are observed.
- Leveled text not phonetically decodable

Growth in Fluency by Intervention



ScaleUP

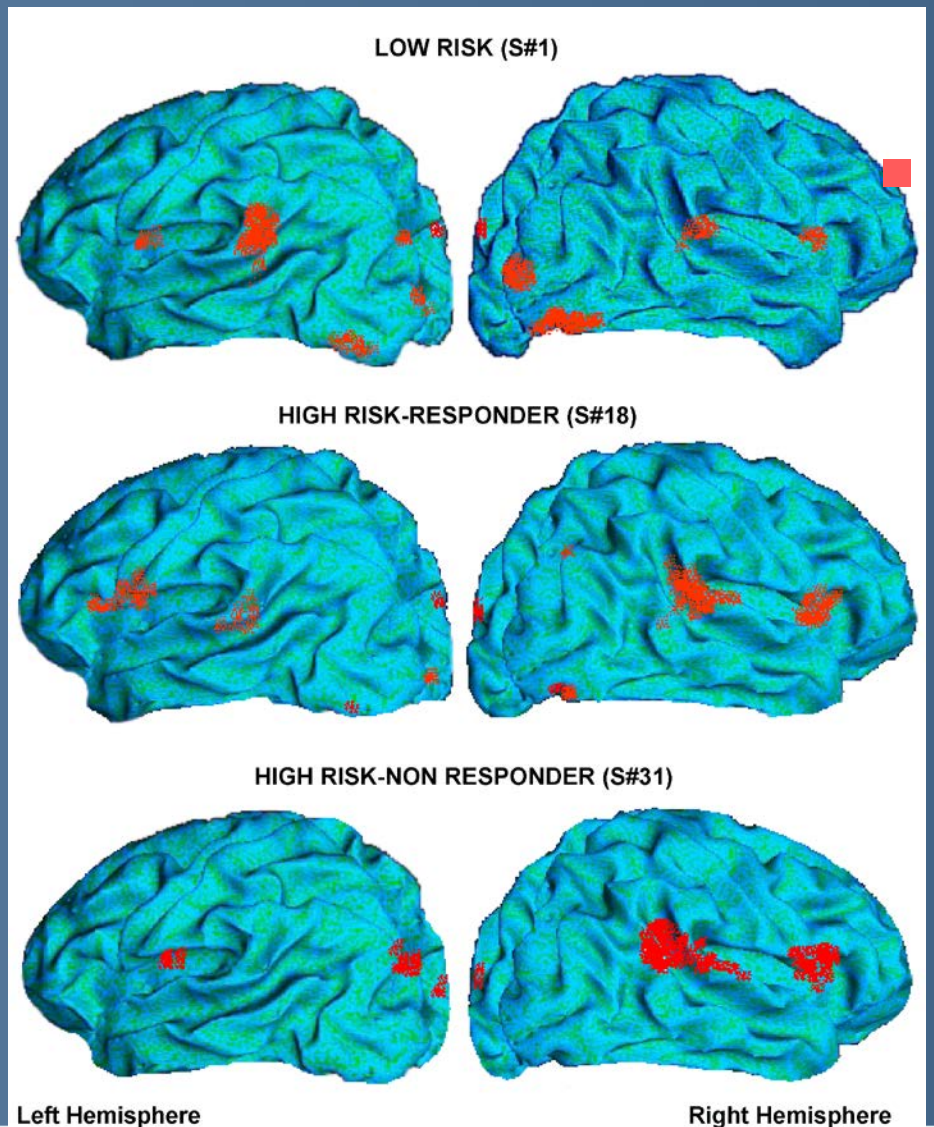
Brain Activation Profiles Before Intervention (end K) (letter sound task)



N= 45 children 6 yrs old

Simos et al., J Child Neural, 2002

Grade 1 Intervention (pseudoword task)



- Simos et al (Neuropsychology, 2005)- after Grade 1 intervention in Mathes et al. (RRQ, 2005)

What percentage of children don't respond adequately to quality intervention?

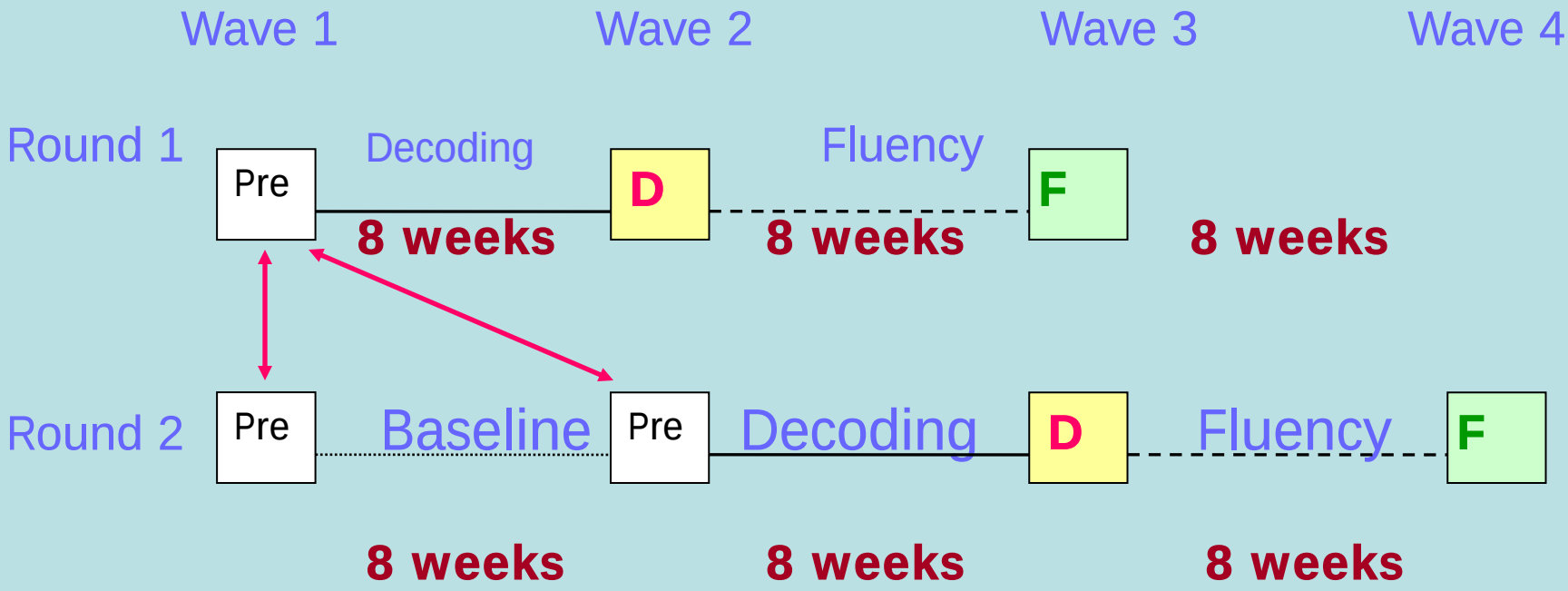
ECI only: 15/92 = 16% (3.2% of school population)

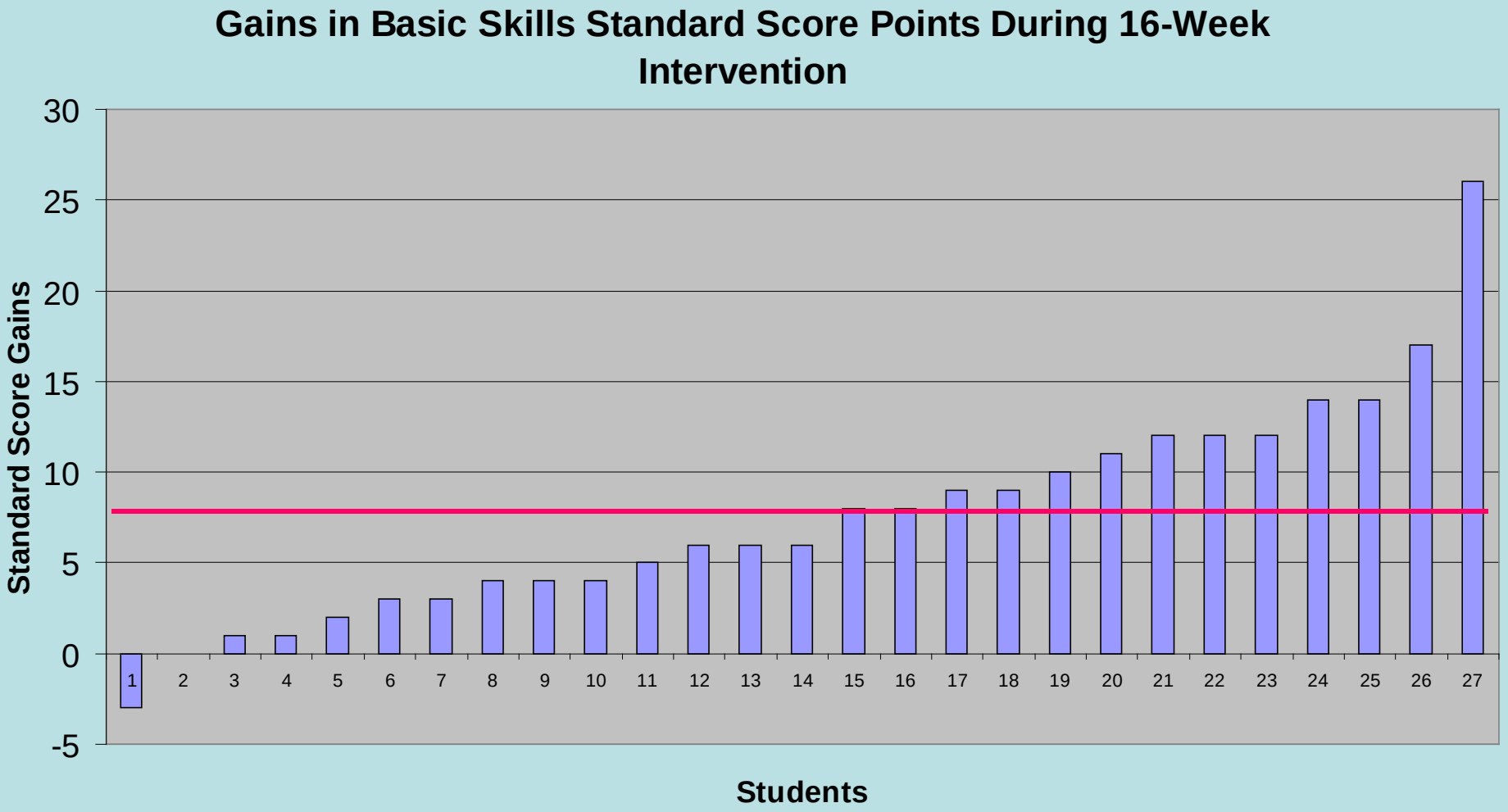
ECI + Tutoring:

- **7/163 = 4% (<1% of school population)**

(Basic Reading < 30th percentile) (5 others did not meet fluency benchmarks)

Tier III Design (Denton et al., JLD, 2006)





(Denton et al., JLD, 2006)

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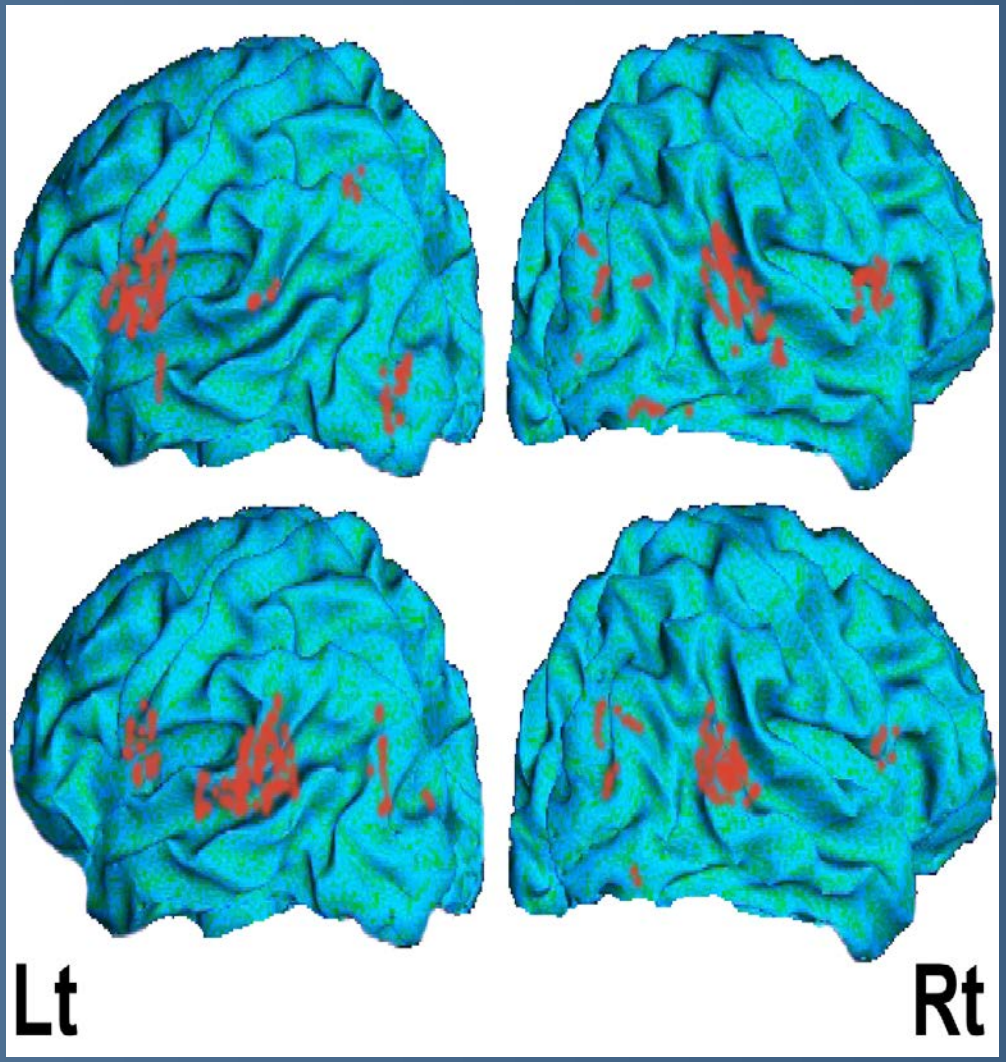
Response to Tertiary Instruction Simos et al., JLD, 2007)



Blachman, Schatschneider, Fletcher, Shaywitz, Shaywitz- J Ed Psych, 2004

Effects of intensive reading intervention emphasizing phonologic and orthographic connections on the functional organization of the brain in Grades 2/3 children with RD randomly assigned to intervention or standard practice

INTERVENTION

Each lesson is built around a 5-step core that includes:

(1) Review of sound-symbol associations

(2) Practice making words to develop a new decoding skill (e.g., work on building words with the final “e” pattern)

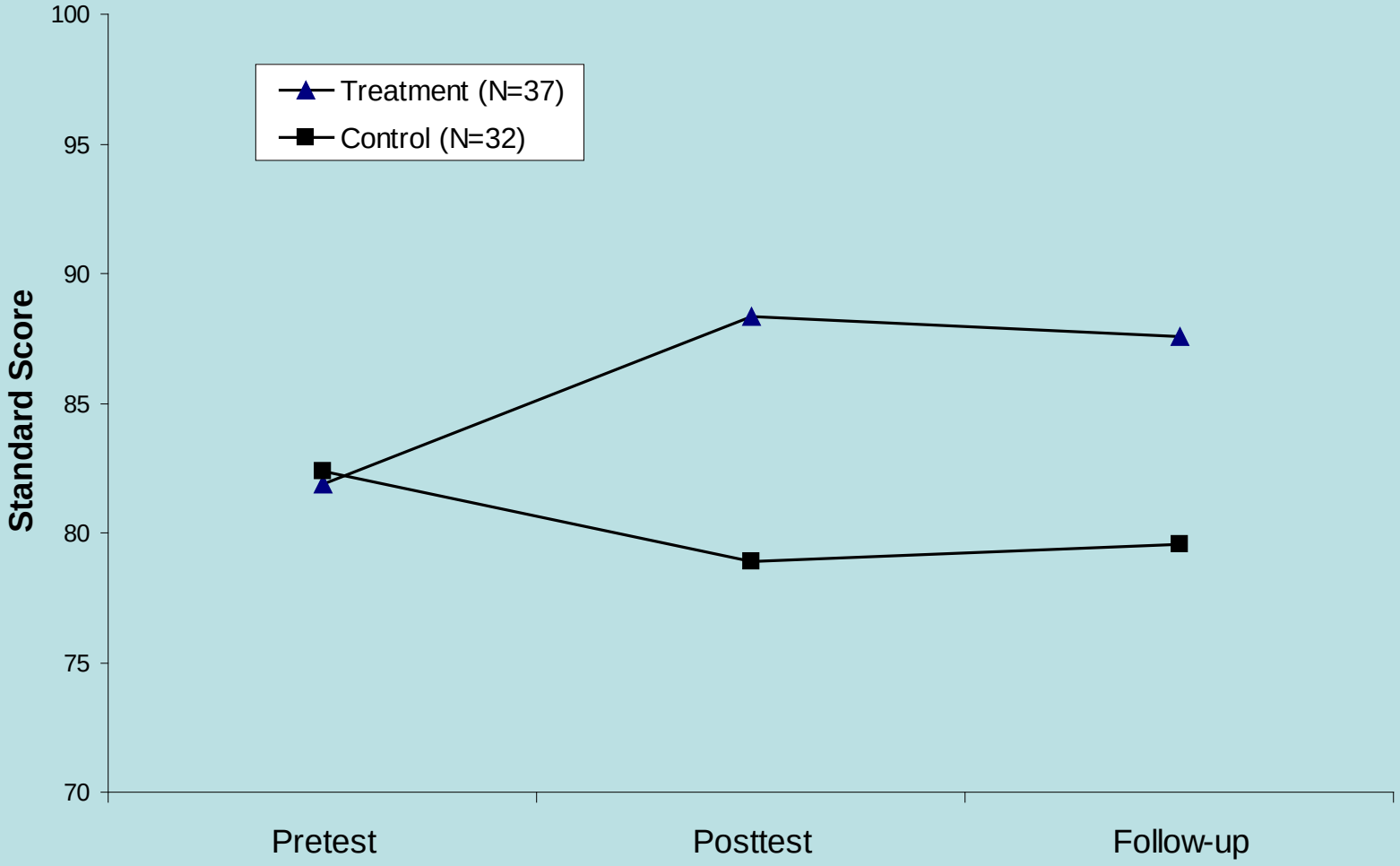
(3) Review of previously learned phonetically regular words and high frequency sight words

(4) Oral reading of stories

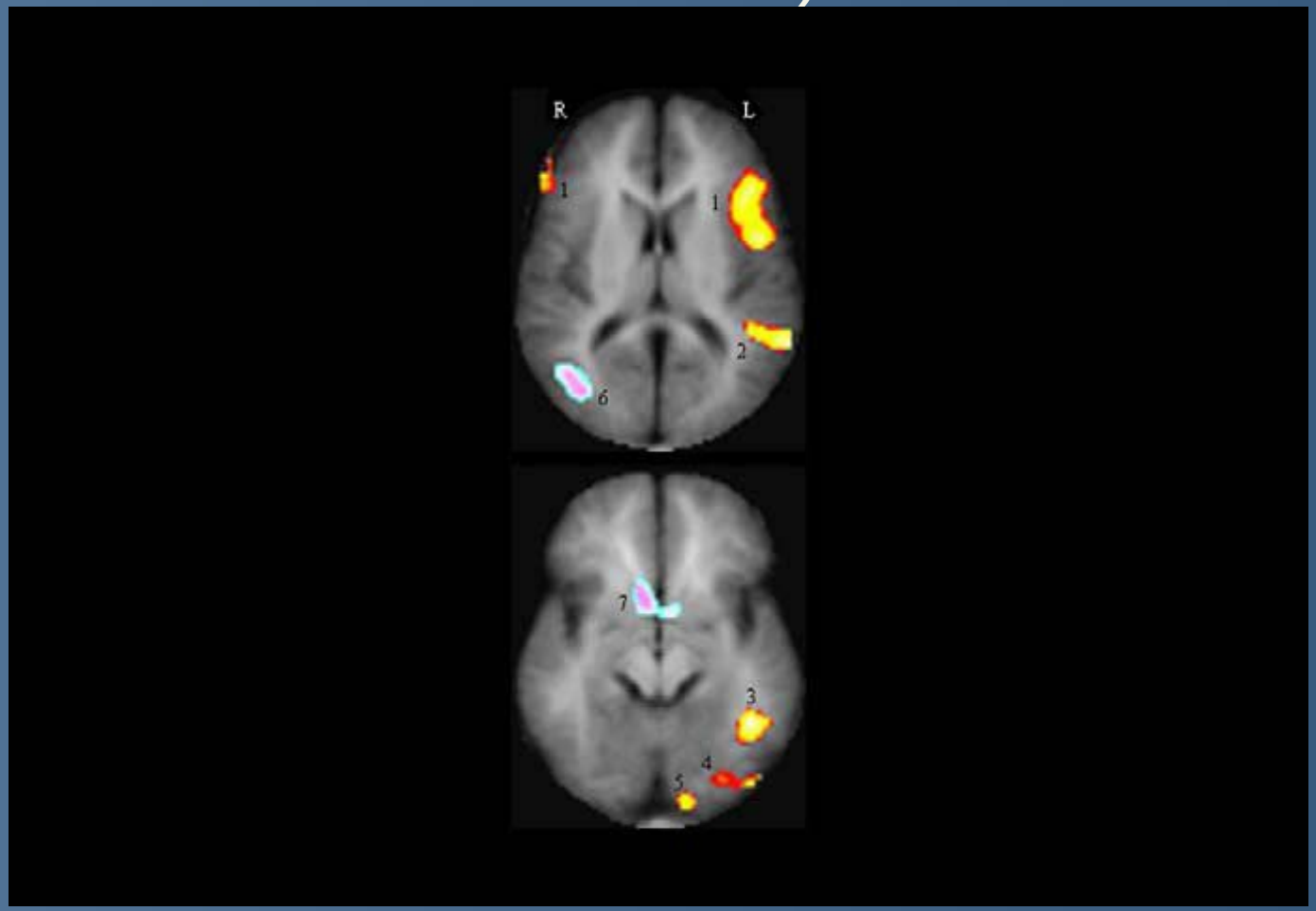
(5) Writing to dictation words and sentences from earlier steps in the lesson

Each lesson also includes “extended activities,” such as additional reading of both narrative and expository texts to enhance fluency, comprehension, and a sense of enjoyment, as well as additional writing activities and games.

Pretest, Posttest, and Follow-Up for the Woodcock Reading Basic Skills Cluster by Group



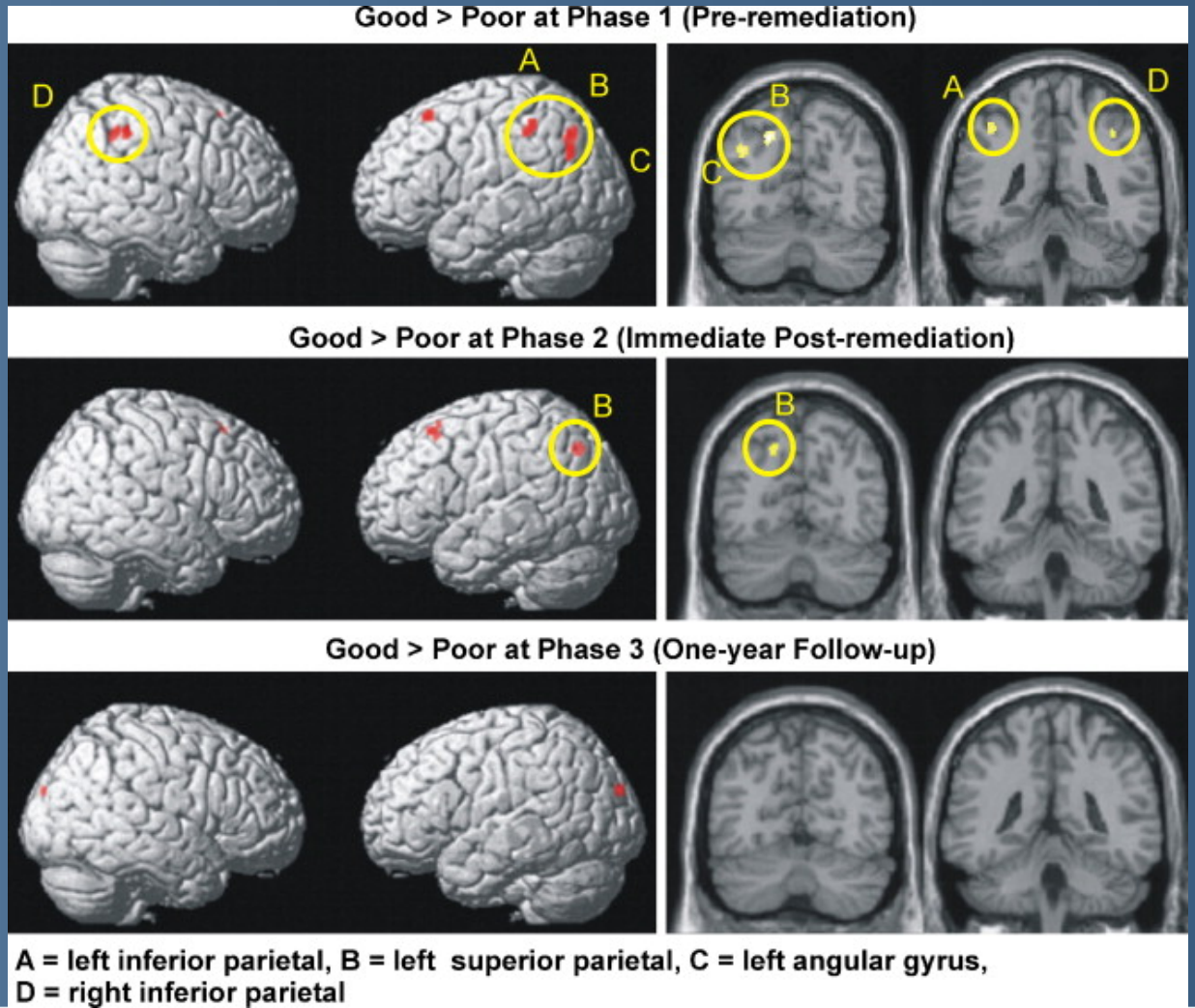
Shaywitz, Pugh et al., 2004- Biological Psychiatry (Letter Sound Task)



Meyler et al., Neuropsychologia, 2008

- Good and poor readers in Grade 5
- Year long intervention through Power4Kids (compared 4 remedial programs; about 100 hours; no differences in outcomes)
- Brain activation (fMRI) to a sentence comprehension task before and after intervention, and one year post-intervention

Meyler et al., Neuropsychologia, 2008



Adolescent Studies (Vaughn et al., 2010; 2011; Wanzek, 2011)

- Sample selected on the basis of reading comprehension performance in grades 6-8 and randomized to typical practice or different reading interventions over 3 years
- **Typical Readers** (pass state test), n=974:
- **Struggling Readers** (don't pass or don't take state test), n=1032:
  - 81% decoding/fluency problems; 19% primarily comprehension

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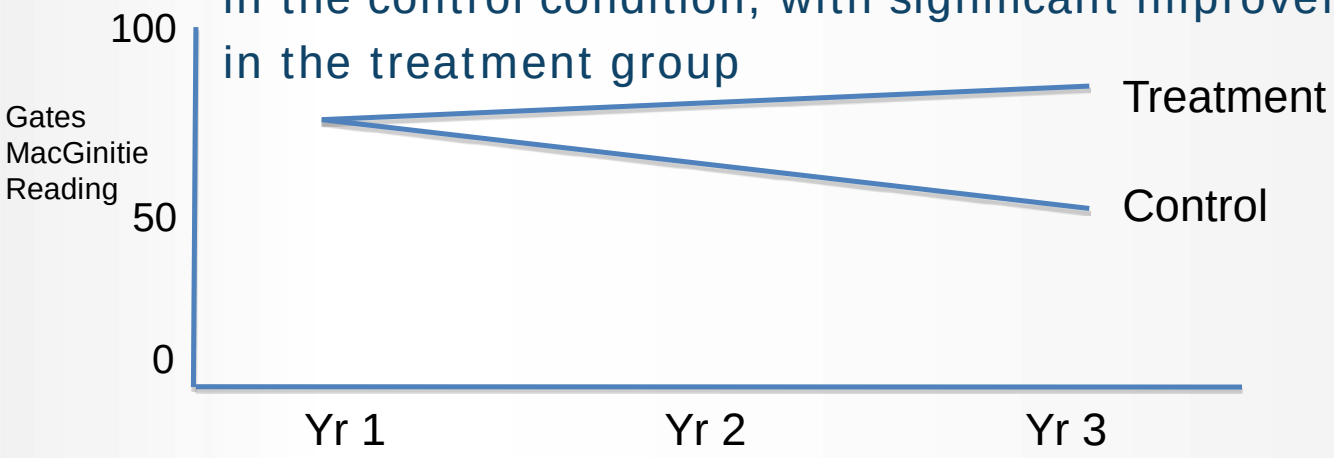
Results

- Year 1: Small effects generally not statistically significant; no effect of group size
- Year 2: Moderate effects on decoding, fluency, and comprehension; no difference in standardized vs. individualized instruction exception for children identified with special needs (better with standardized intervention)
- Year 3: Moderate to large effects on decoding, fluency and comprehension

- NICHD middle school studies – intensive interventions for adolescents with severe reading difficulties

Cohort of minimal responders followed for three years indicated a decline in performance for the participants in the control condition, with significant improvement in the treatment group



Neural Correlates of Adolescent Intervention

- Inadequate responders (fluency criteria) show underactivation of left supramarginal and angular gyri, as well as in the superior and middle temporal gyri, bilaterally
- Functional neuroimaging measures of activation predict intervention response especially engagement of left temporal regions (Rezaie et al., JINS, 2011)

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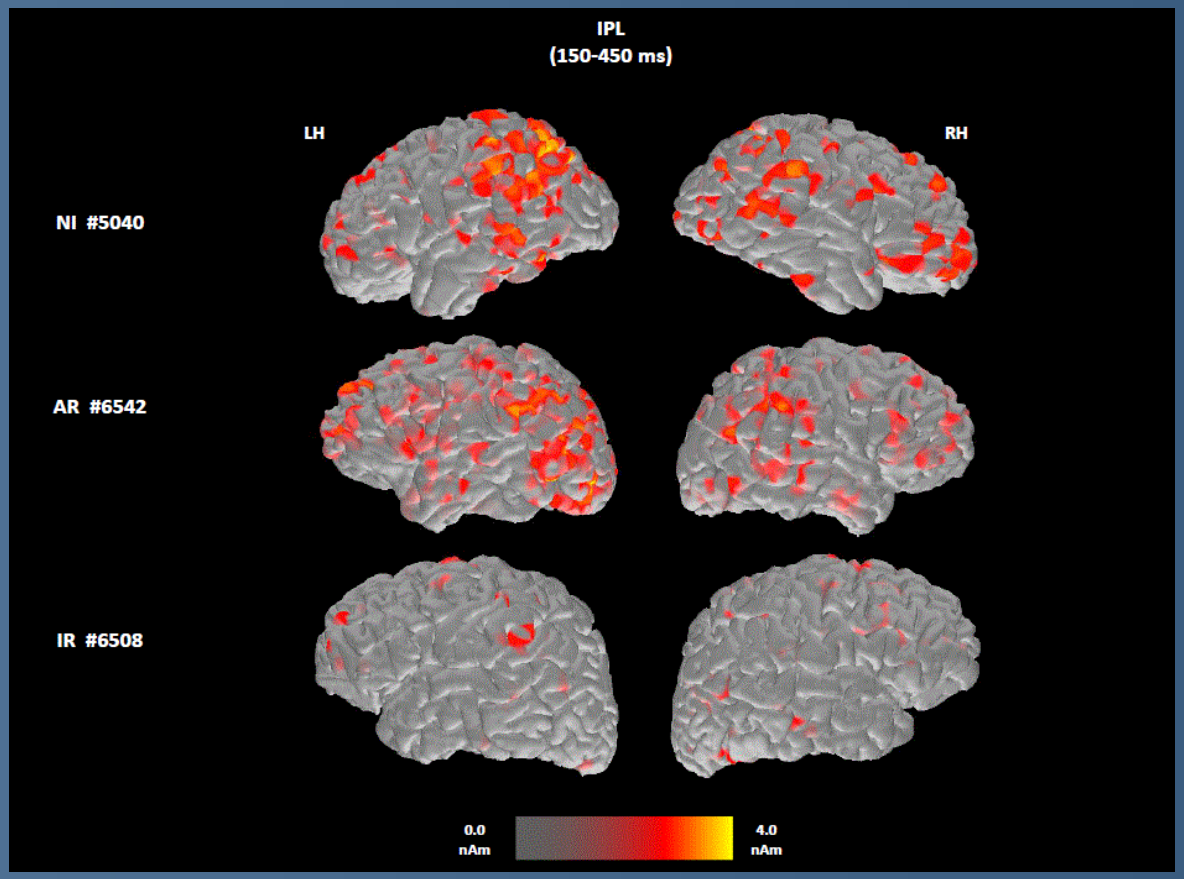
Baseline MEG Patterns for Adolescent Adequate and Inadequate Responders



Is plasticity an issue?

- The neural systems underlying reading seem malleable, show plasticity across the age range, and are not disorder-specific; continuum of severity (Vellutino).
- Mostly normalizing, not compensatory
- Don't know much about inadequate responders
- Need to tie functional results to structural correlates (gray matter increases with intervention (Eden) and parallels differences in literate and illiterate adults (Castro-Caldes); coregister across imaging modalities
- Are neuroimaging measures effective predictors of growth and intervention response?

Who is LD (Instructional Model)?

- The student who does not respond to quality instruction: hard to teach, not unable to learn
- Low achievement and inadequate instructional response
- Often preventable with early intervention
- Heritable, but neural systems are malleable
- Advances in science occur at the boundaries of disciplines (Wilson, 1998)

Reading Sculpts the Brain, But Must Be Taught!!

- "We are all born with dyslexia. The difference among us is that some are easy to cure and others are not."

  - Liberman, 1996

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