How the Reading Brain Reframes our Concept of Dyslexia and its Intervention

Maryanne Wolf
Tufts University
The Help Summit
Los Angeles, CA Oct 14, 2016

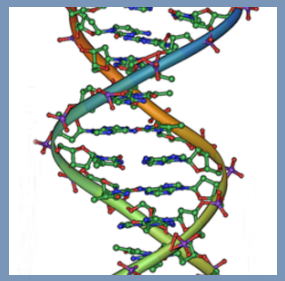
The Center for Reading and Language Research

Committed to the pursuit of multi-disciplinary research about how the brain learns to read across all ages and stages of development

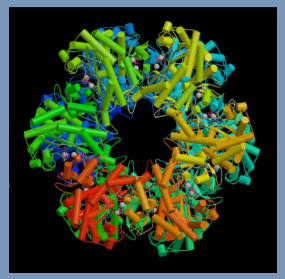
Tufts UNIVERSITY

ase.tufts.edu/crlr

Gene

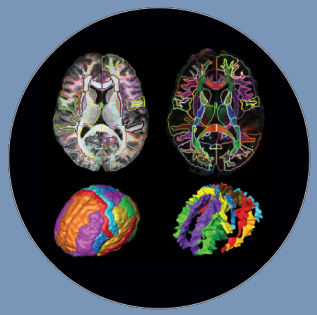


Cognitive Behaviors



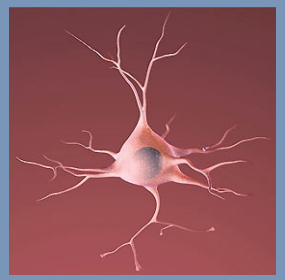
Protein

Connecting Evolving Knowledge Bases



Brain Areas

Neural Circuits



Cell/ Neuron

Tales from Neuroscience: How the Reading Brain Informs

Early Reading Development

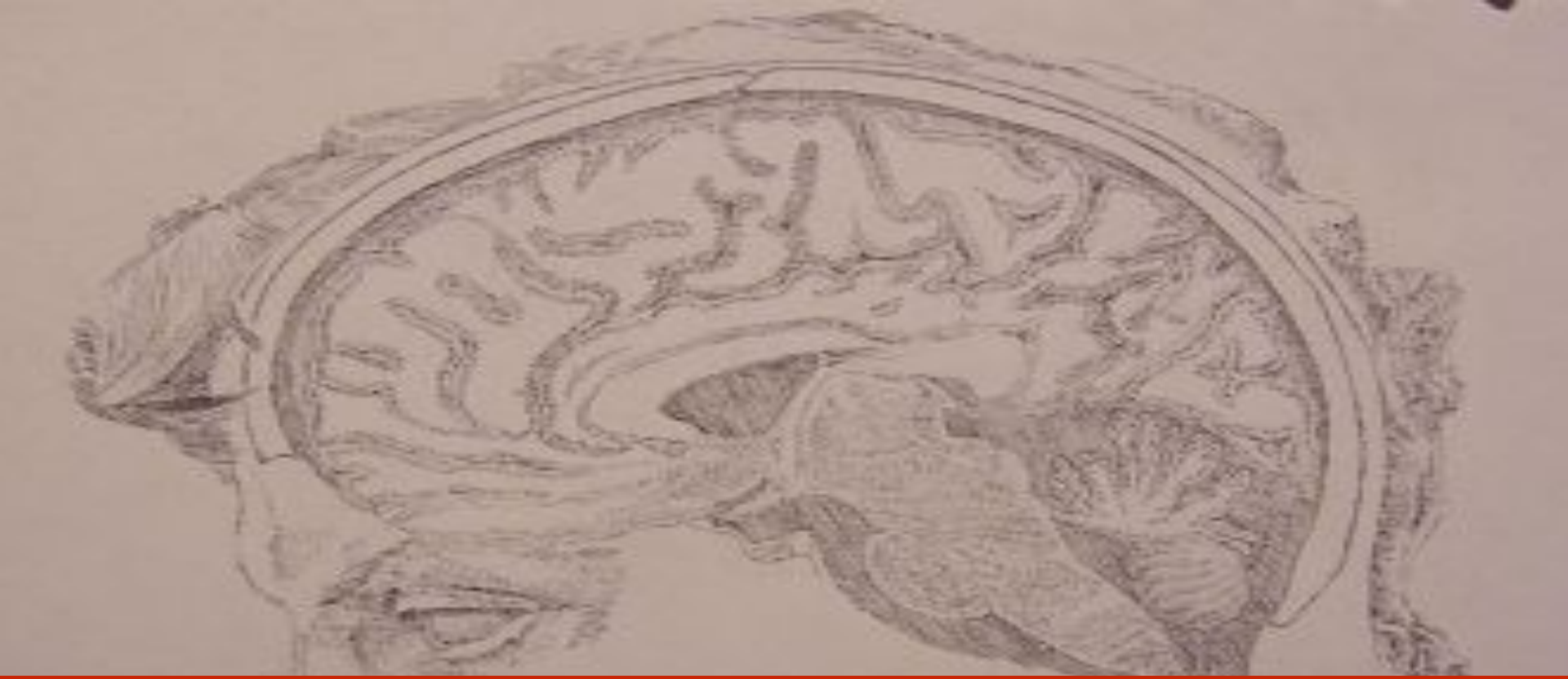
.

Dyslexia

Digital Reading Challenges

Non-Literate Cultures

Preface: The Mystery



The human brain was never born to read or multiply numbers or program.

How then does the human brain learn new cognitive functions?

Principles of the Brain's Plasticity within Limits for Cultural Inventions

1.

Ability to form whole new connected circuits

2.

Ability to recycle and repurpose areas

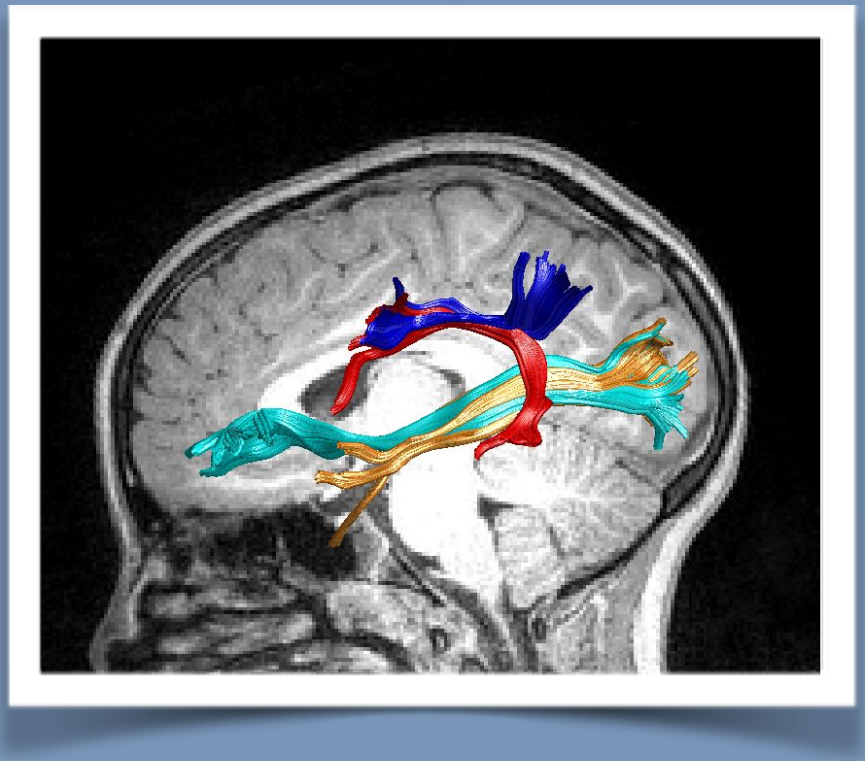
3.

Depends on environment/ limits

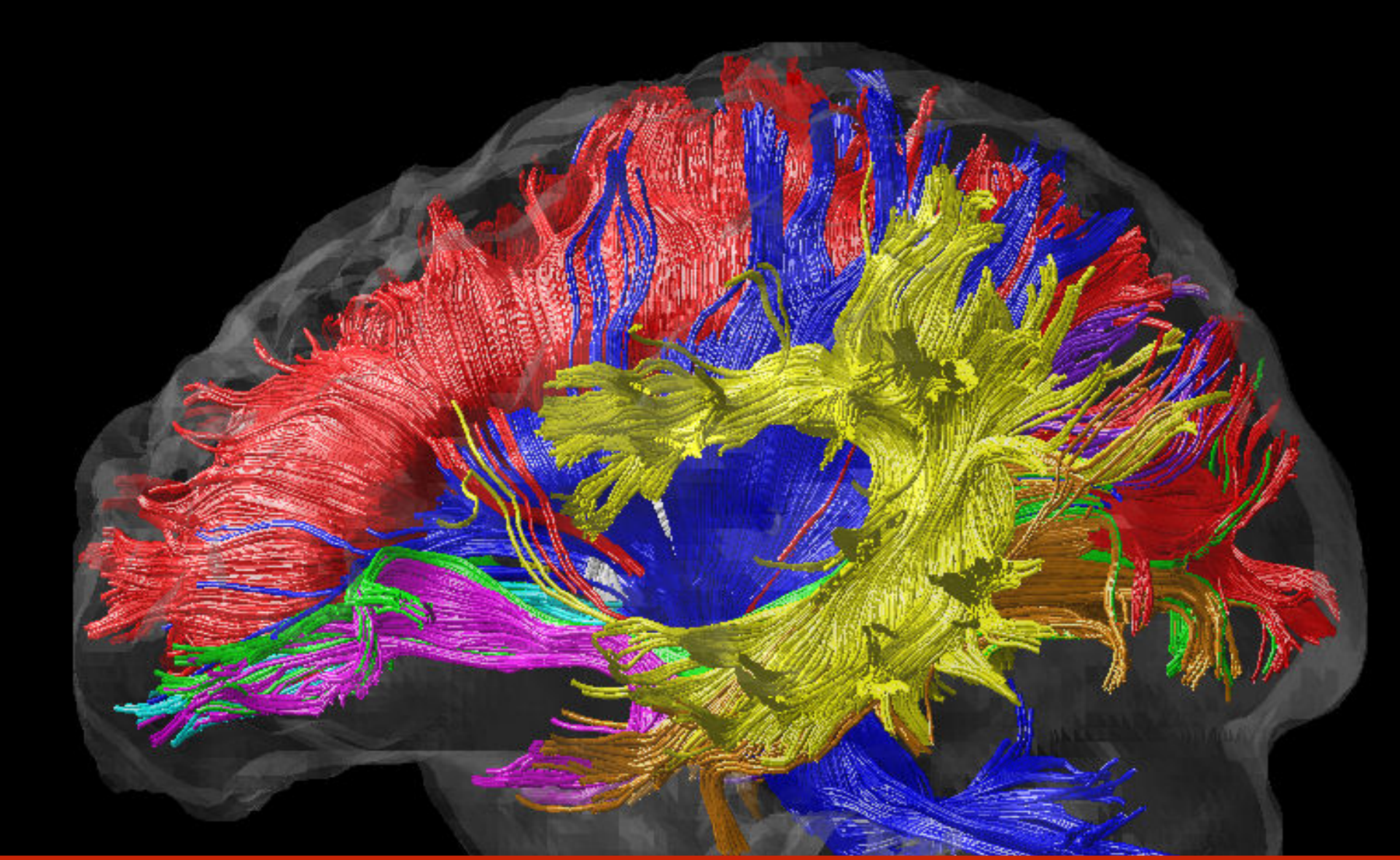
Dehaene, 2015

Whole New Reading Circuit

Existing circuits of neurons



Originally designed for vision, language, & cognition



The Plastic Reading Brain Circuit

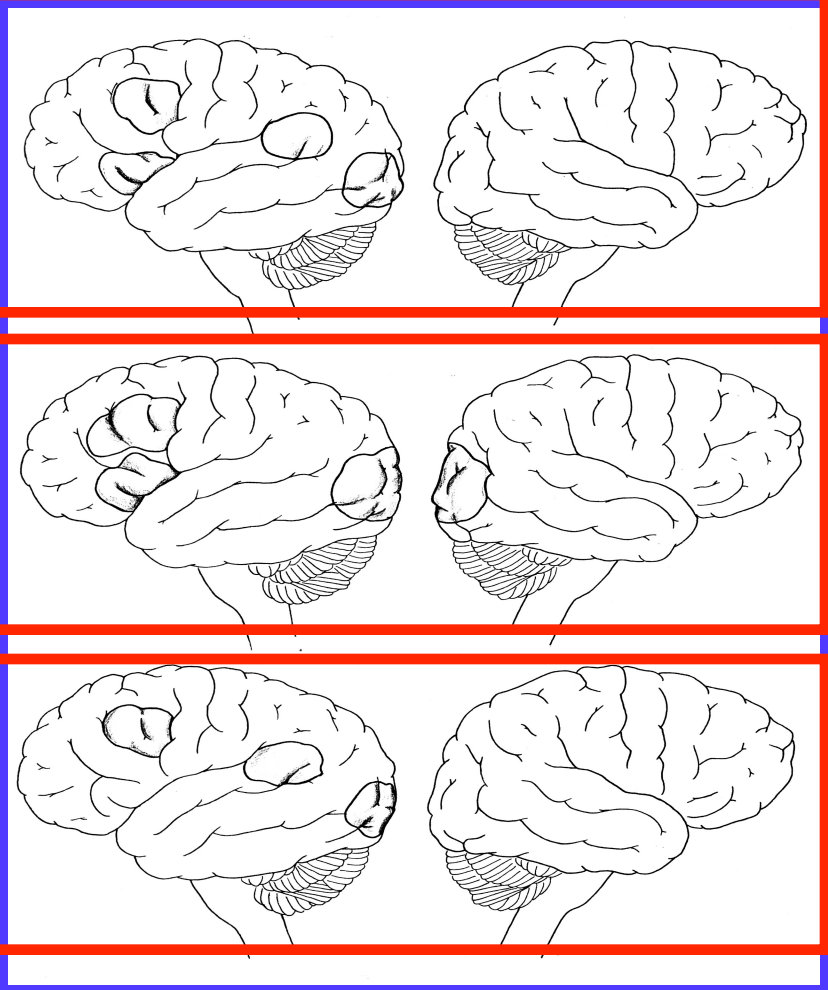
Multiple Circuits

Plasticity of Reading Brain

English

Chinese & Kanji

Japanese Kana



Brain can rearrange itself in multiple ways to read, depending on **writing system** and **medium**.

Bulger, Perfetti, & Schneider

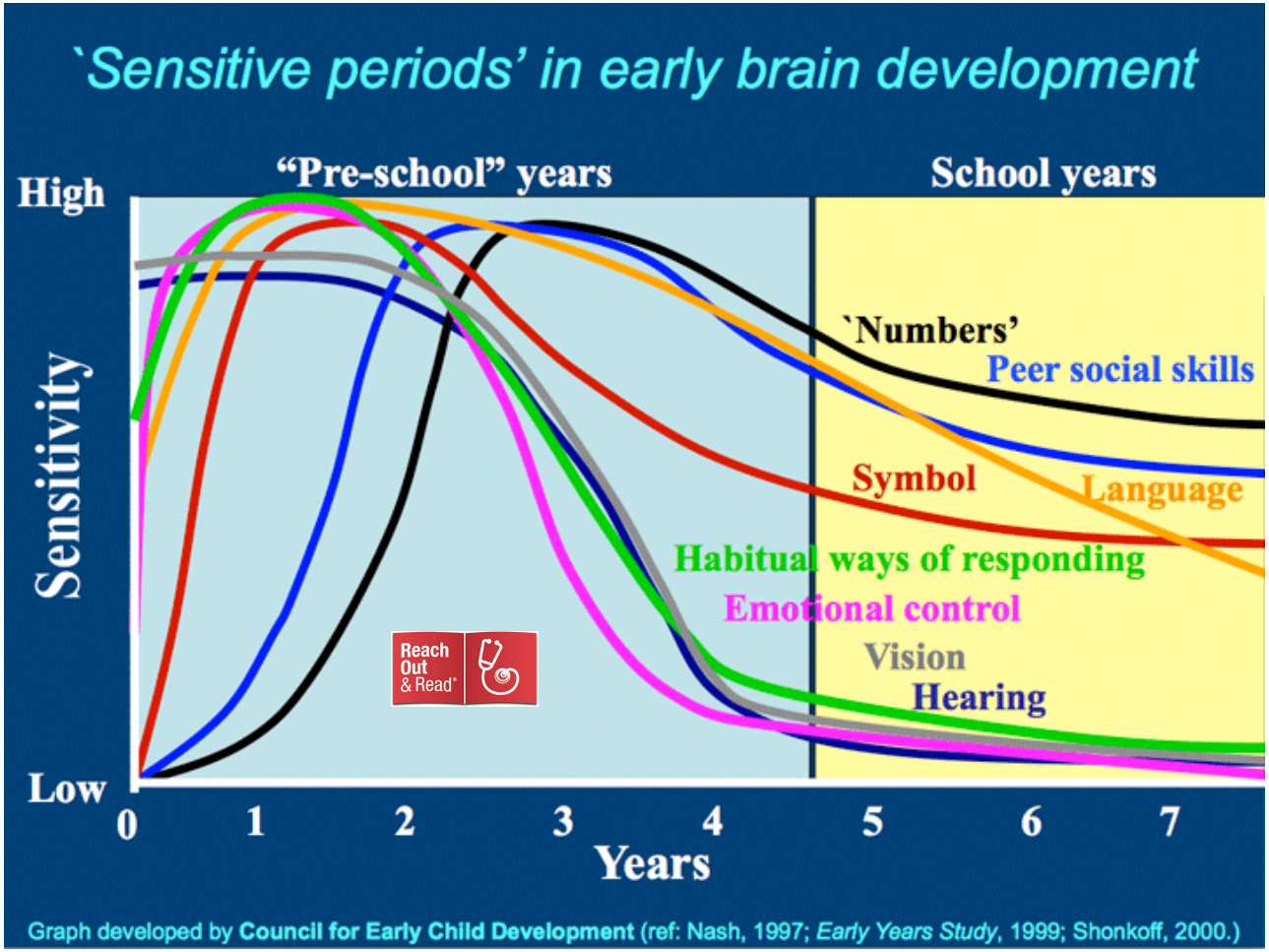
First Lesson:

The Developing Brain

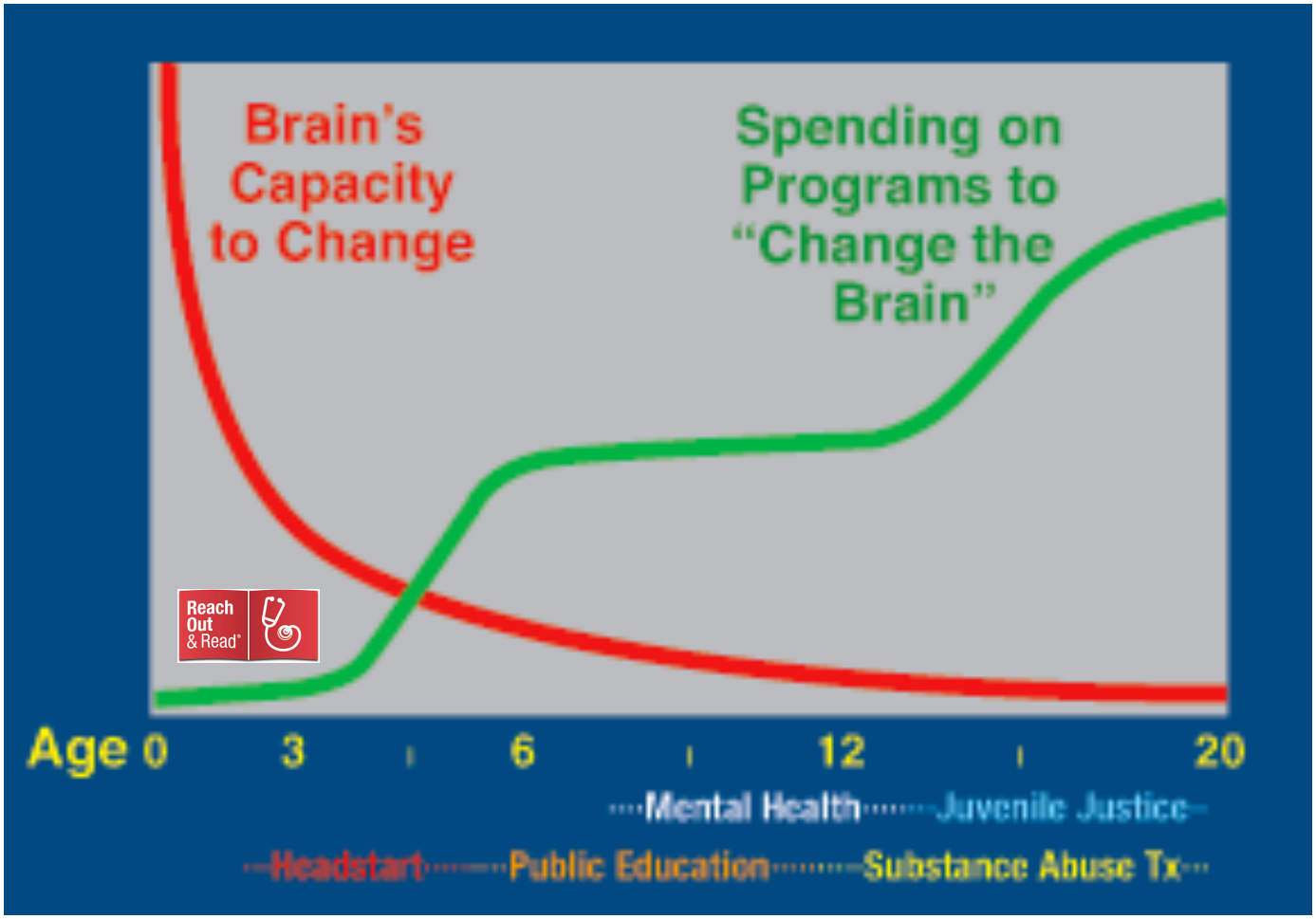
How does the Young Brain Learn to Read?

Each new reader must create a ***new reading circuit*** from older cognitive and linguistic structures and their connections

Best To Start Early…



And Invest Wisely…



Early Contributions to Language

Phonemes
Orthography
Semantics
Syntax
Morphology

Phonemes

Phoneme Awareness

Explicit emphasis on sounds' representations

Orthography

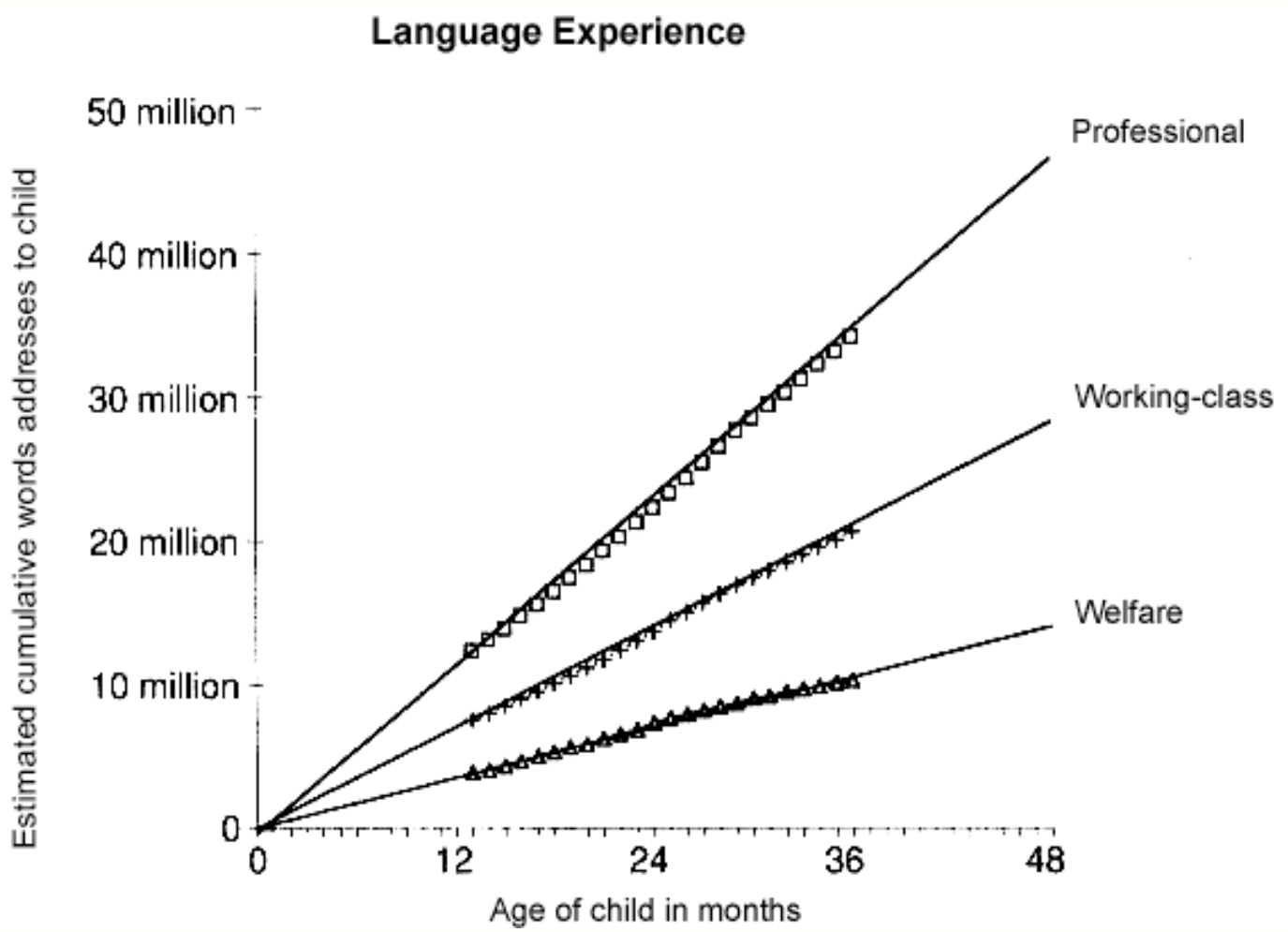
Representations of Letters & Letter Patterns

Conventions of Print

Left to Right Scanning

Semantic Development

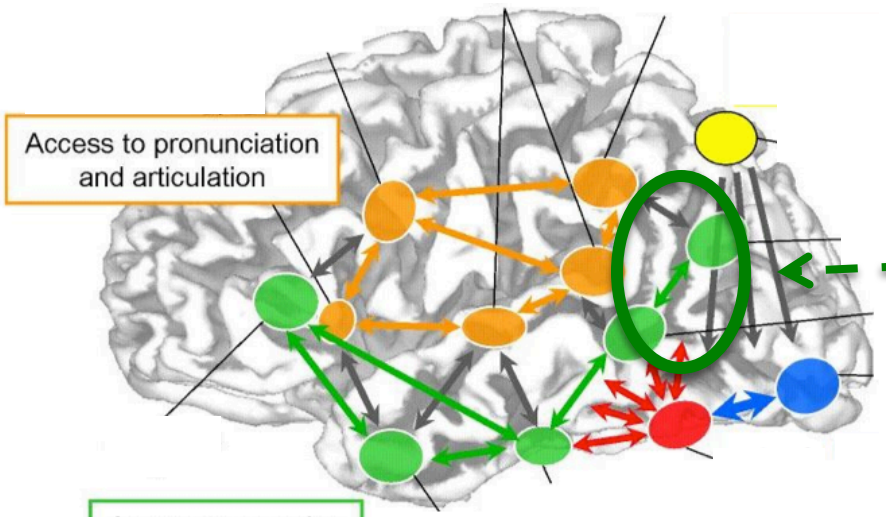
Semantic Development in Every Book and Story

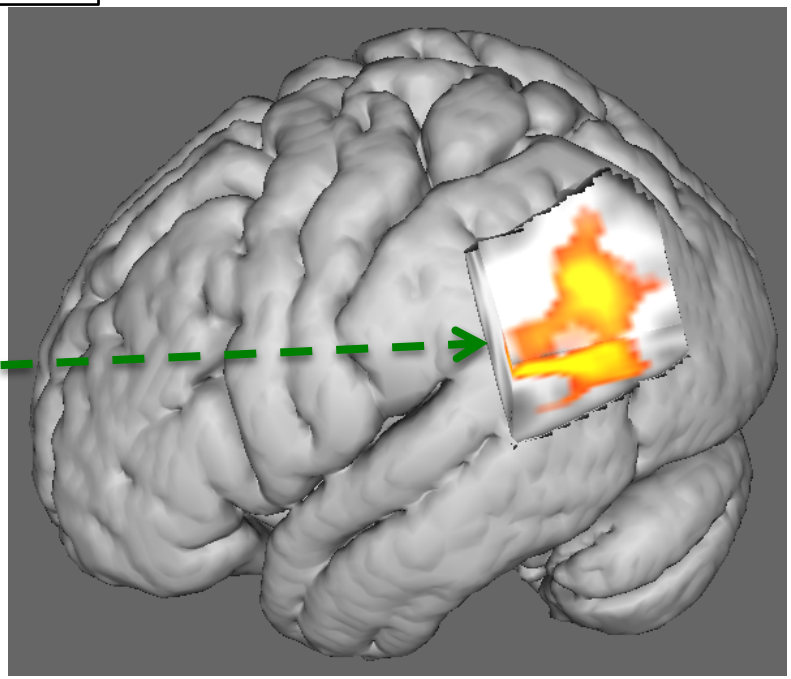


32 Million Word Gap

Study 1: Quantitative Home Reading Environment and Neural Activation During Story Listening in Preschoolers 3-5 y/o: John Hutton, Cincinnati Hospital

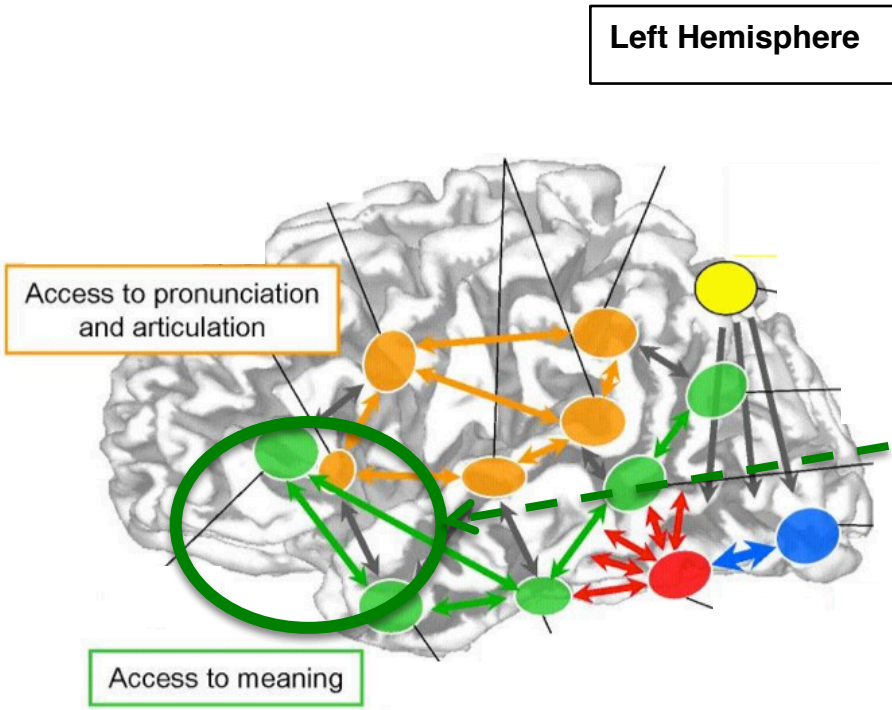
Left Hemisphere



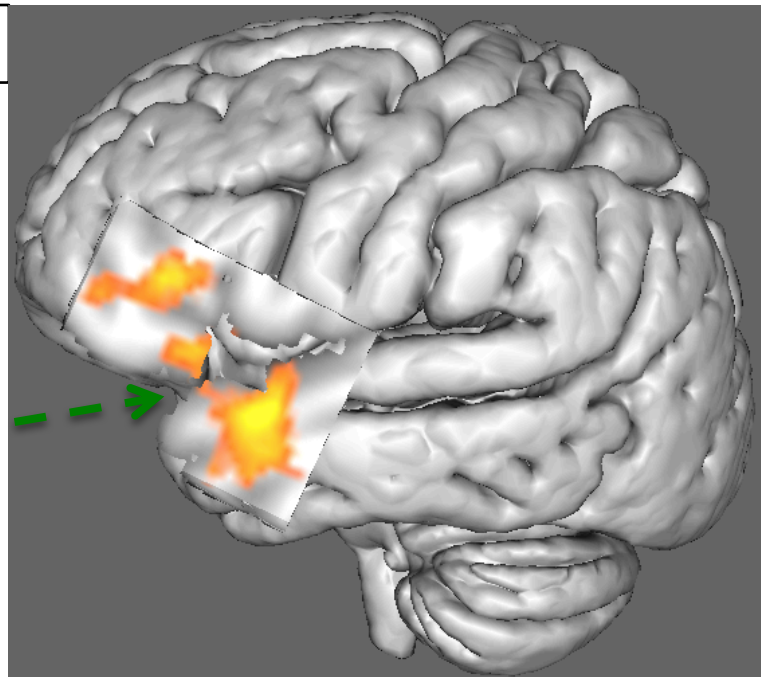


- **Semantic Processing** (Understanding)
- **Visual Imagery**
- **Controlled for household income**

Study 2: Maternal Shared Reading Engagement and Neural Activation During Story Listening in 4 y/o low-SES girls

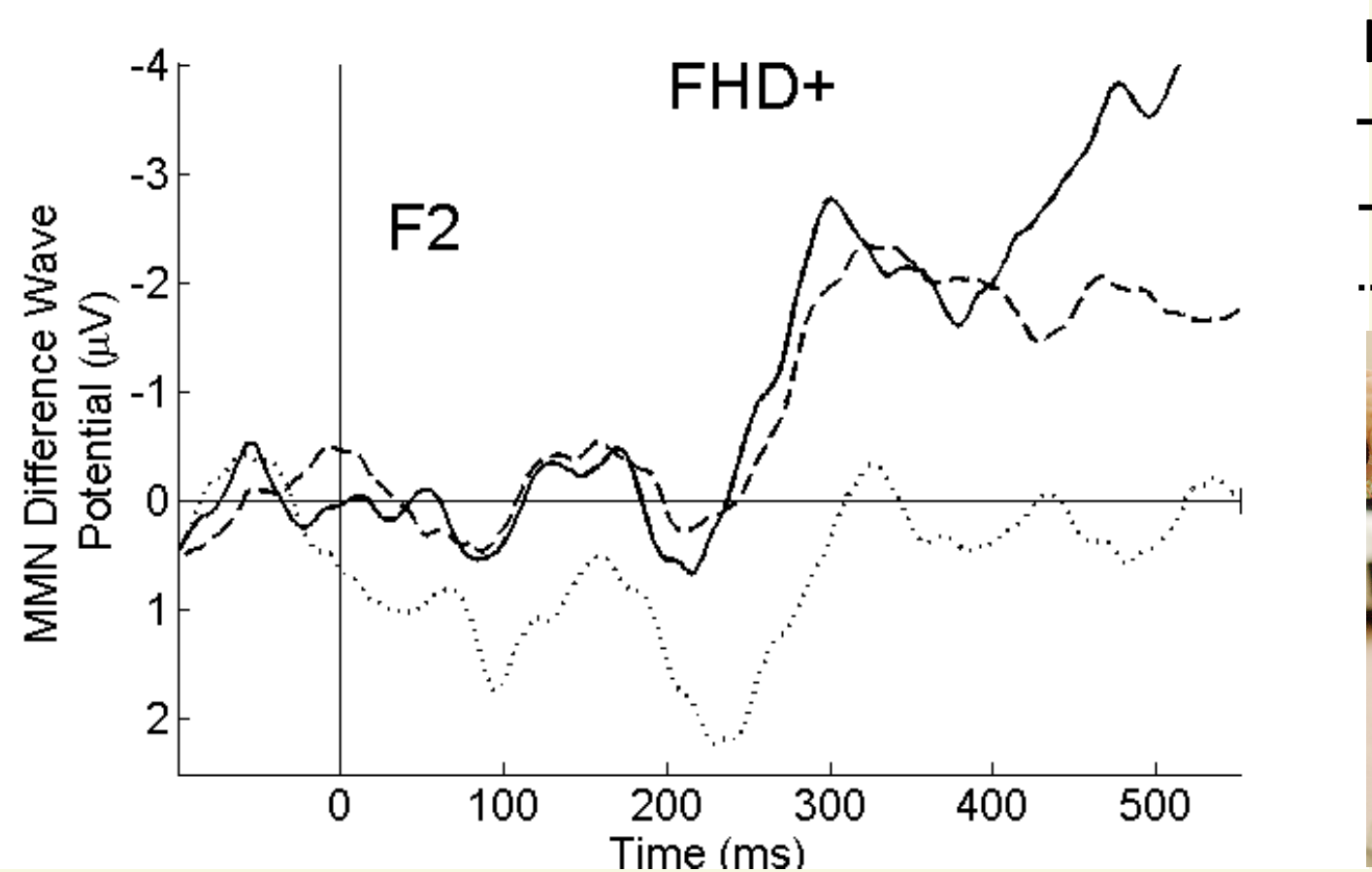


Left Hemisphere



- **Expressive language**
- **Complex language processing**
- **Social-emotional integration**
- **Working memory/attention**

Greater home literacy is associated with a stronger response in children with family history of dyslexia (FHD)



Home Literacy

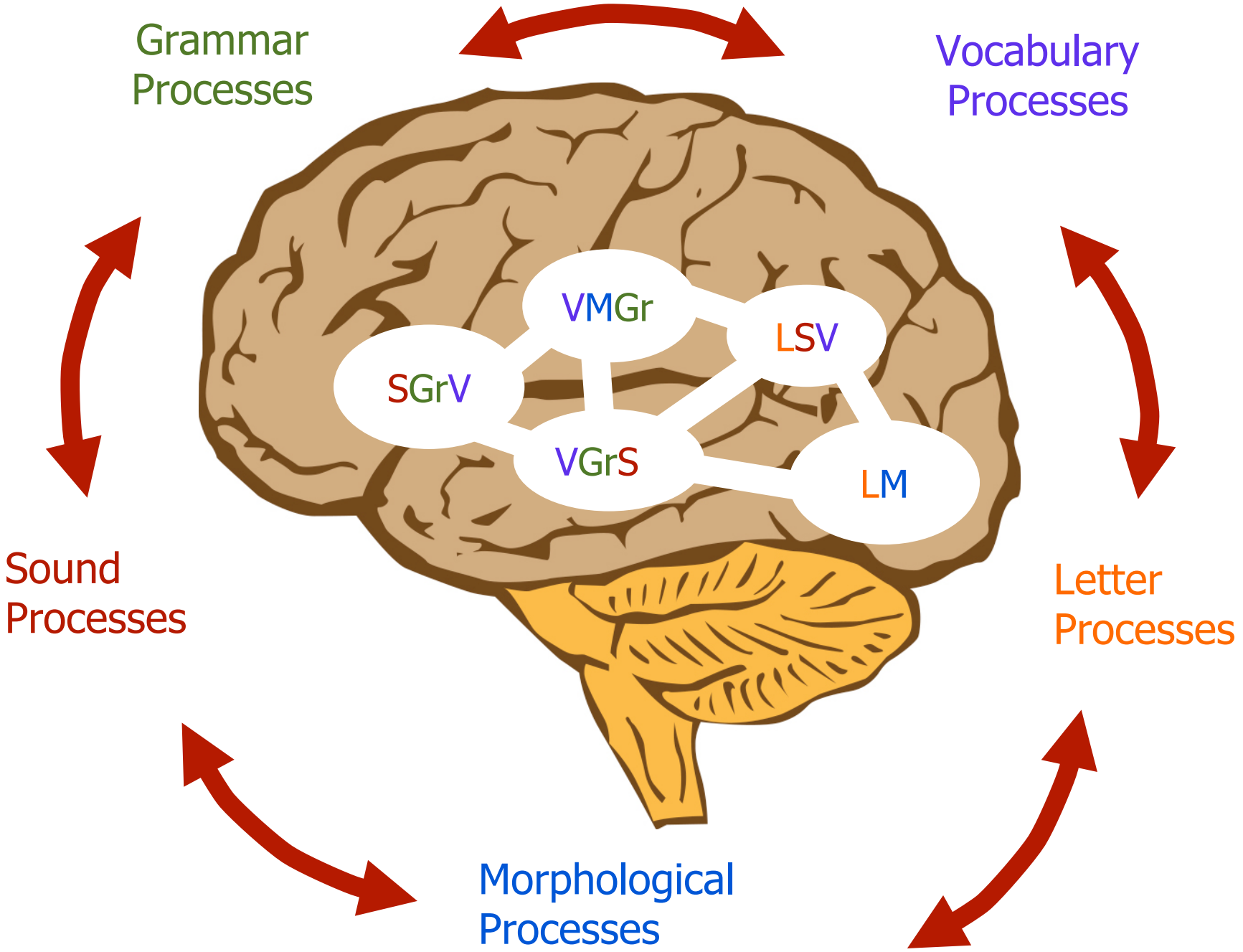
——— High

- - - - - Medium

····· Low

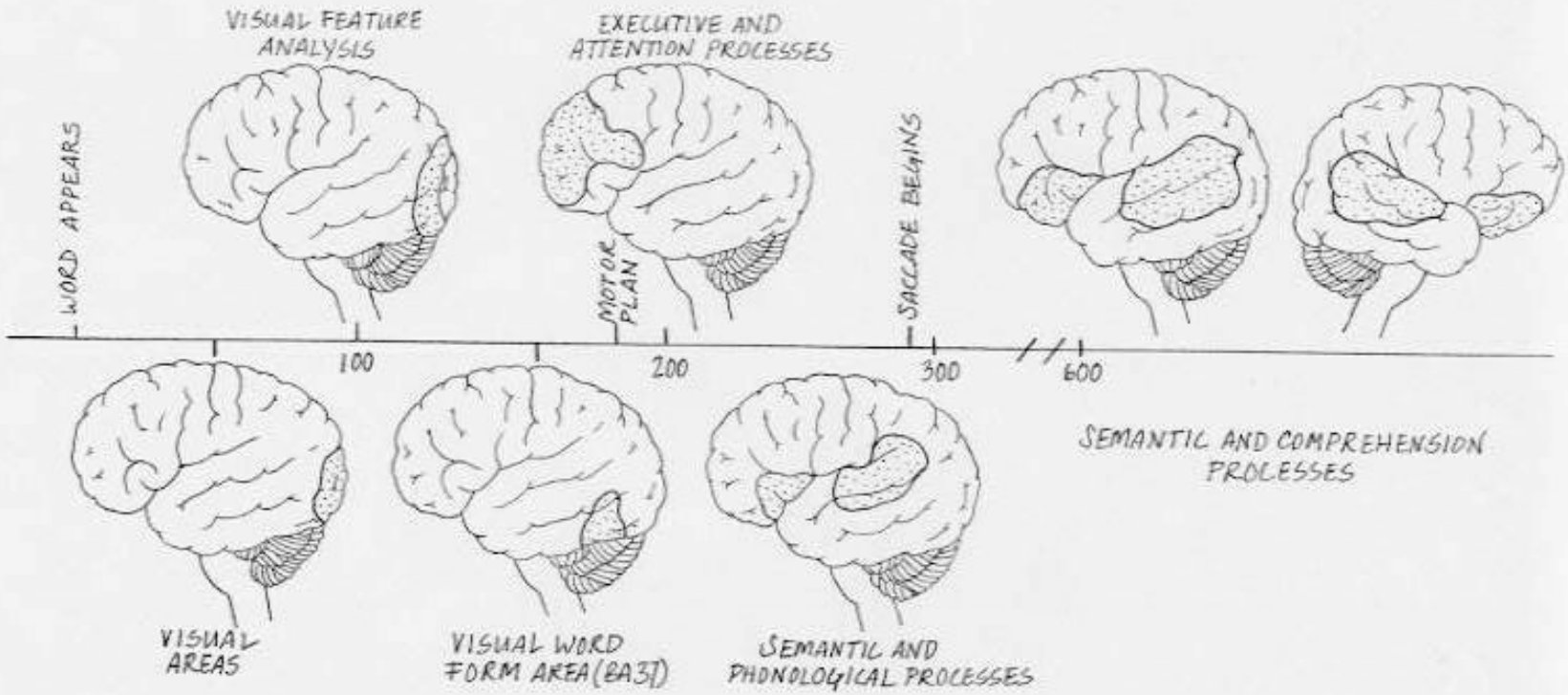
n=18

Norton et al., in prep


Grammar Processes
Vocabulary Processes
VMGr
LSV
SGrV
VGrS
LM
Sound Processes
Letter Processes
Morphological Processes

Decoding plus "Deep Reading"

Connected in Milliseconds



The Heart of Expert Deep Reading

At the heart of reading, 100 to 200 milliseconds allow us

“time to think our own new thoughts”.

Deep Reading

Background Knowledge

Perspective Taking

Critical Analysis

Novel Thought

Inference,
Deduction/Induction,
Analogical Thinking

Imagery

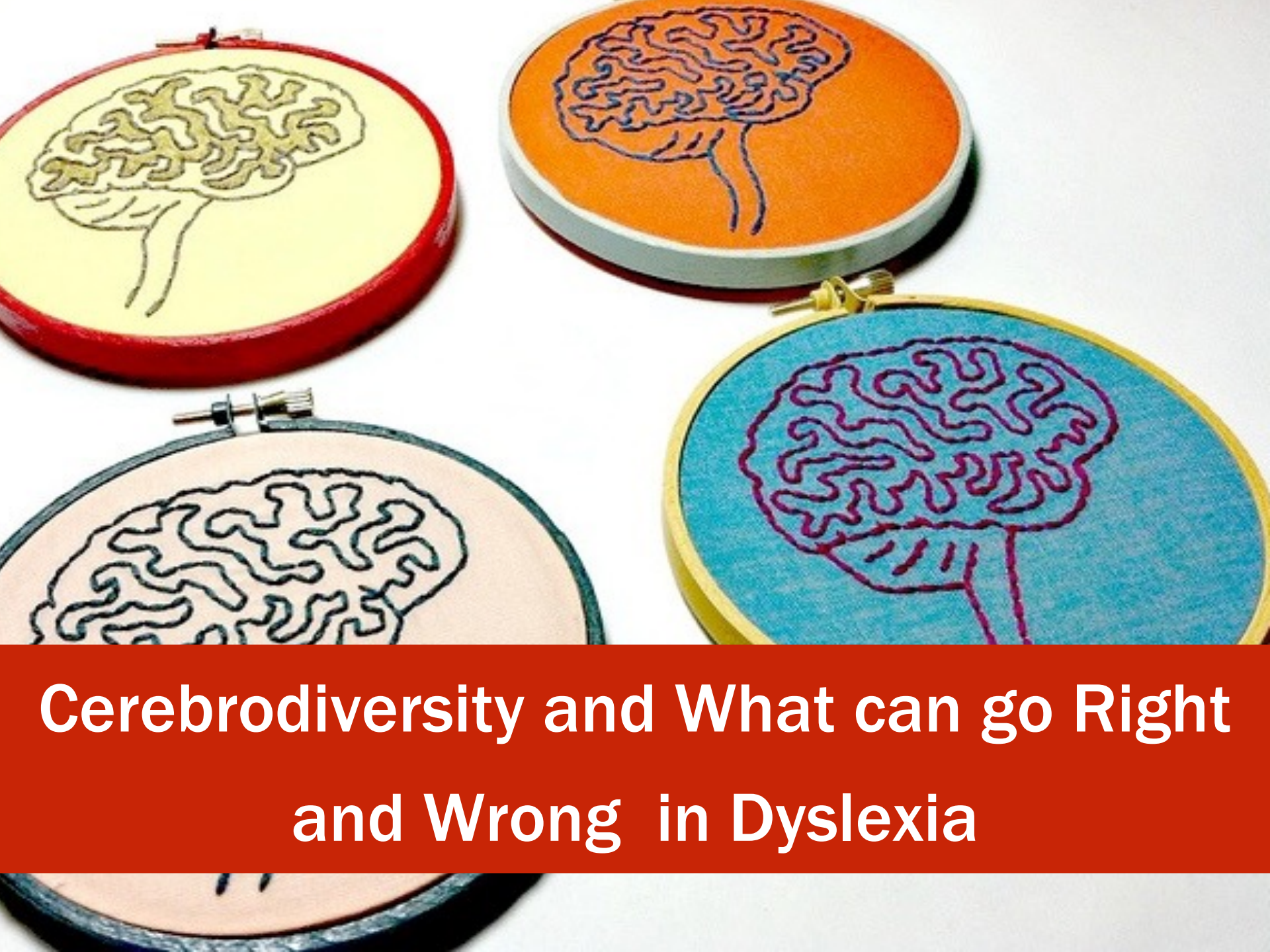
Insight &
Reflection

Going beyond the wisdom of the author


THE TALE
WITHIN A TALE:
“Here is the Golden Key. It is the capacity to pass over to others and come back to ourselves. We all have the capacity, but we do not all discover it, come to use it, learn to pass over. “
-Fr. John S. Dunne

Second Lesson:

How the Reading Brain helps us
learn how to teach readers with dyslexia

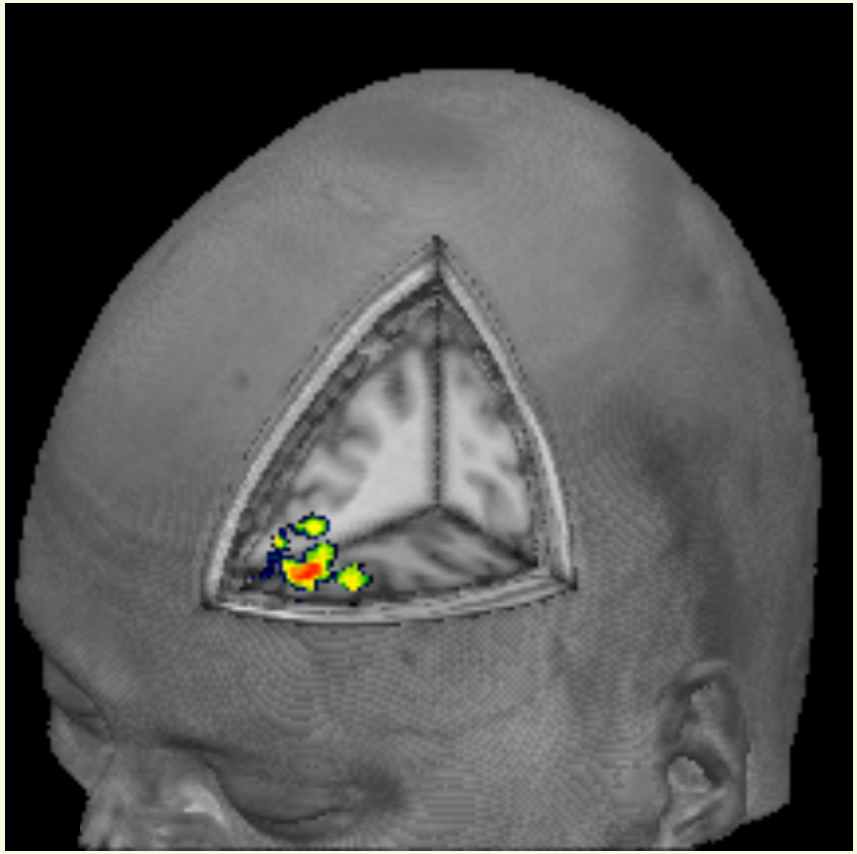


Cerebrodiversity and What can go Right and Wrong in Dyslexia

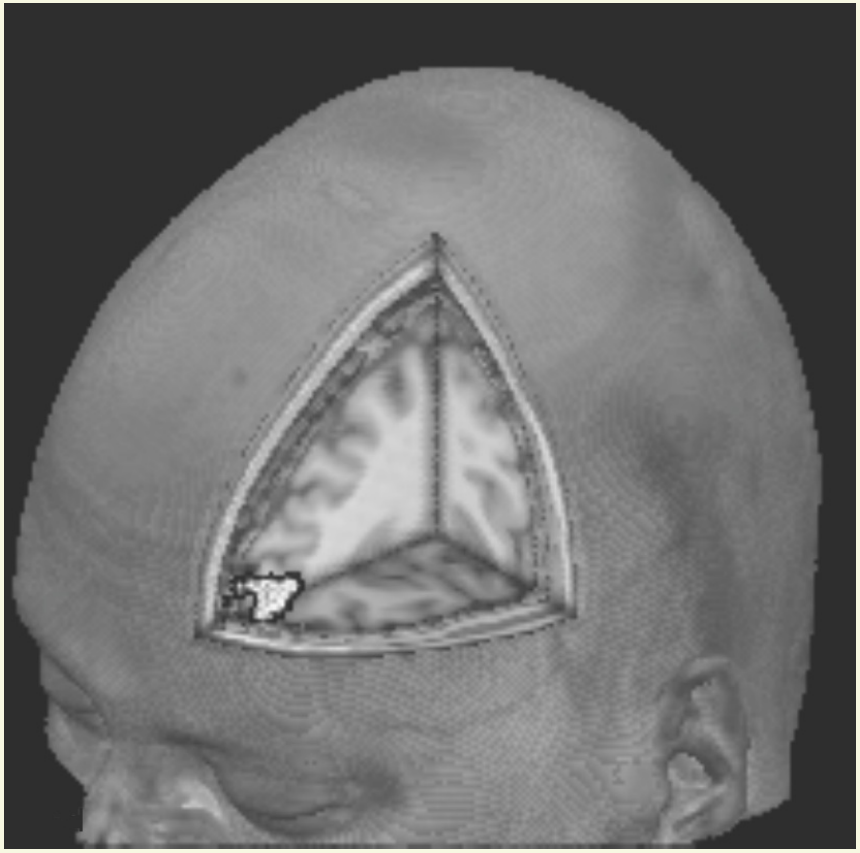
How do Children with Dyslexia differ in brain organization?

- Functional Magnetic Resonance Imaging (fMRI), EP, MEG
- Giant magnet, measures anatomy and blood flow (activation patterns) in brain structures

Phonology Differences: Rhyming

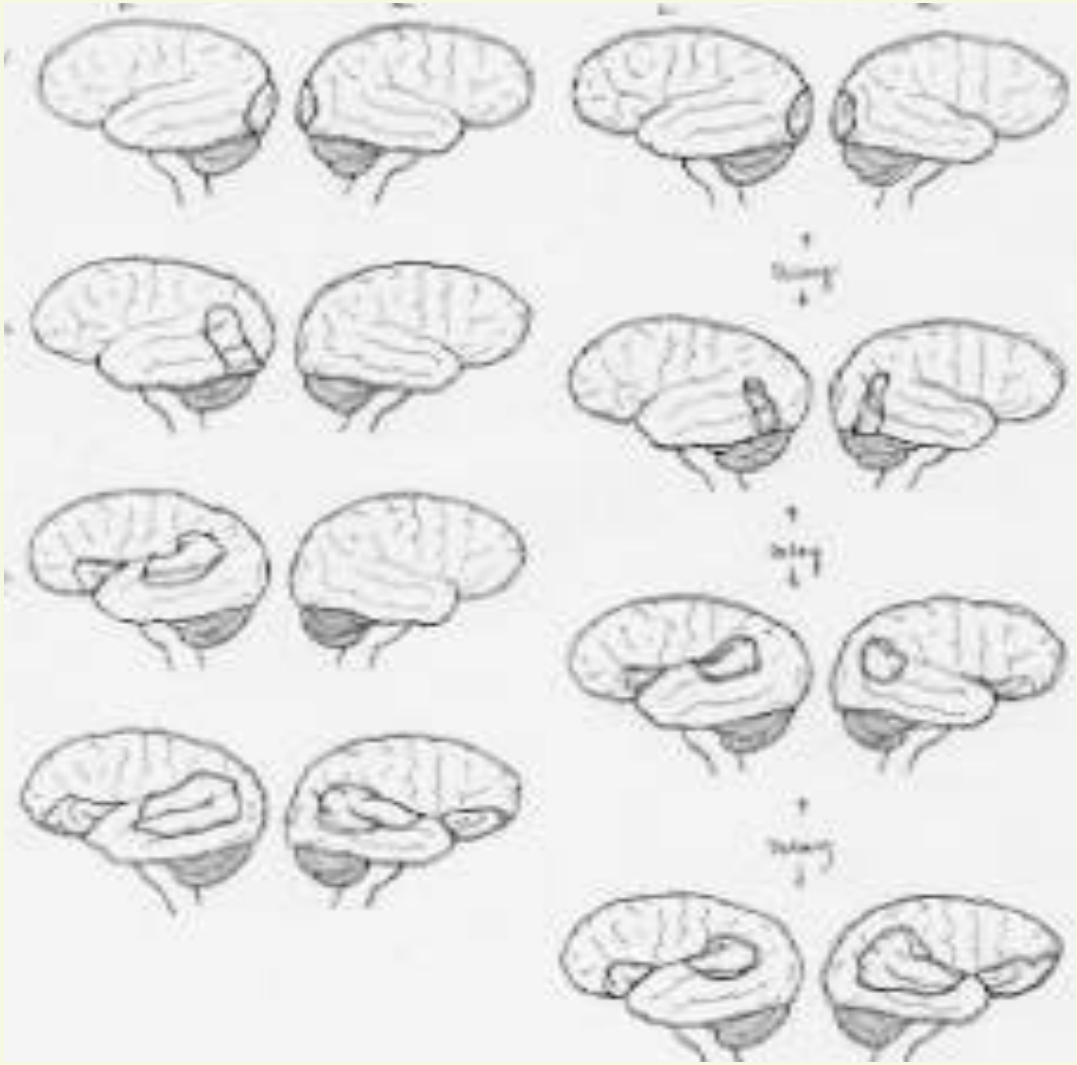


Young Readers



Children with Dyslexia

Kovelman, Norton, Wolf, Whitfield-Gabrieli, Gabrieli, et al, *Cerebral Cortex,* 2011

	Typical Readers	Dyslexic Readers	
Visual Recognition 0-100 MSEC			Delay
Word Specific Activation 150 MSEC			Delay
Phonological Processing 180-300 MSEC			Delay
Semantic Processing 200-500 MSEC			Delay

Naming Speed:
Identification of Retrieval Deficits

Estimation of the brain's ability to recognize a visual symbol and name it accurately.

How quickly can the brain integrate visual and language processes?

Rapid Automatized Naming (R.A.N.): Predictor of Fluency

o a s d p a o s p d

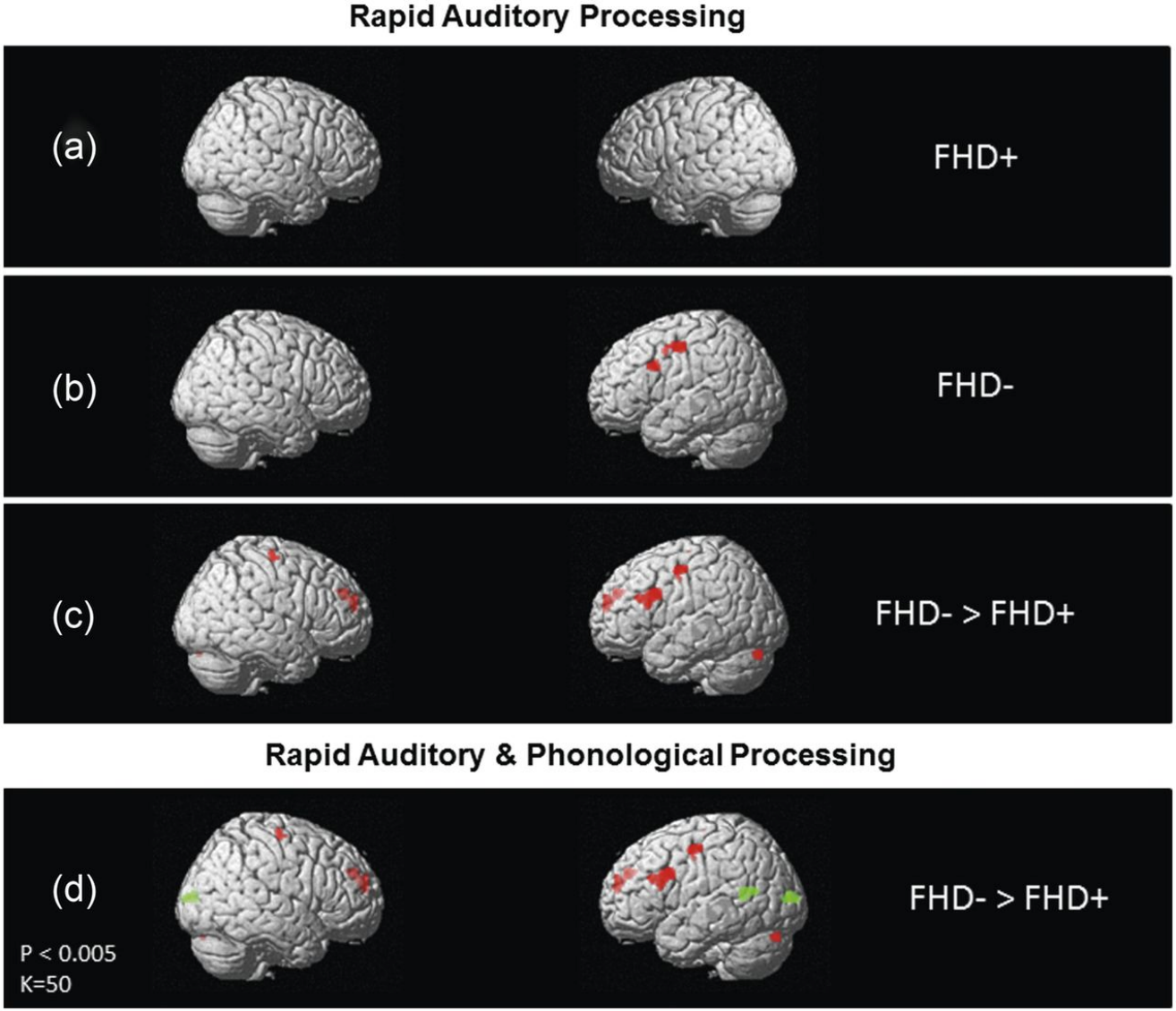
s d a p d o a p s o

a o s p s d p o d a

d a p o d s a s o p

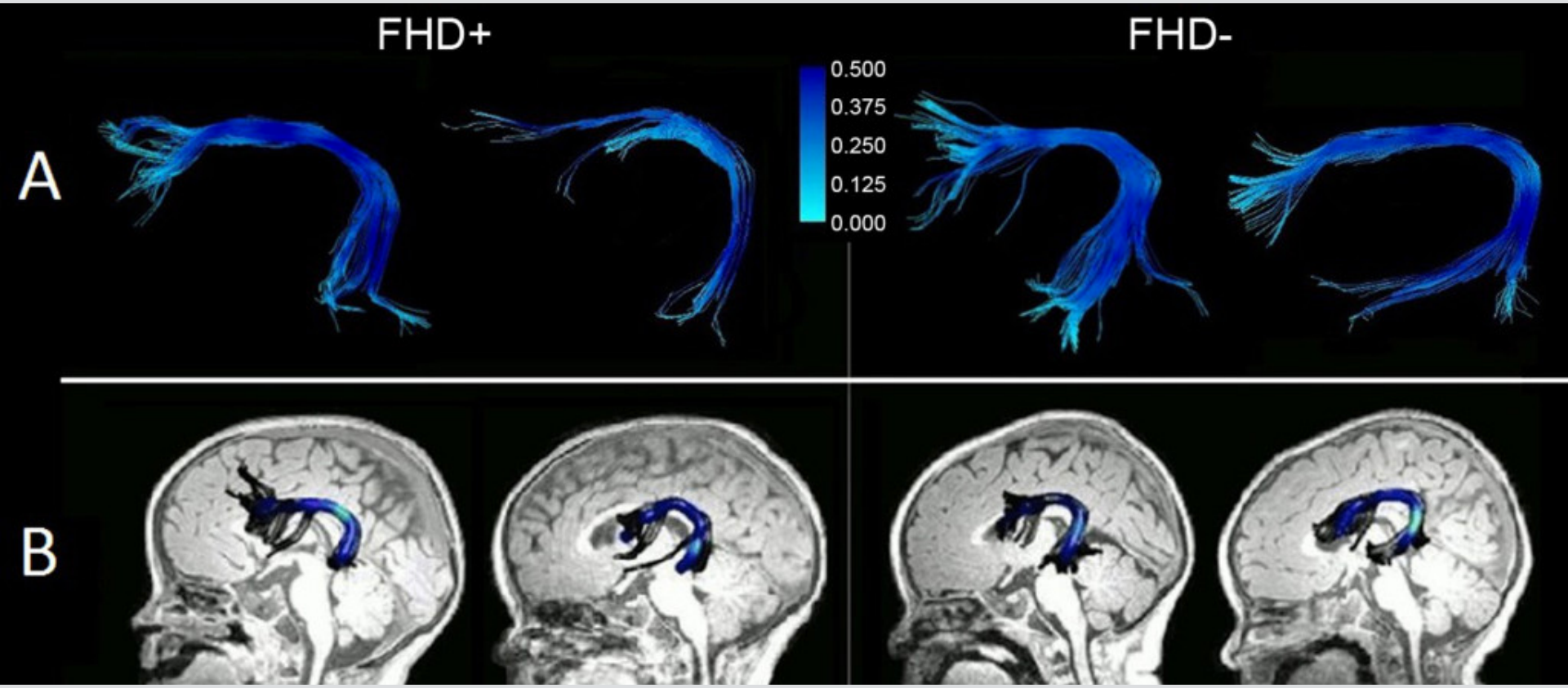
o a d s d p o a p s

Pre-reading 5 year olds



Raschle, Sterling, Meissner & Gaab, 2014

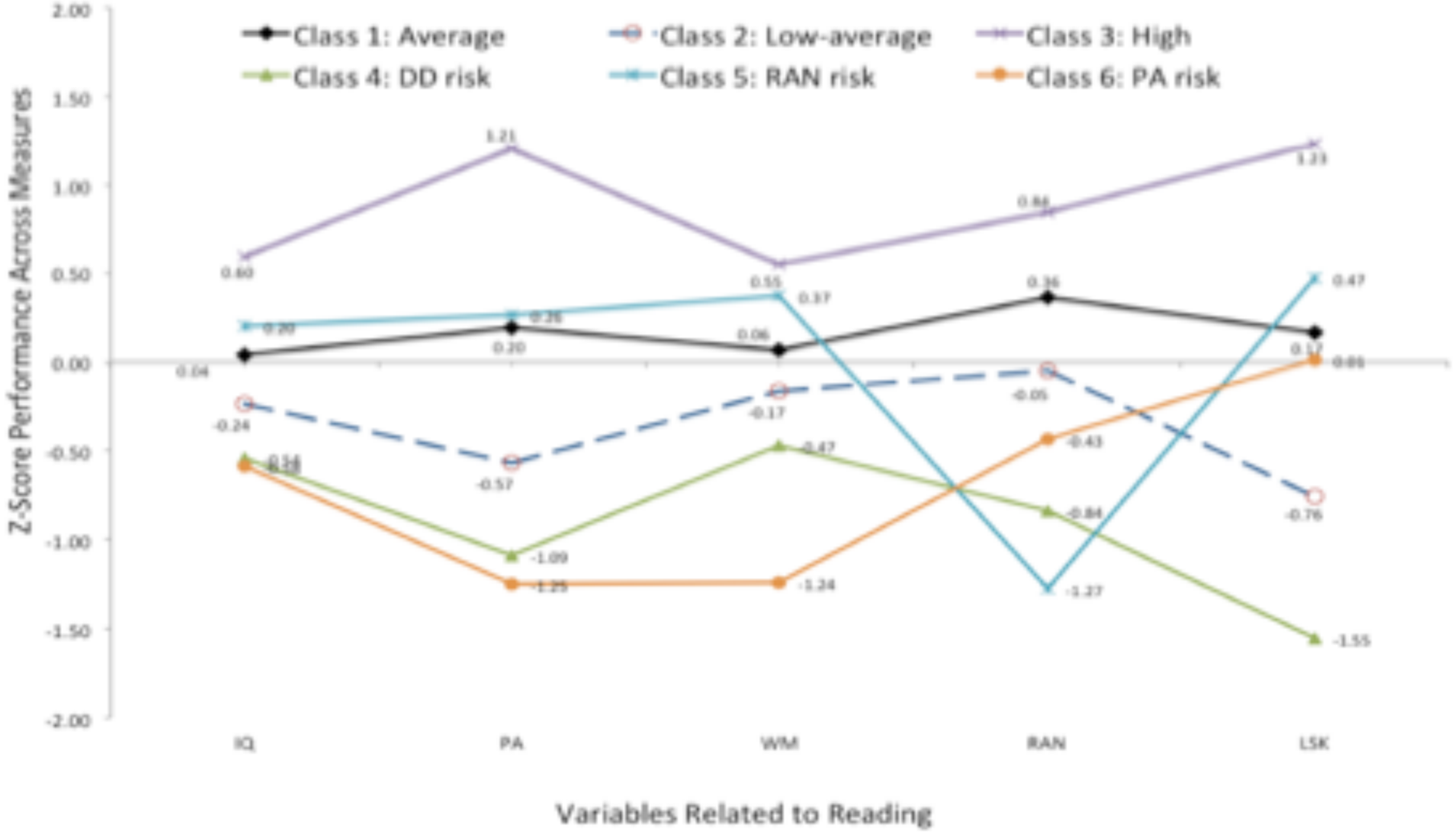
Dyslexia Risk Evident in Infancy



Less robust arcuate fasciculas correlated to familial risk.

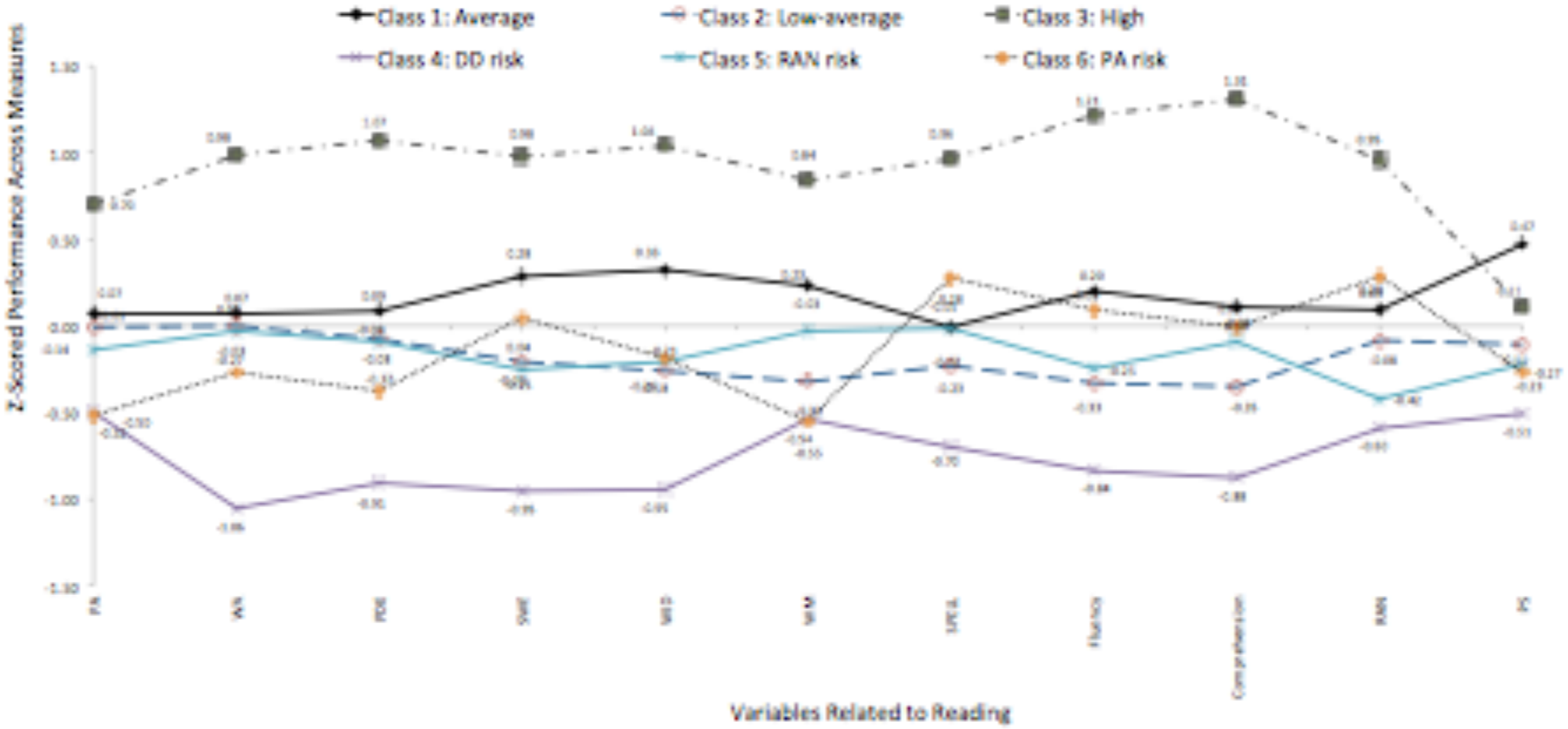
Lange, Peysakhovich, Zuk, Drottar, Sliva, Smith,Becker, Grant, & Gaab, 2015

Six distinct cognitive profiles of early reading have emerged in a diverse sample of 1,200 children



Ozernov-Palchik et al., (in prep.)

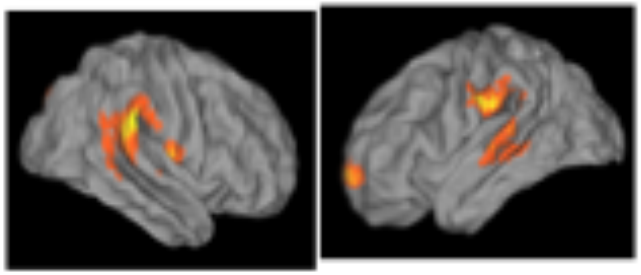
These profile were highly stable with a 100% of children remaining in the same group 2 years later



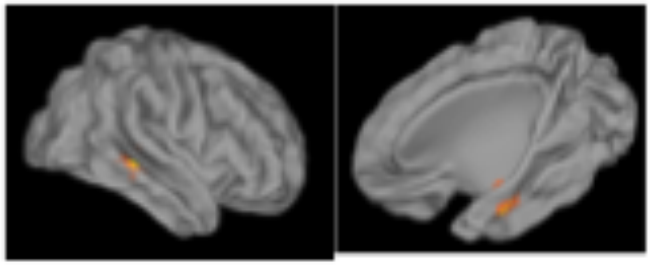
Ozernov-Palchik et al., (in prep.)

Distinct patterns of grey matter volume reductions in the risk groups as compared to the average kindergartners

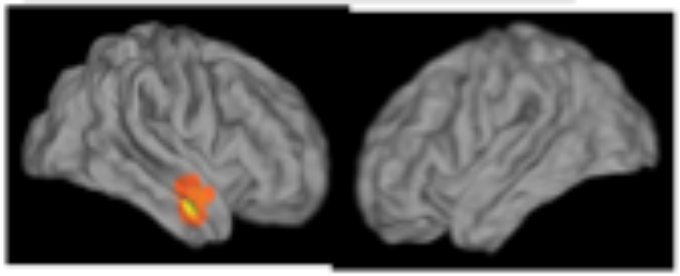
Average > Low-Risk



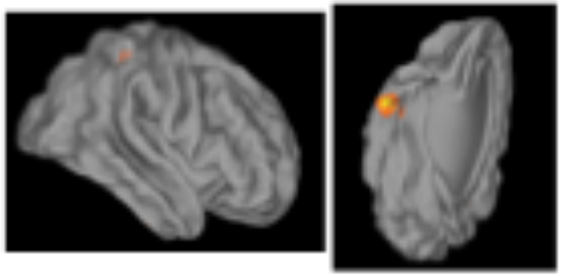
Average > Double Deficit



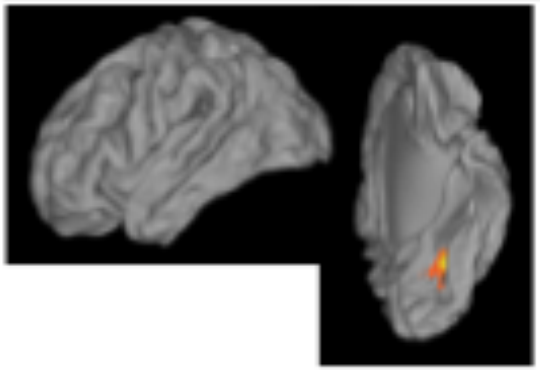
Average > RAN Risk



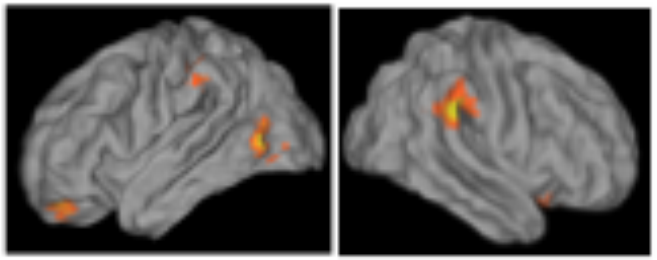
Average > PA Risk



Low Risk > DD Risk



DD Risk > LSK Risk



Ozernov-Palchik et al., in prep.


37%

61% AA
54% H
26% EA

Third Lesson:

Using the Reading Brain Circuit to Inform Instruction and Intervention


The Dyslexia Paradox
Early Intervention is Best.
Identification at 9 is the Norm.

Components of the Reading Brain Circuit (POSSuM)

Millisecond Connections

Deep Reading Processes

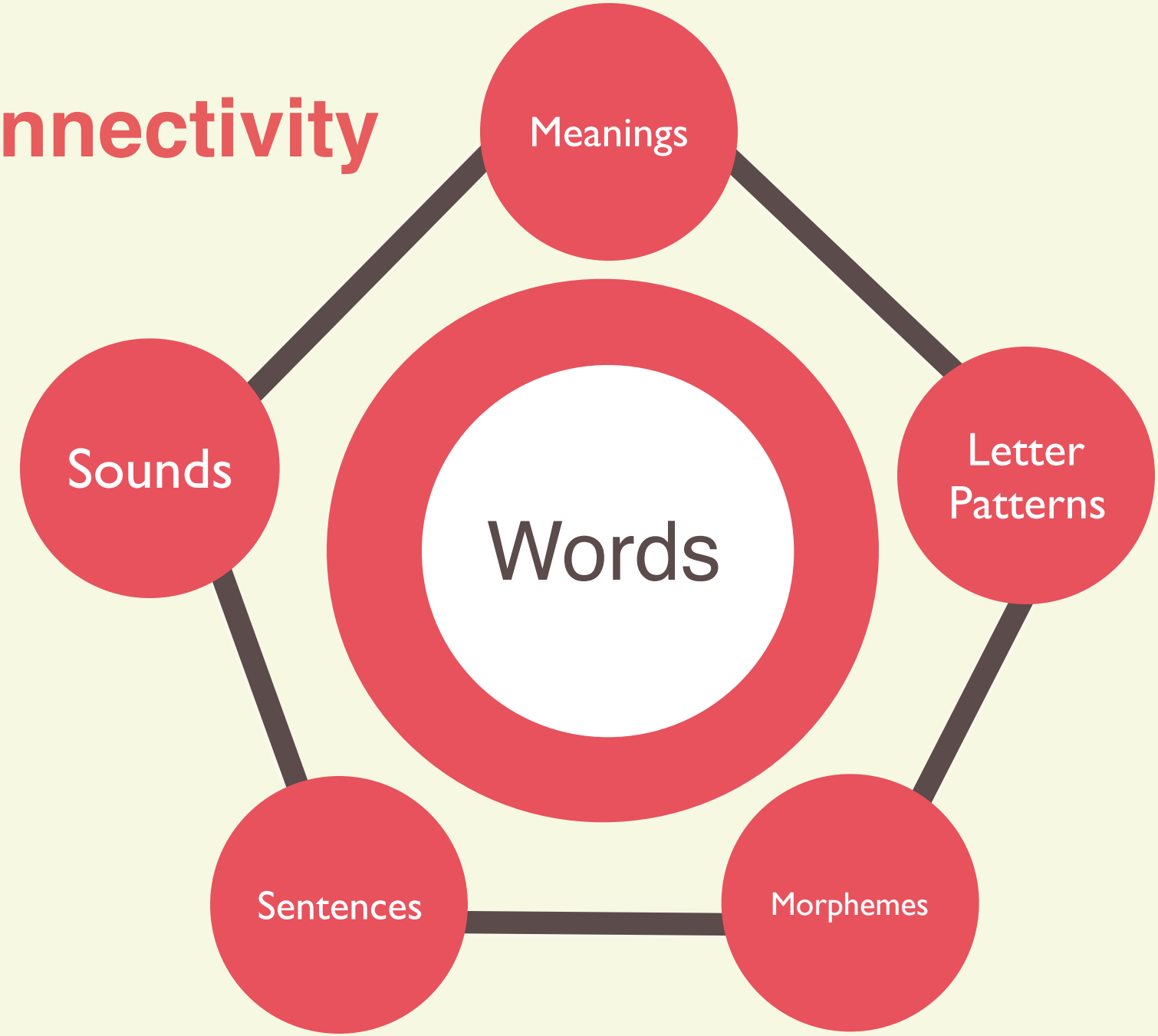
Reverse Engineering of Reading Brain Components for Differences in Dyslexic Brain and Dysfluent Readers

1. Explicit emphases on circuit parts and how words work

2. "Deep reading" comprehension processes

3. Their millisecond connections

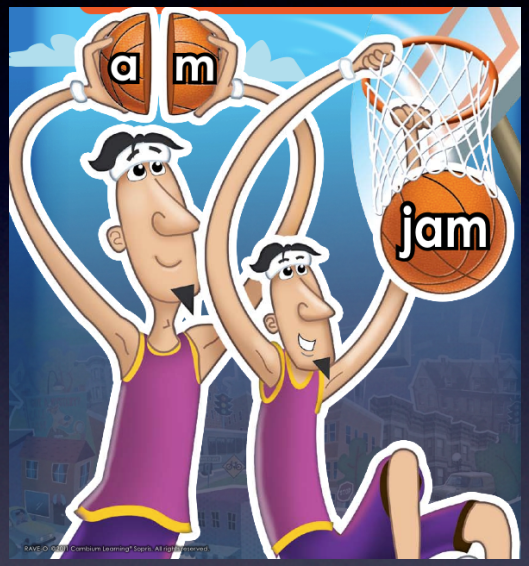
Connectivity



RAVE-O Characters

Metacognitive Strategies Embodying Circuit

RAVE-O Characters: Metacognitive Strategies Addressing Each Component



Strategies for semantic skills

Many Interesting Meanings

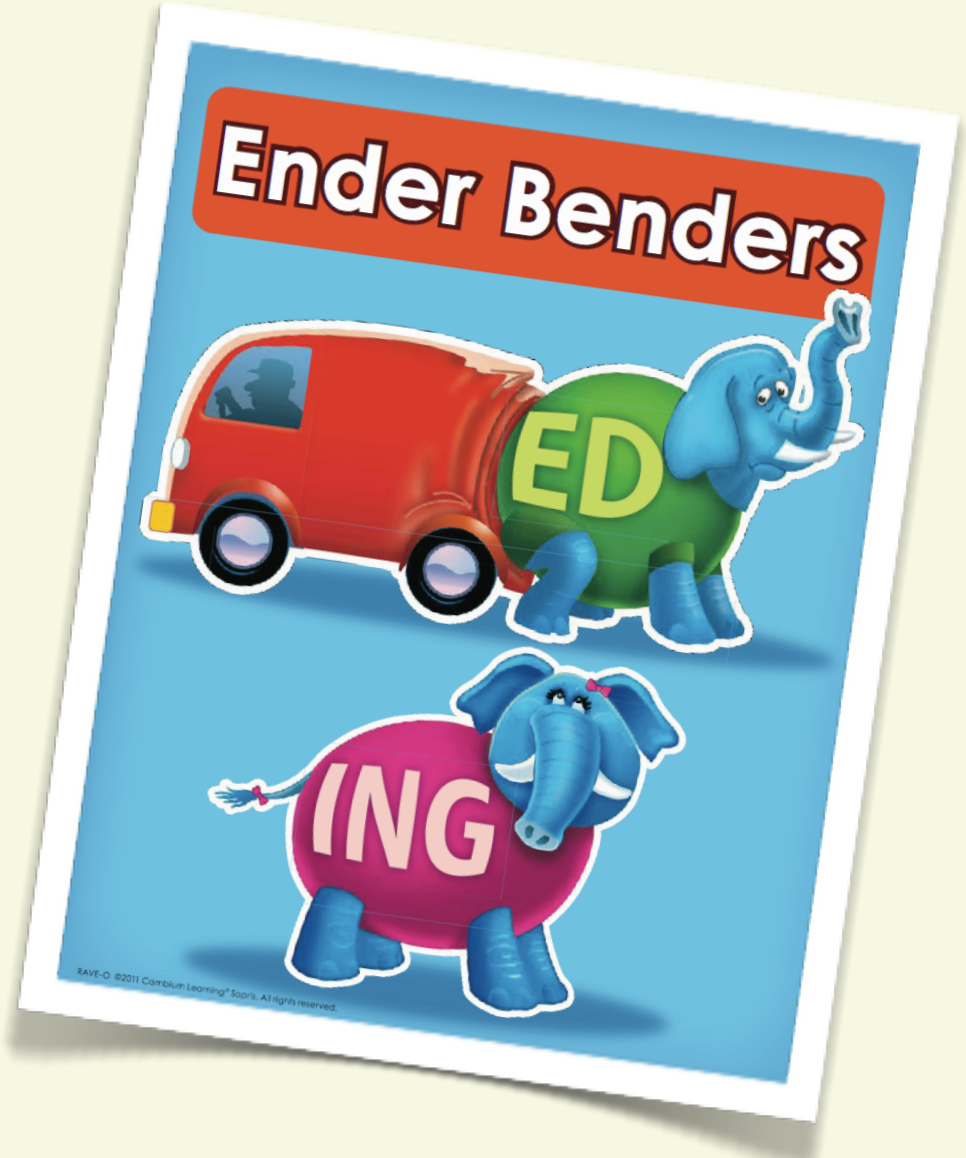
Many Interesting Connections

Morphological Analysis Skills

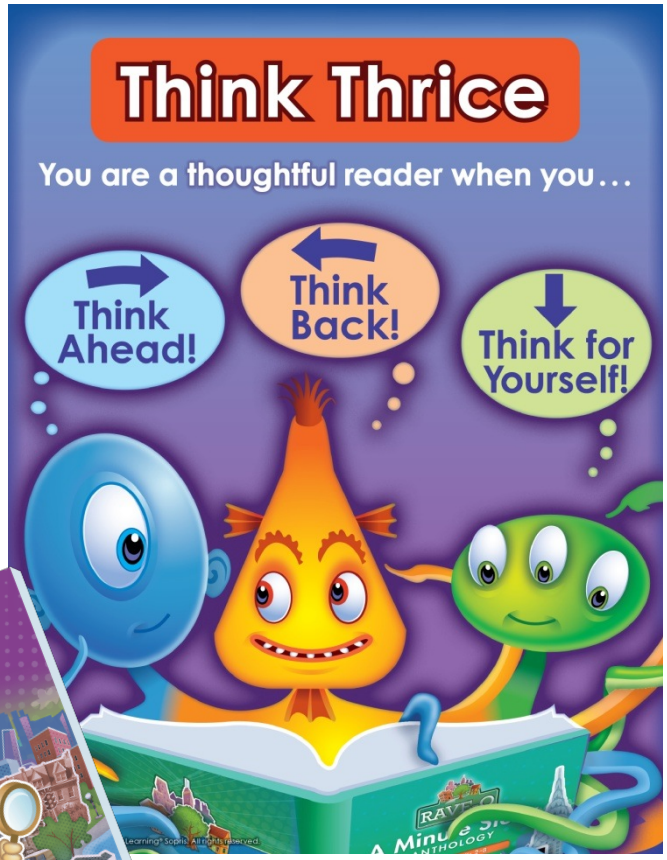
j am s

j am m ing

j am m ed



Strategies that Promote Memory

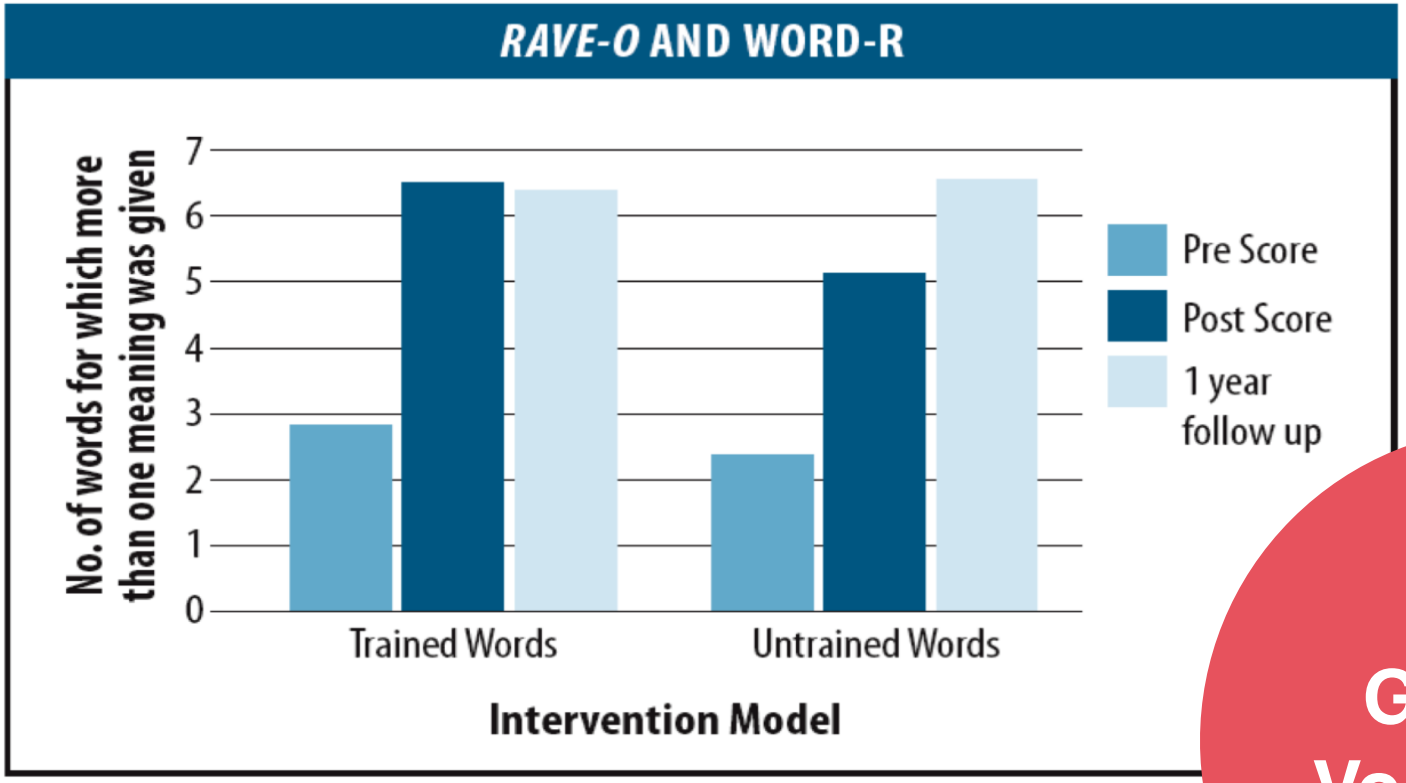


- Interesting Characters
- Strategies to Support Memory

"Think Thrice" is one way students learn to interact with text in a meaningful way.

WORD-R Test (elementary): Expressive Vocabulary and Semantics

Gains both short- and long-term in vocabulary knowledge and semantic flexibility after 70 one-hour instruction sessions.



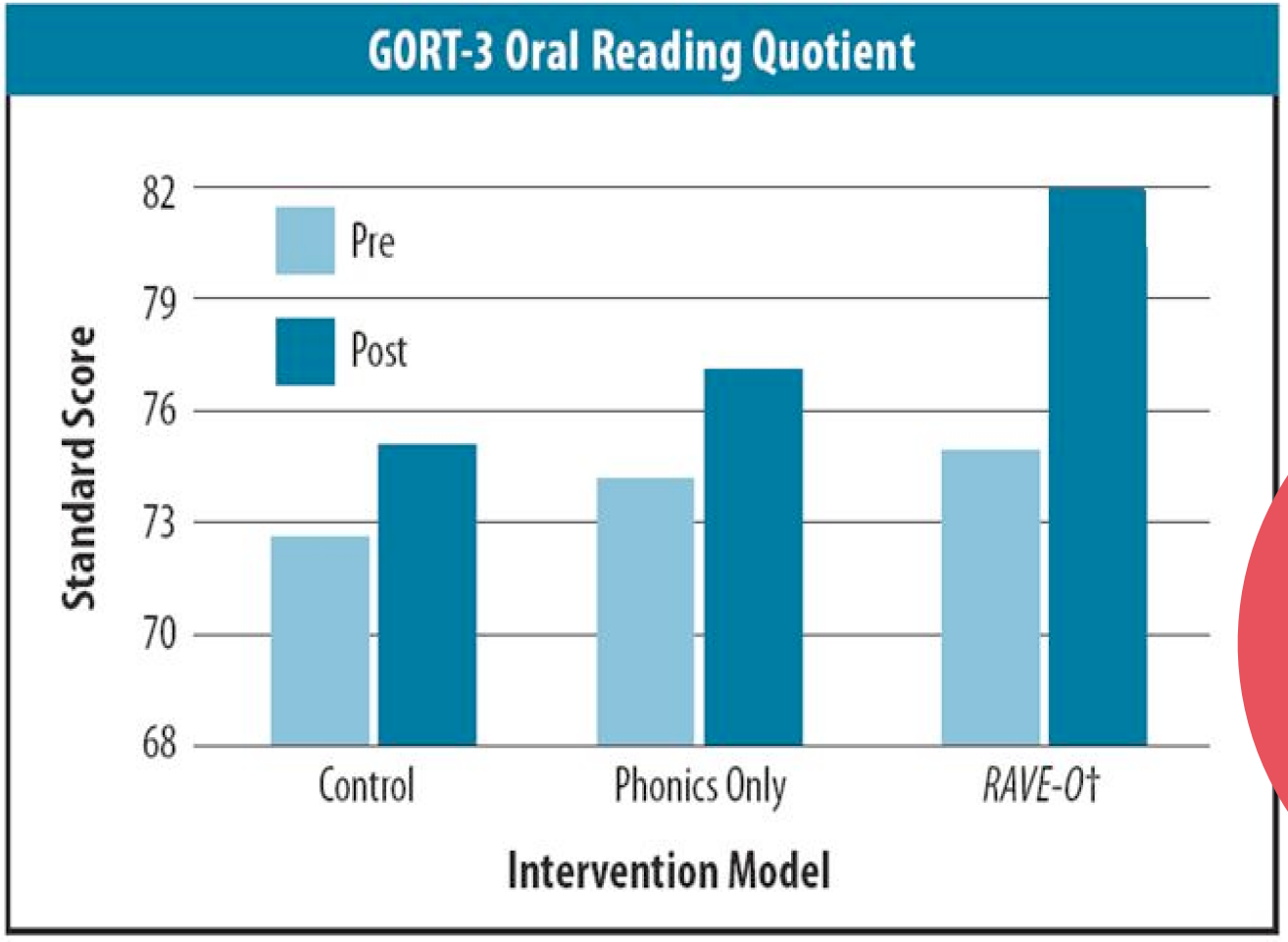
Trained Words = *RAVE-O* Core Words Untrained Words = Word-R T

(All results significant at $p \leq .001$ level.)

Gains in Vocabulary

Gray Oral Reading Test-3: Fluency and Comprehension

Changes in Oral Reading Quotient (fluency + comprehension) Standard Scores on Gray Oral Reading Test-3 after 70 one-hour instruction sessions.



Gains in Text Reading & Comprehension

Study Population GAP

Characteristic	Distribution
SES	50% High- 50% Low
Race	50% CA - 50% AA
IQ	50% Average- 50% Below Avg.

Learning Rate was SAME for all groups: GAP remained, but arrested. Implications for preschool language and later emphases.

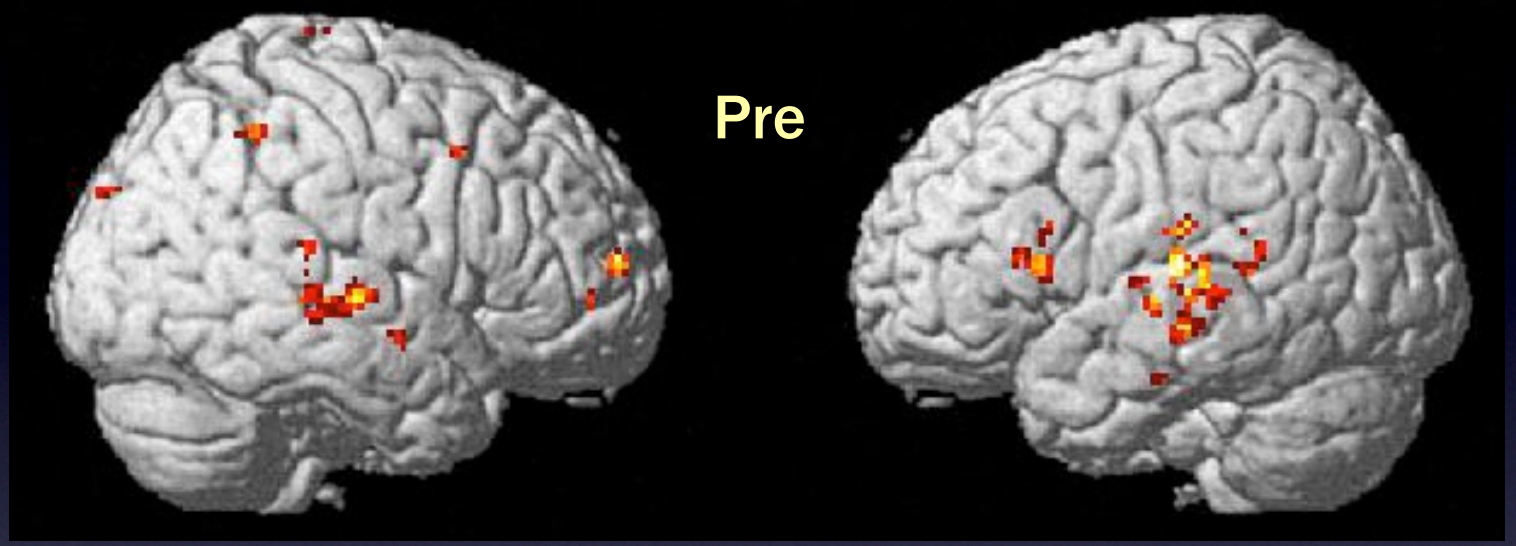
Auditory Rhyme > Rest

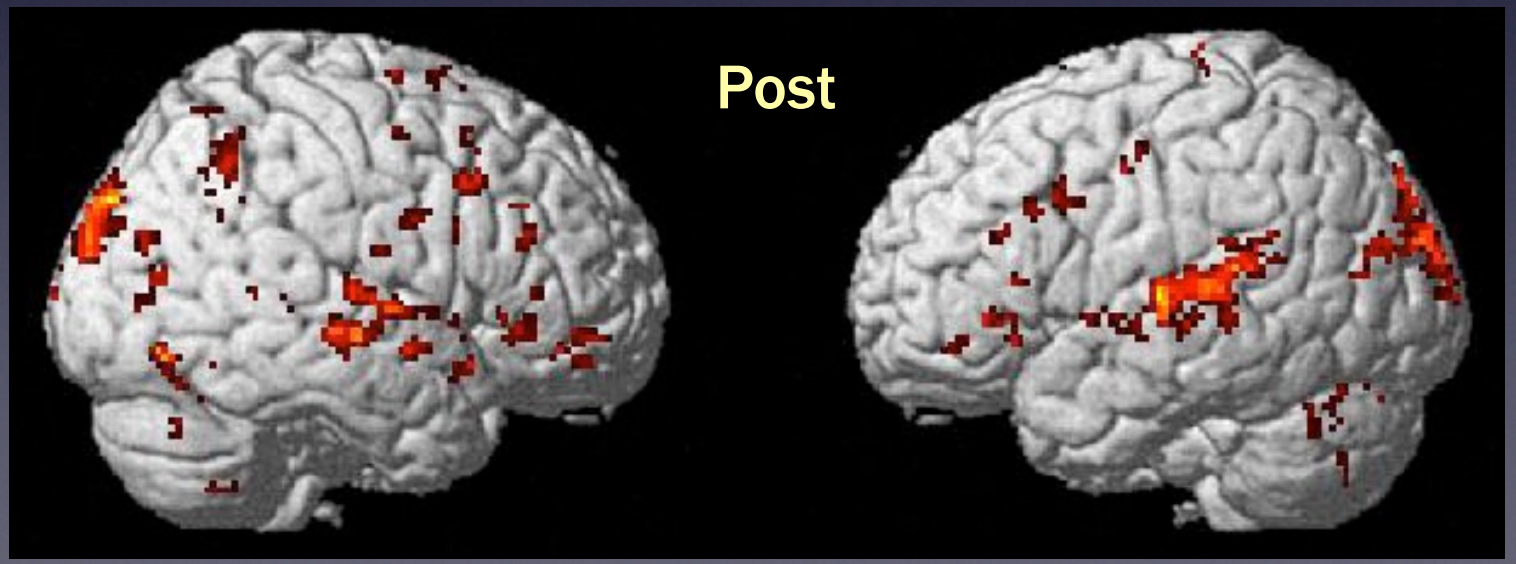
Audio Task

-Task vs. Rest
-Rhyme vs. Match

Visual Task

-Task vs. Rest
-Rhyme vs.Match





- $p < .005$
- $k > 5$

Fourth Lesson

Knowledge about the plasticity of the "reading brain" and its intervention informs our questions about the *transition as a species to a digital culture*

What are the deeper implications of having a **plastic reading circuit** as we move to a digitally dominated set of **mediums**?

"The real question is whether the affordances of reading on screen lead us to a new normal, one in which *length* and *complexity* … and *memory* and especially *concentration* are proving more challenging."

(Baron, 2015--CASBS 2013-14)

“Skimming is the new normal”:
So is Distraction, Attention Switching, and Voluminous Information

1.

In scanning, browsing, bouncing, keyword spotting

(Liu, 2005, 2009,2014)

2.

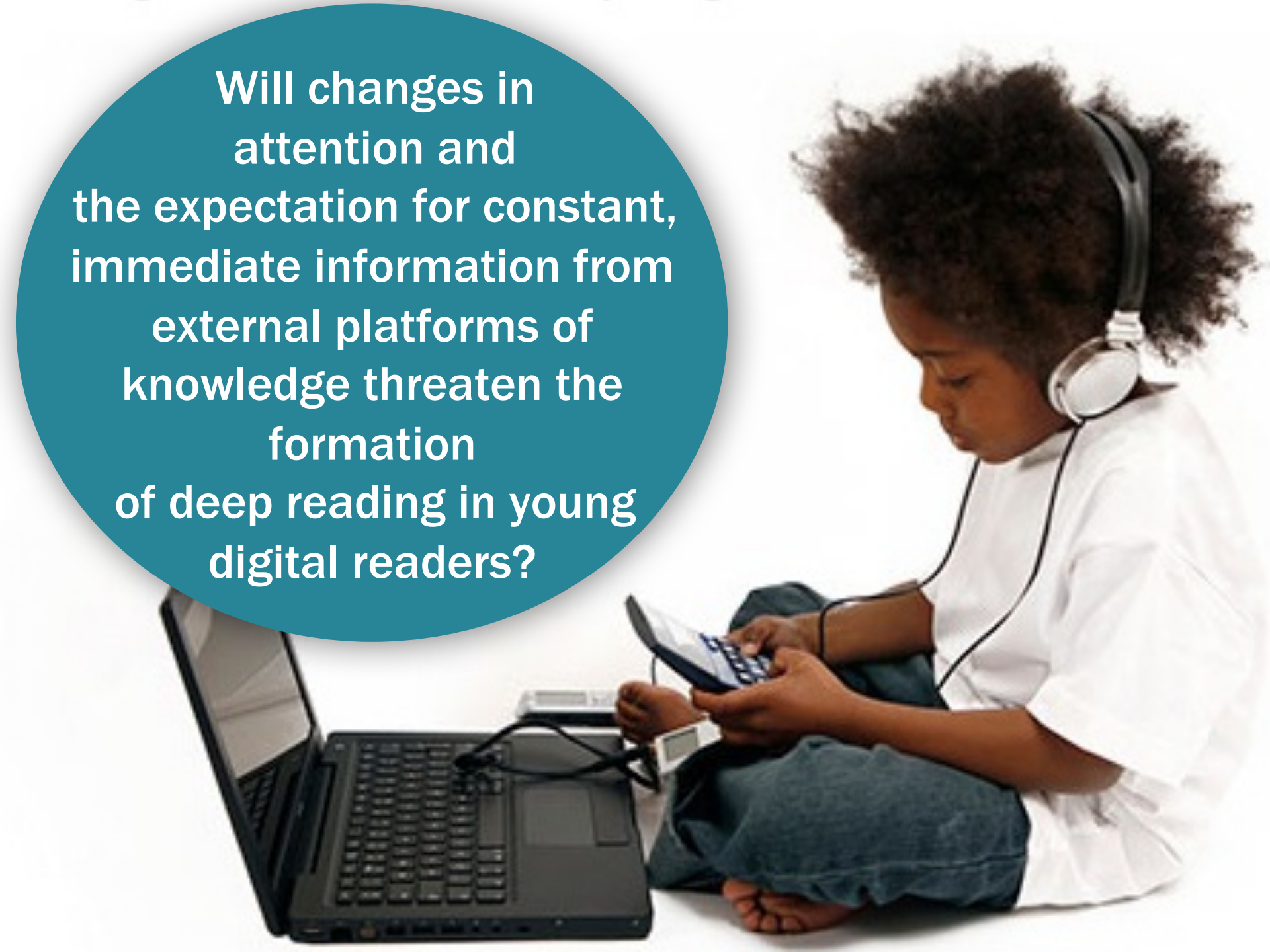
Less time on in-depth, concentrated reading; 27 distractions an hour.

3.

Decreased sustained attention and memory.

(Baron,2014)

Will changes in attention and the expectation for constant, immediate information from external platforms of knowledge threaten the formation of deep reading in young digital readers?



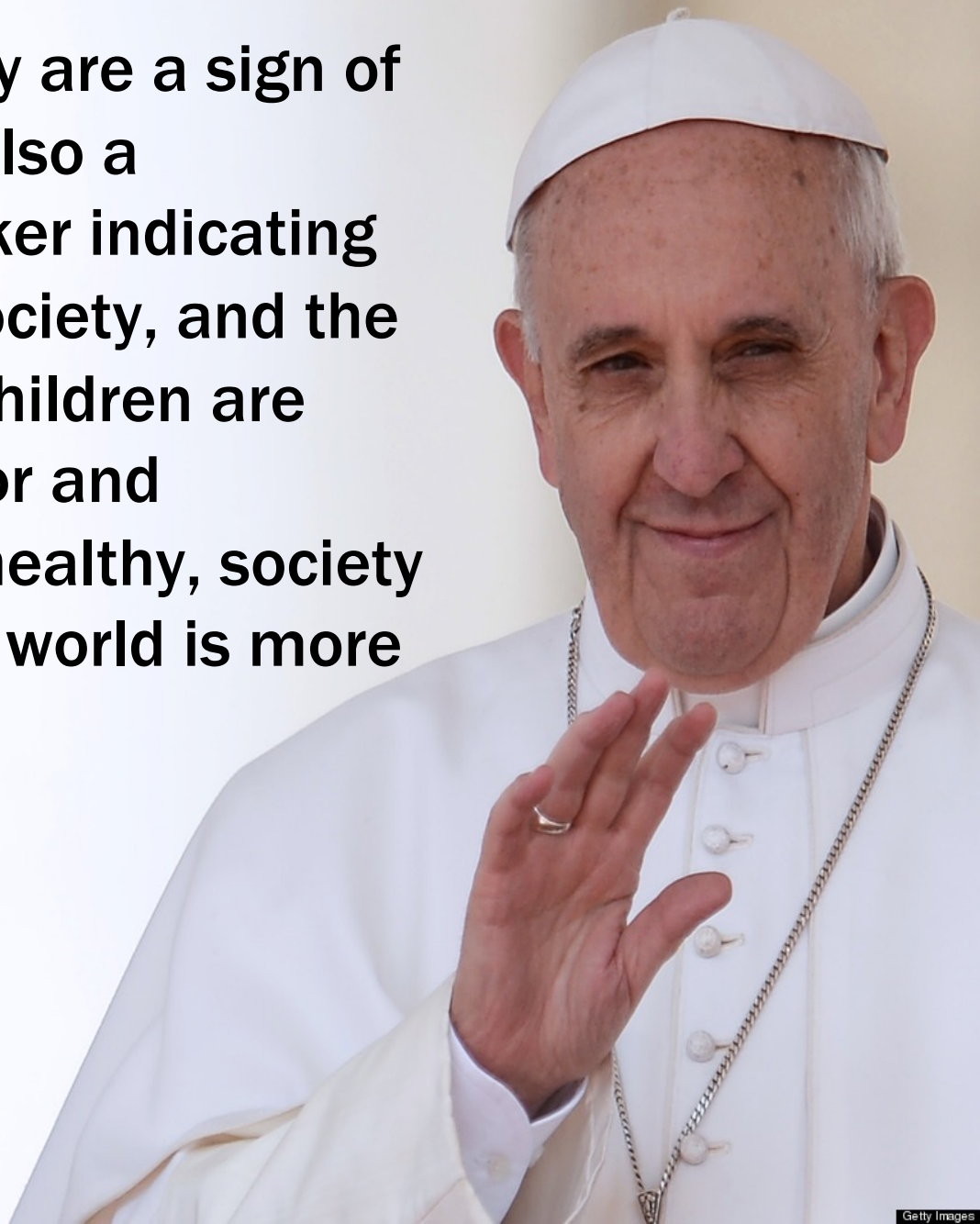
We can not go back to a pre-digital time; but, we should not lurch forward without understanding **what we will lose**, **what we will gain**, for our species' cognitive repertoire.


Can all children become literate?
Can we create an experience on a tablet that can help children learn to read who have inadequate or no schools in remote parts of the world or our backyards?


CURIOUS LEARNING: A Global Literacy Project
Collaboration: Tufts University, MIT MEDIA LAB, GSU


A
B
C
D
E
F
G
H
I
J
K
L
M
N

“Children are a sign. They are a sign of hope, a sign of life, but also a “diagnostic” sign, a marker indicating the health of families, society, and the entire world. Wherever children are accepted, loved, cared for and protected, the family is healthy, society is more healthy, and the world is more human”.



Our Hope with YOU for the Next, Literate Generation