



## **THE READING BRAIN:**

***“We Were Never Meant To Read”***

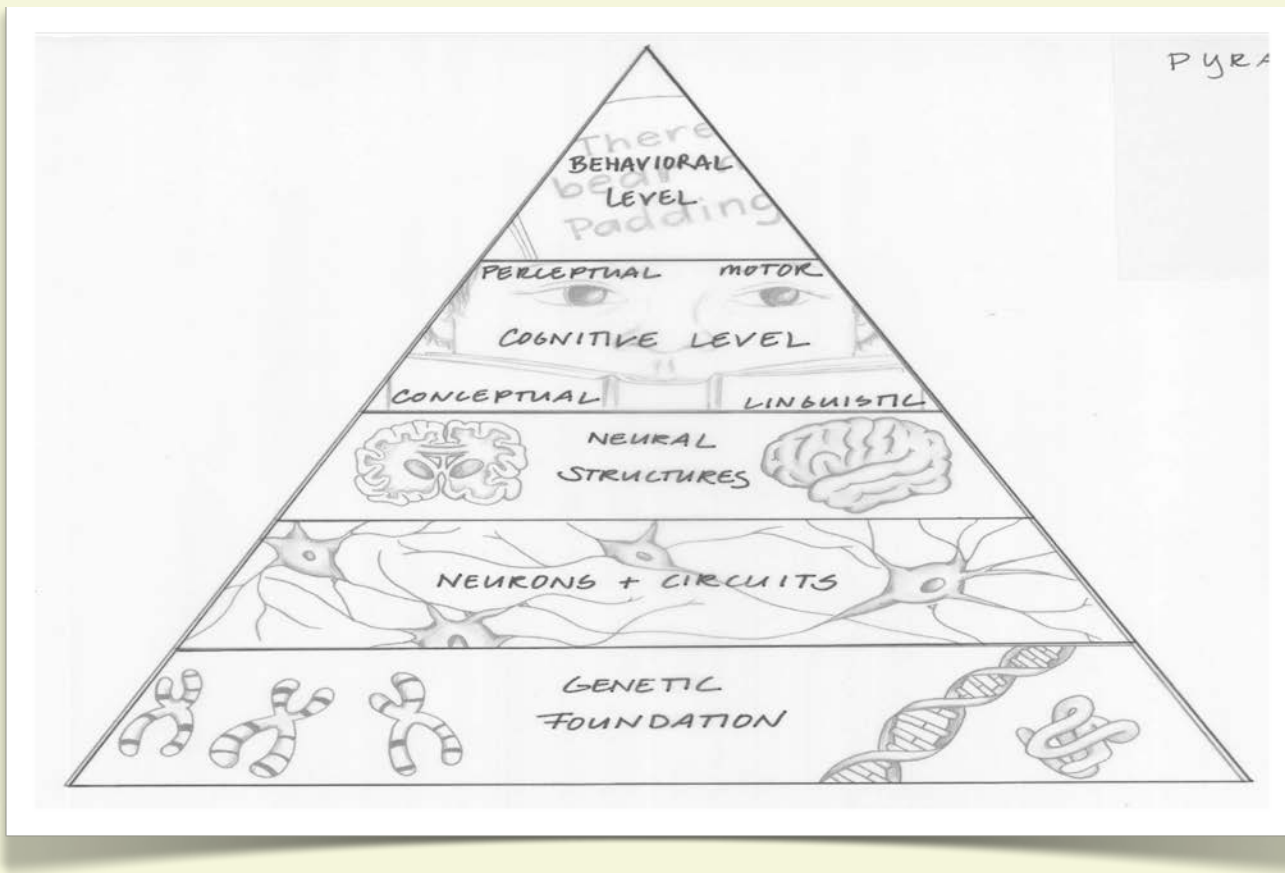
Maryanne Wolf

Ministry of Education, Science, and Culture

Reykjavik, Iceland

# Center for Reading and Language Research

- Maryanne Wolf, Director
- Stephanie Gottwald, Asst. Director, Linguistics, Teacher Training
- Yashira Perez, Genes, Dyslexia, African-American & Latino children
- Cathy Moritz, Music and Reading
- Yvonne Gill (Arizona) and Lynne Miller, Curriculum Development for RAVE-O Basic and Plus
- Mirit Barzillai, Semantics, Global Literacy, Technology
- Elizabeth Norton, Brain Imaging in Early Predictors of Dyslexia
- Kate Ullman, African-American Dialect and Reading
- Surina Basho, Memory and Dyslexia Subtypes
- Melissa Orkin, Affective Development and Dyslexia



# The Study of Reading and Dyslexia from Boston to Reykjavik:

Part 1: Reading Development

Part 2: Dyslexia, Reading in Digital Age; Global  
Literacy

# Part 1: What can we know?

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The **reading brain circuit**  
development

**Dyslexia** and all **struggling** readers

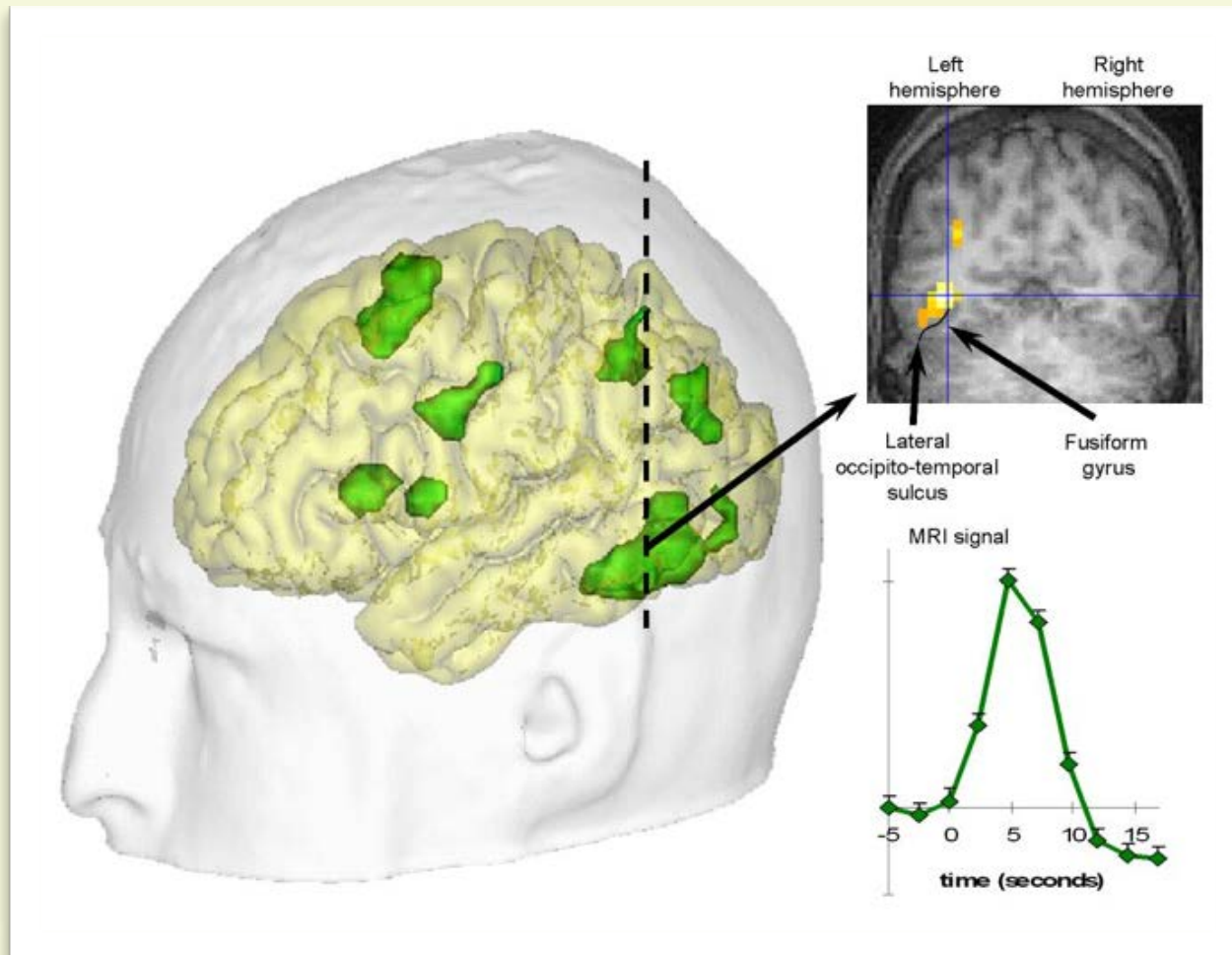
How do we **connect knowledge**  
about the reading brain in schools and  
in concepts of dyslexia?



The human brain was never born to read.

How did the human brain learn to read with  
**no genetic program or specific reading center?**

# Dehaene's Concept of “Neuronal Recycling” for Numeracy and Literacy



# Principles of Brain Design

## Underpinning Cultural Inventions

- Ability to form new **connections**
- Capacity for “working groups” of neurons to **specialize** (pattern recognition)
- Capacity for **automatization**

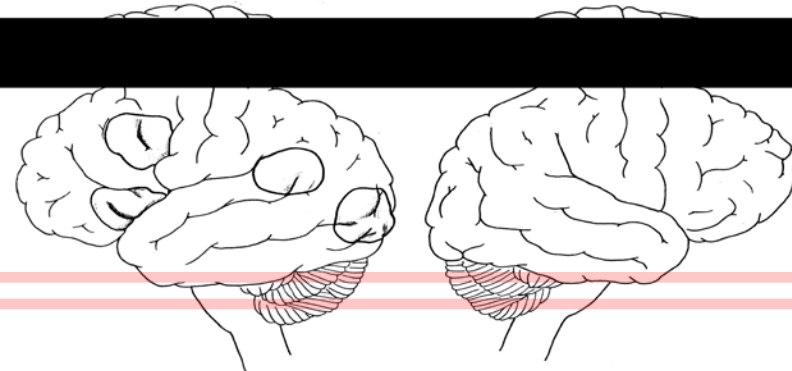




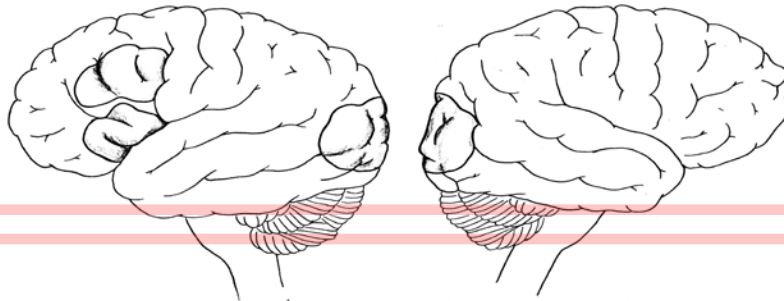
**Existing circuits of neurons-  
originally designed for vision, language,  
and cognition -  
learned to forge a  
whole new reading circuit.**

# Multiple Circuits of Reading Brain

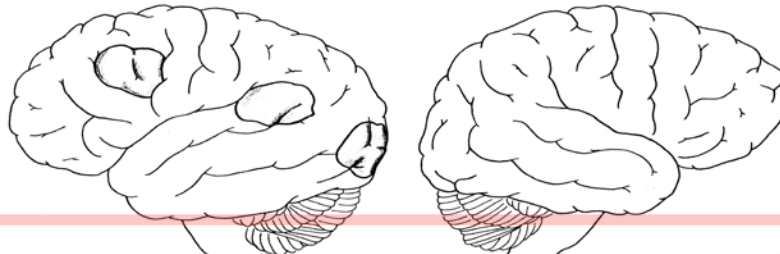
**English  
and  
Icelandic**



**Chinese  
& Kanji**

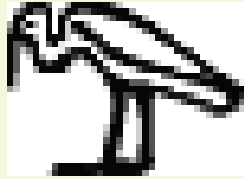


**Japanese  
Kana**

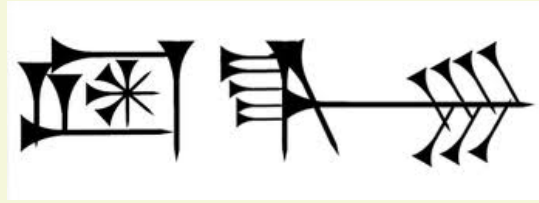


**Brain can  
rearrange itself  
in multiple ways  
to read,  
depending on  
writing system  
and medium.**

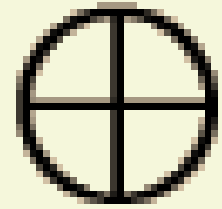
Bulger, Perfetti, & Schneider



Symbolic  
representation



Symbols for  
language and concepts



**ka**

Symbol for  
each sound



2000 years

**Development of Insights into  
Written Language by the Species**

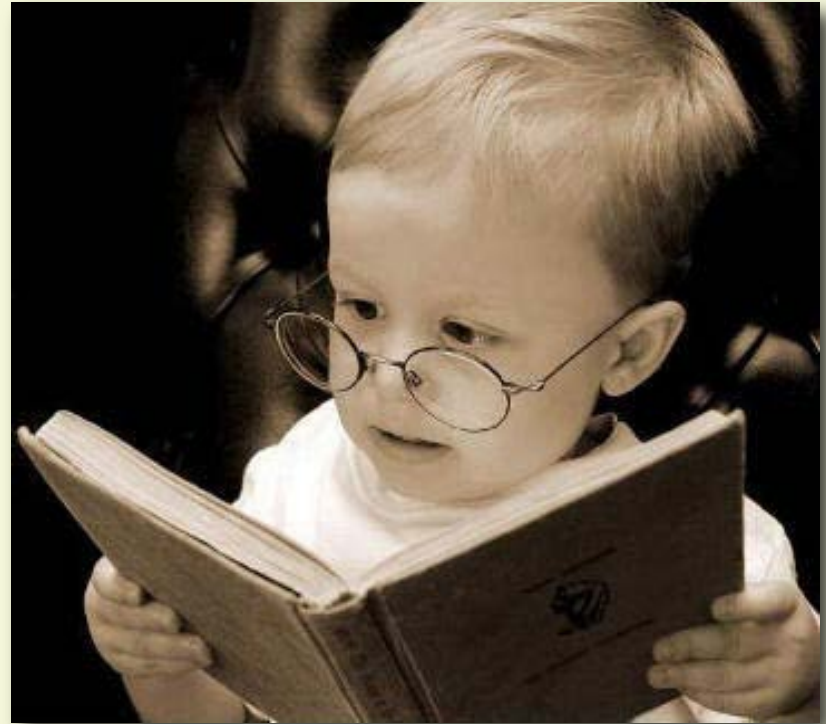
# Development of Reading



The child is given  
**2000 days** to  
gain the same  
insights.

# How does the Young Brain Learn to Read?

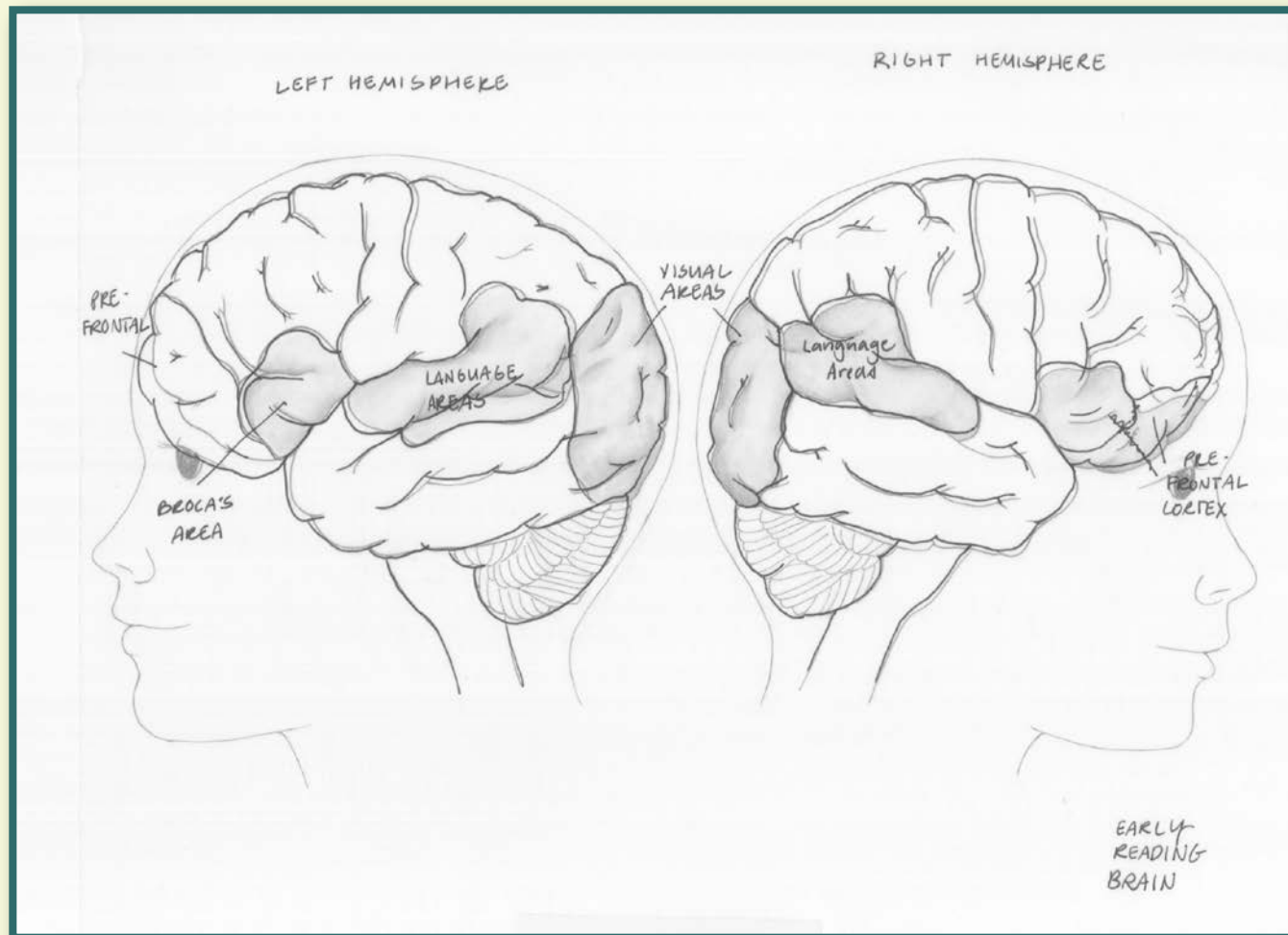
Each new reader must  
create a  
**new reading circuit**  
from older cognitive and  
linguistic structures and  
their connections



# Brain Imaging Center



# Early Reading Brain: Everything Matters in the Development of the Reading Circuit





## Cognitive Development: Concepts Matter

Concepts in first language are essential platform for concepts and vocabulary in second language

# Language Development

**P**honemes

**O**rthographic Patterns

**S**emantics

**s**yntax

**M**orphology



# Phonemes Matter

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Phoneme Awareness

Explicit Emphasis on Manipulation of Sound



# Orthography Matters

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Letters & Letter Patterns

Conventions of Print

Left to Right Scanning



## Sticker Story Hores

I like hores. Hores  
have other hores frinds. Hores  
like carrots. You woudn't think  
they could, but they can put thir  
legs strait up. Hores make you  
feel good. My dad wants a hores  
but my mom says no. When I am 16  
or 20 I will buy my own hores.



# Semantic Development

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Vocabulary

Semantic Depth & Breadth

Polysemy and Semantic Flexibility

# Semantic Neighborhood



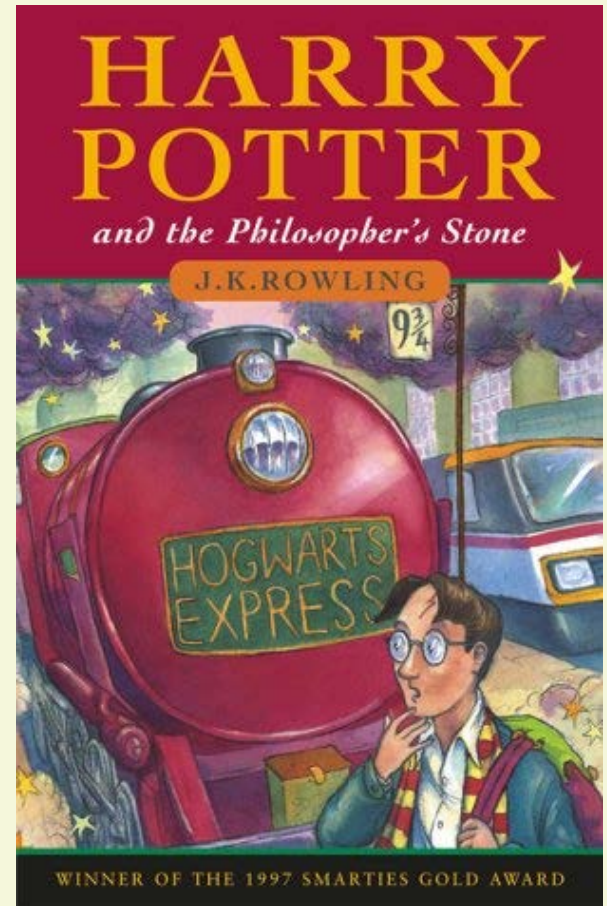
# Word Poverty

- “...economically and educationally disadvantaged children may have **one-half the oral language vocabulary** that is typical of children from middle-class homes with educated parents (Biemiller, 1999; Hart & Risley, 1995)
- By the intermediate grades, we found that the majority of the lower SES children in our study sample were **poorly prepared for the demands** of academic, expository writing (Moats, Foorman, & Taylor, 2006).

# Syntax Matters

“The only thing Harry liked about his own appearance was a very thin scar on his forehead that was shaped like a bolt of lightning.”

- J.K. Rowling



# Morphological Development

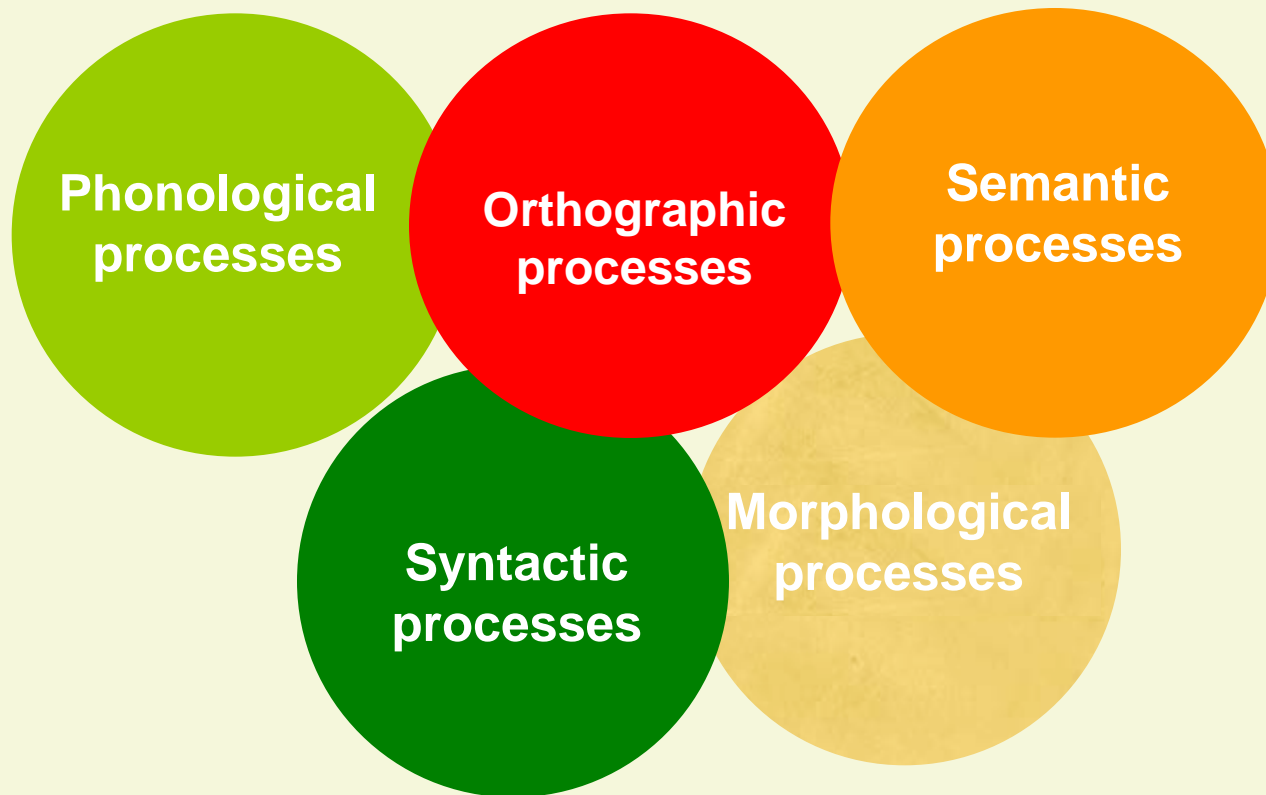
jam

jam**s**

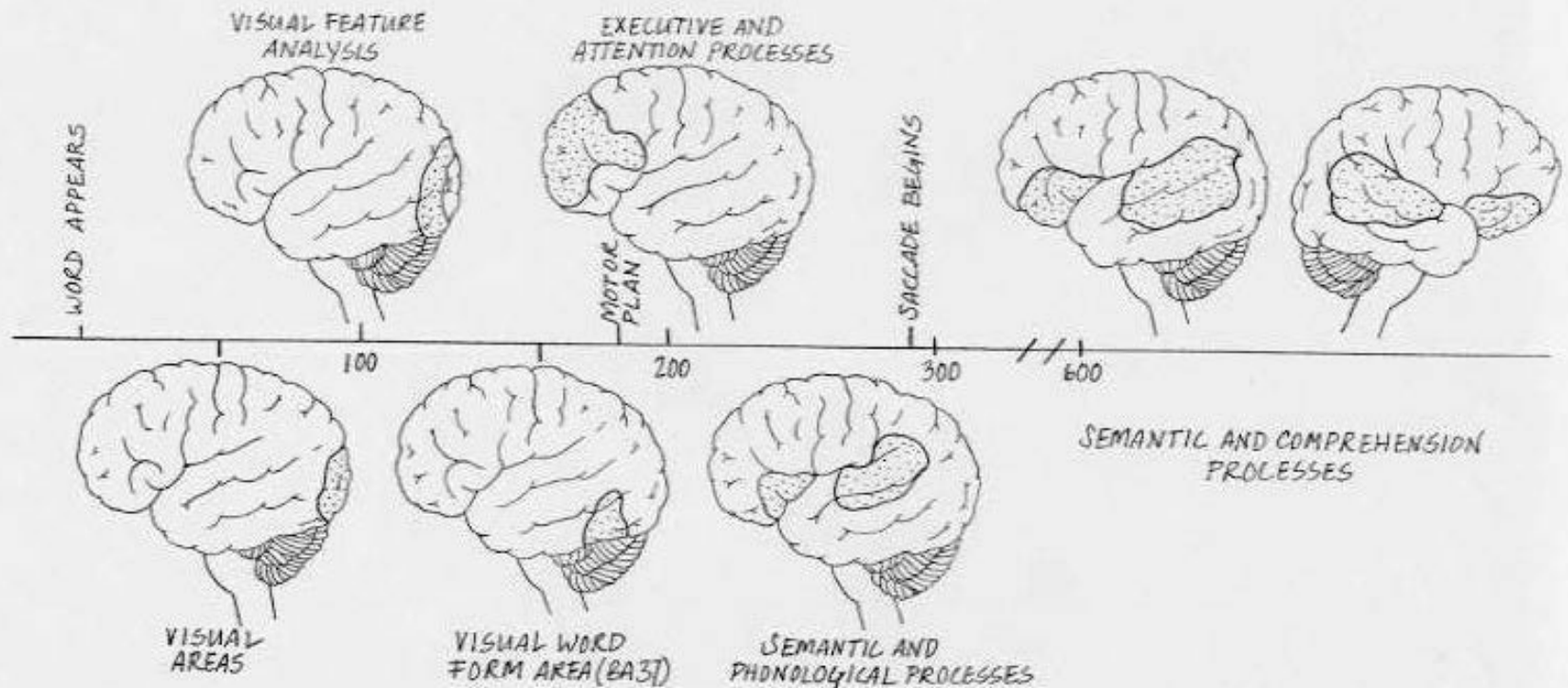
jam**ming**

**un**jam**med**

The more you know about a word  
...the faster you will read and  
comprehend that word.



# Expert “Deep Reading” Brain



# The Heart of Deep Reading

At the heart of reading, **100 to 200**  
**milliseconds**

allow us “time to think new  
thoughts” and to add whole new  
experiences and feeling.



We feel quite truly that our wisdom begins with that of the author...By a law which perhaps signifies that we can receive the truth from nobody, that which is the end of their wisdom appears to us as but the beginning of ours.

-Marcel Proust

Background  
Knowledge

Perspective-taking

Inference

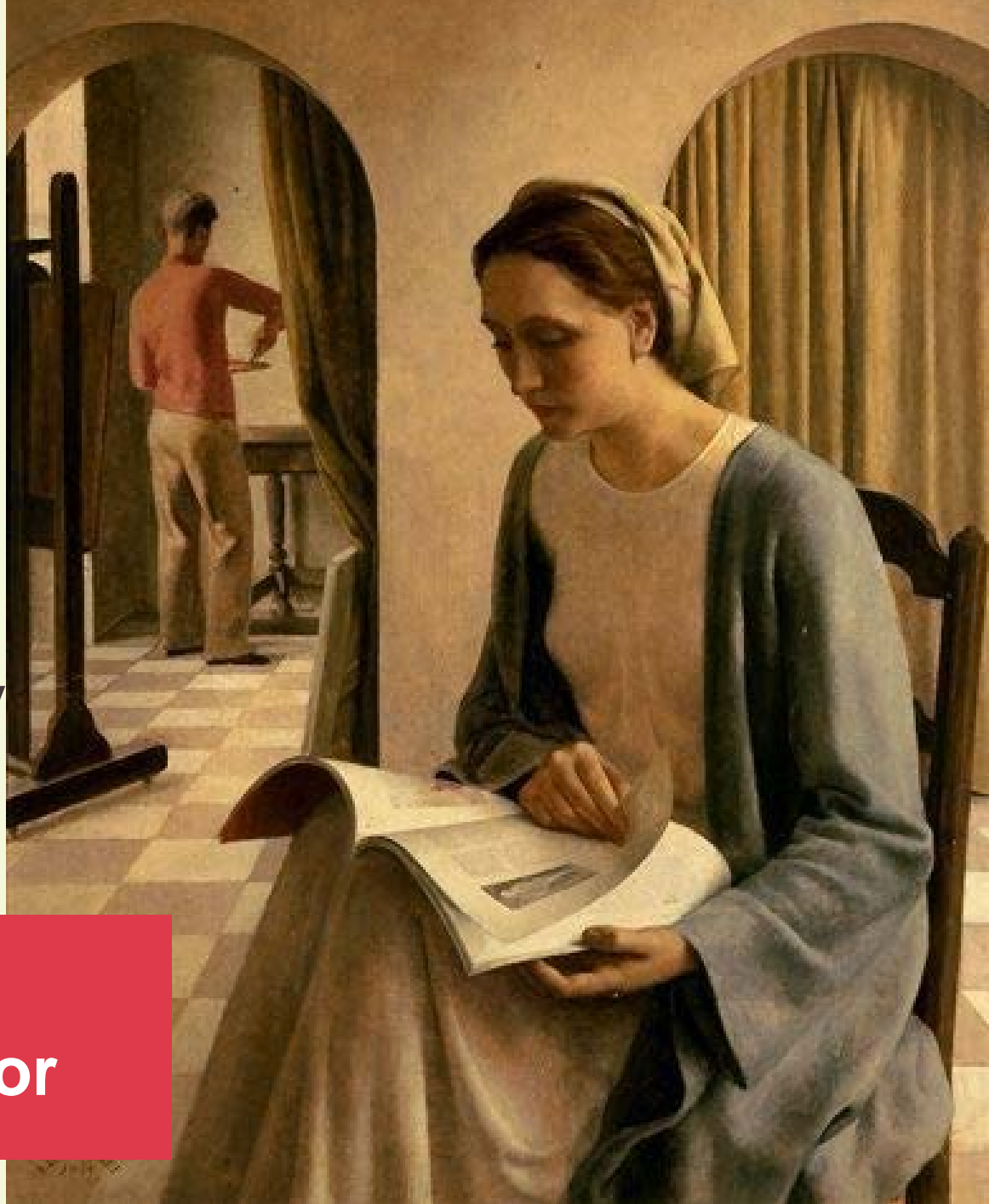
Analogies

Critical Analysis

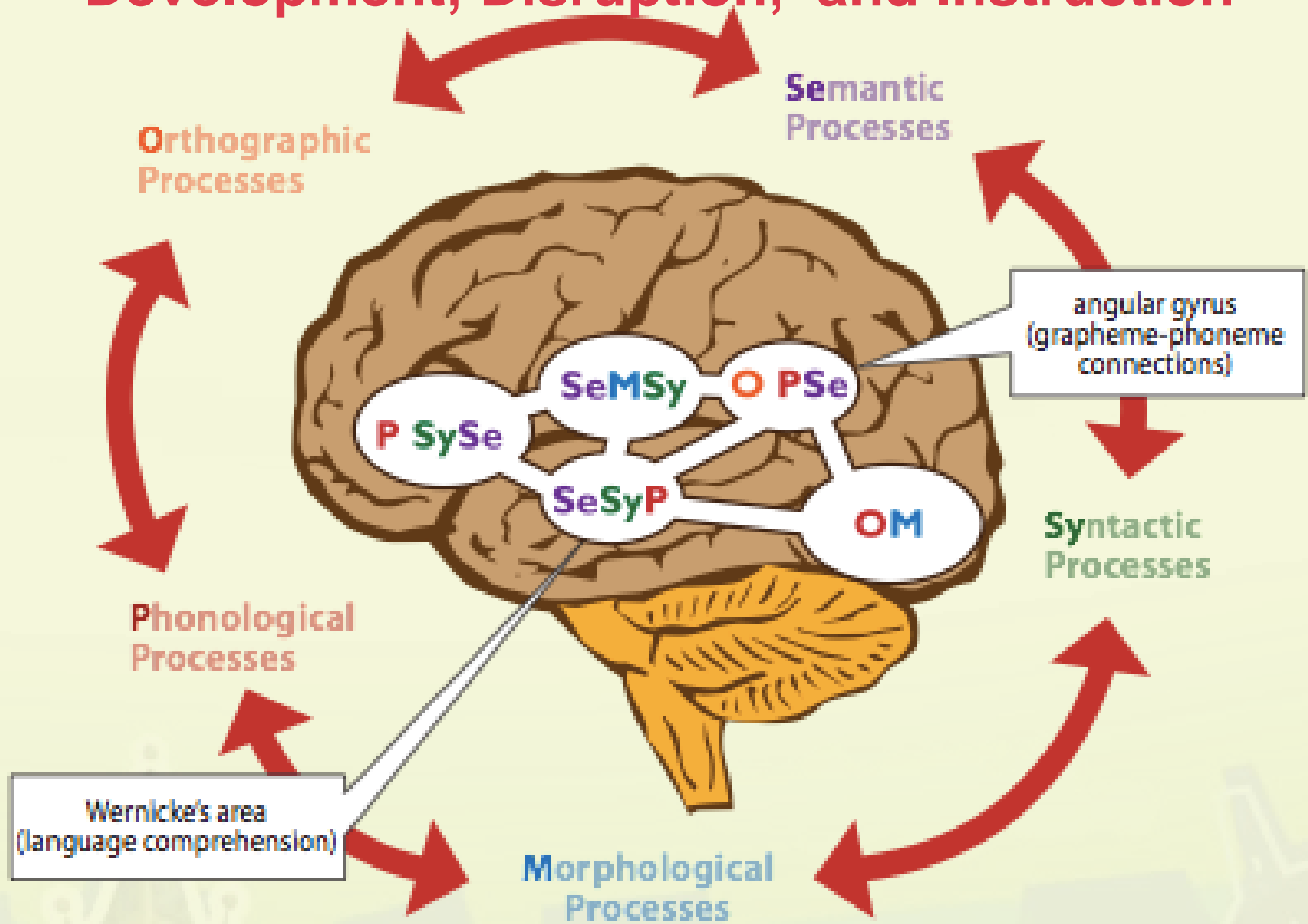
Insight and Epiphany

Contemplation

**Going beyond the  
wisdom of the author**

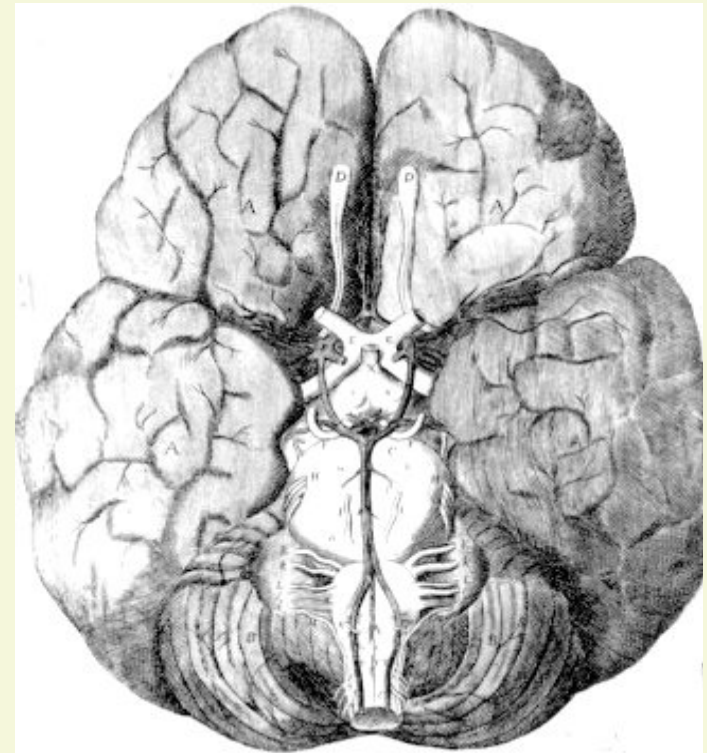



# The Reading Circuit: Basis of Understanding Development, Disruption, and Instruction



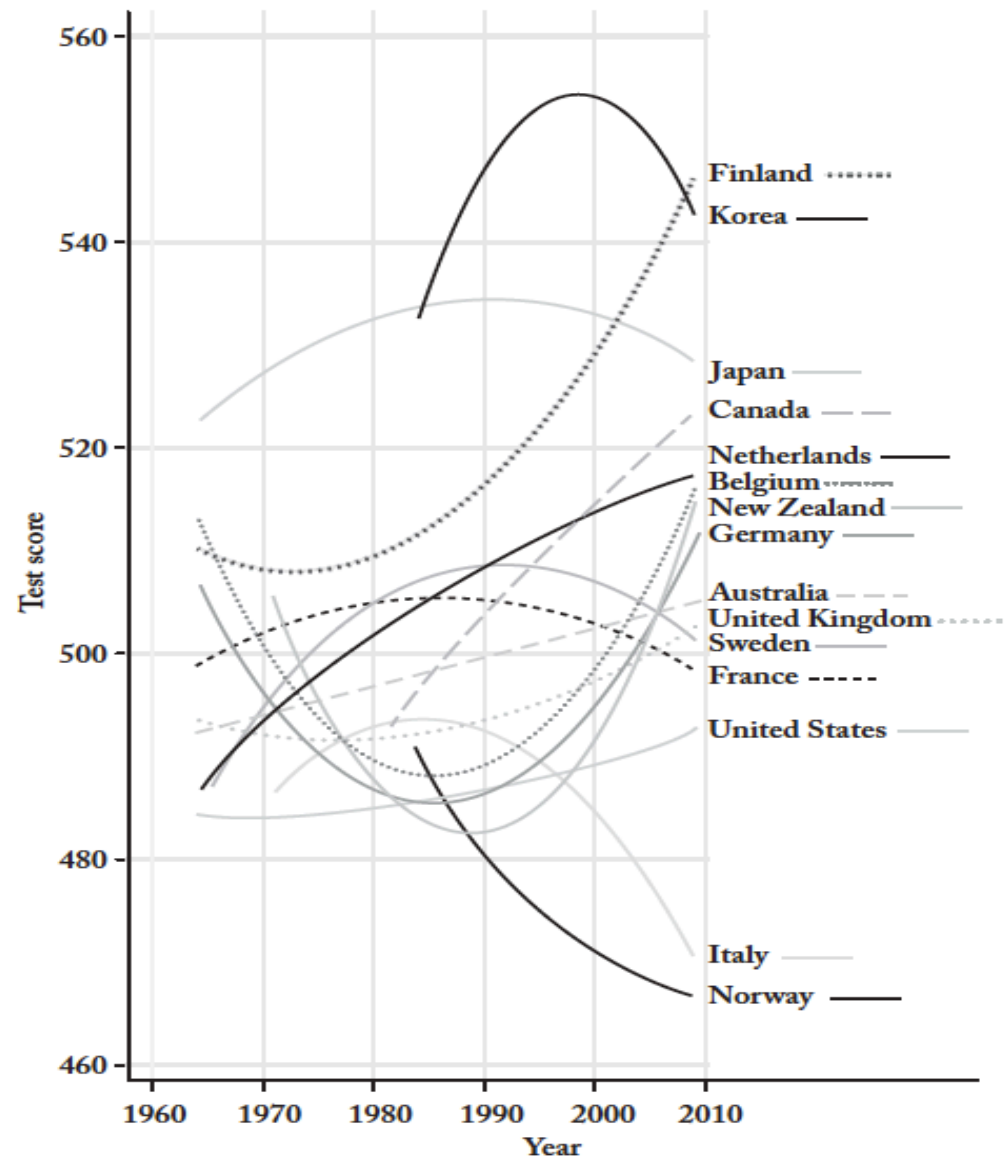
# Lessons from the Reading Brain for Struggling Learners and Dyslexia

- Differences in Circuit Parts: **FLUENCY** and **COMPREHENSION**
- **Language** Environment Differences
- **Different circuit** altogether in Dyslexia





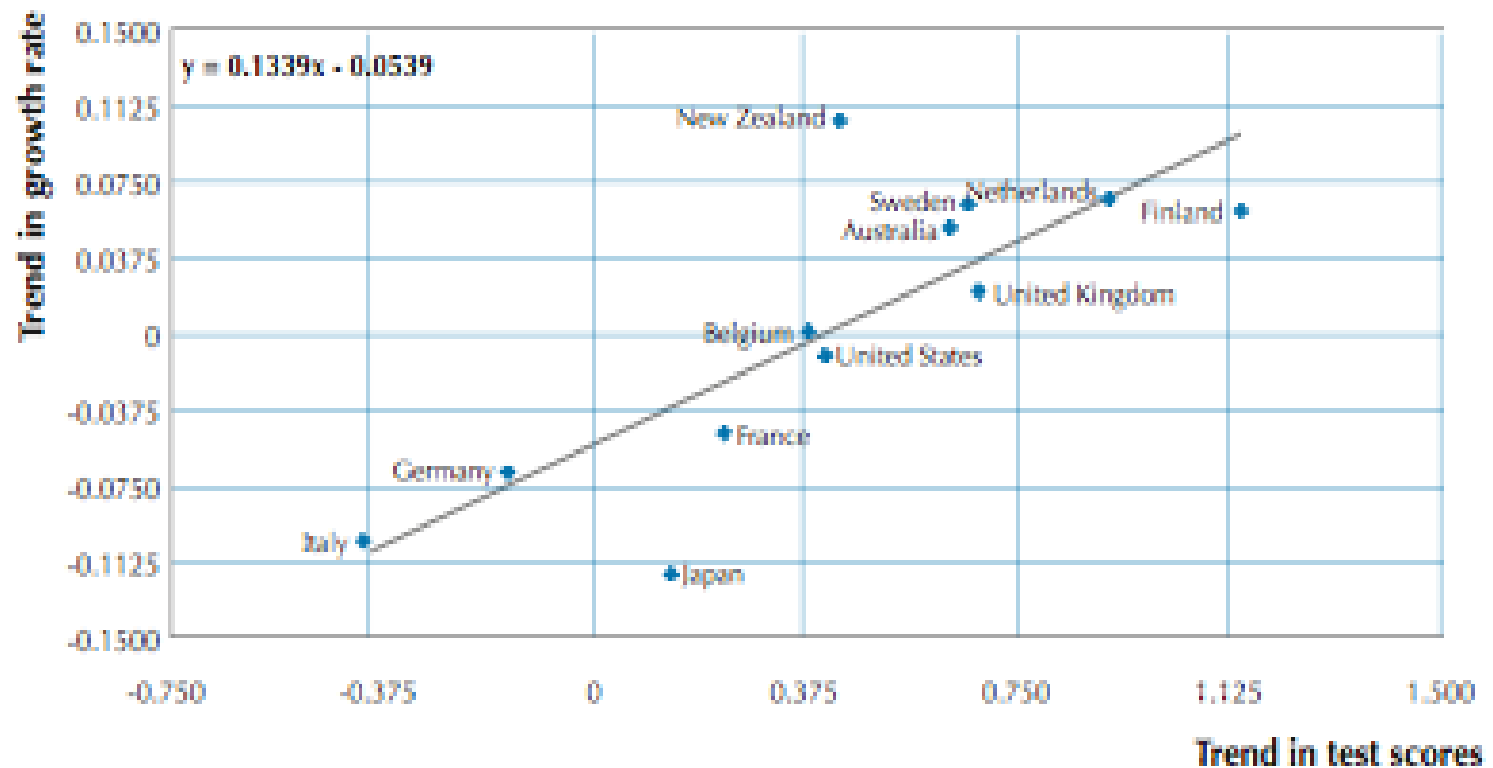
**37%**



Woessmann & Hanushek, 2010

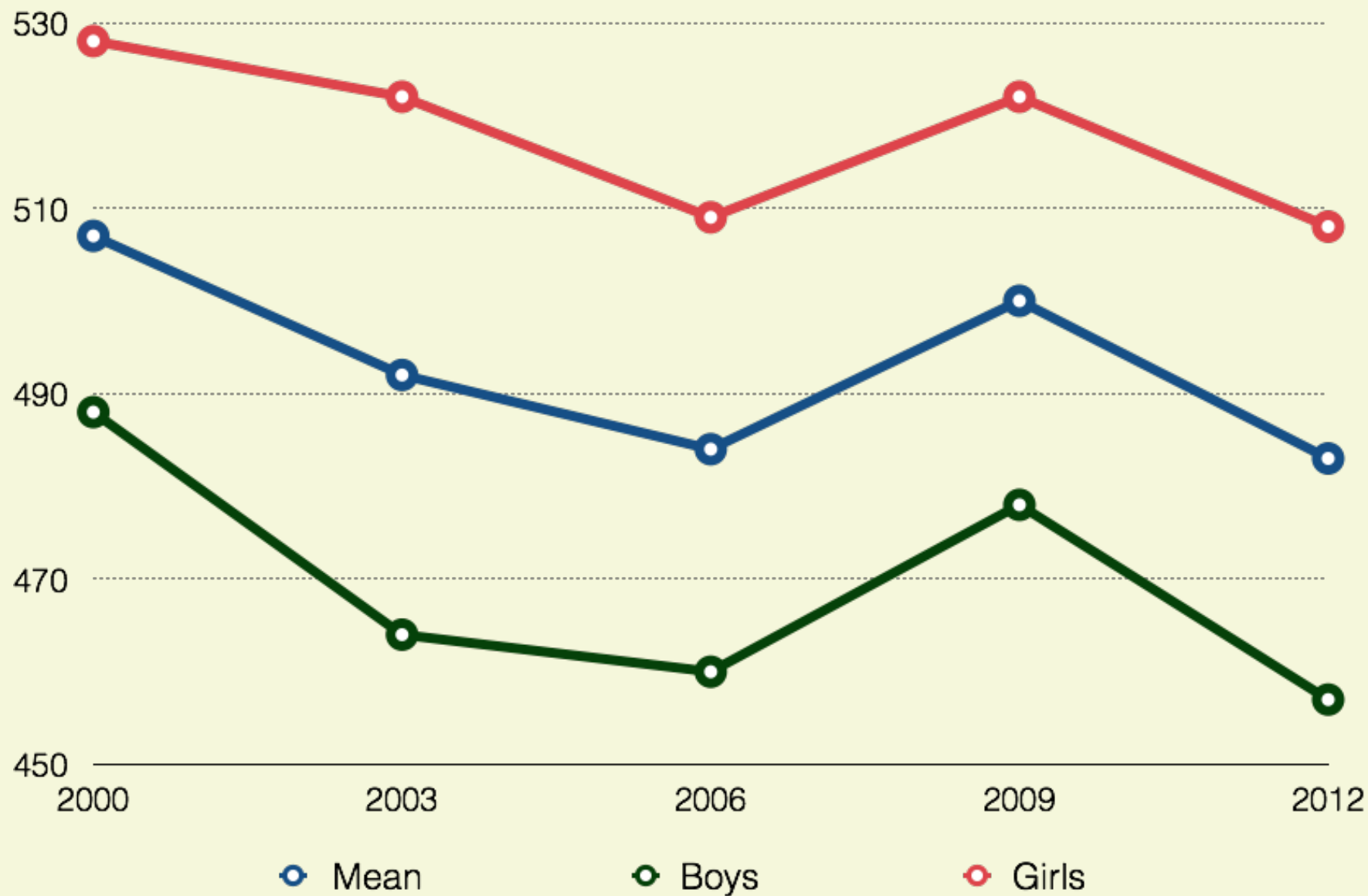
Figure 8

Trends in educational performance and trends in economic growth rates



Notes: Scatter plot of trend in the growth rate of GDP per capita from 1975 to 2000 against trend in test scores for countries whose test scores range back before 1972. Own depiction based on the database derived in Hanushek and Woessmann (2009).

PISA Results- Iceland- Reading



**Hypotheses for  
Gender  
Differences  
among Males**

**Maturation /Dyslexia**

**Possible lack of  
Explicit Instruction**

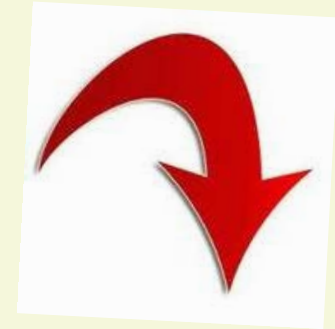
**Less time  
reading/more time  
digital  
devices/games**

**Lack of Fluency in  
Grade 4**

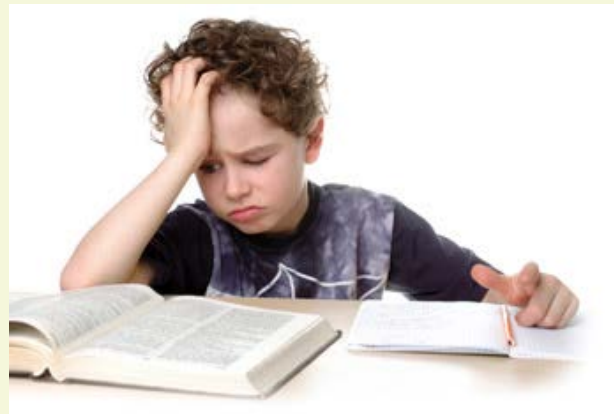
**Lack of Training in  
Later Grades**

# Effects of Poor Reading Fluency

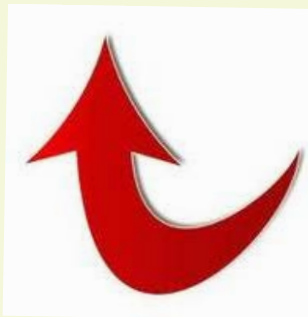
Can't keep up with  
classroom expectations



Lack of interest in  
independent  
reading



Lowers student's  
interest in  
learning



Low  
achievement

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

**o a s d p a o s p d**

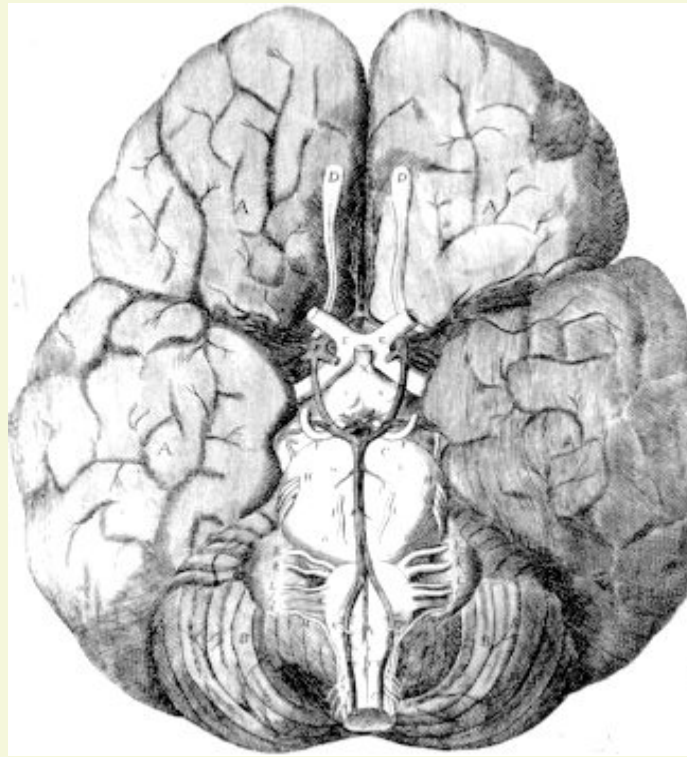
**s d a p d o a p s o**

**a o s p s d p o d a**

**d a p o d s a s o p**

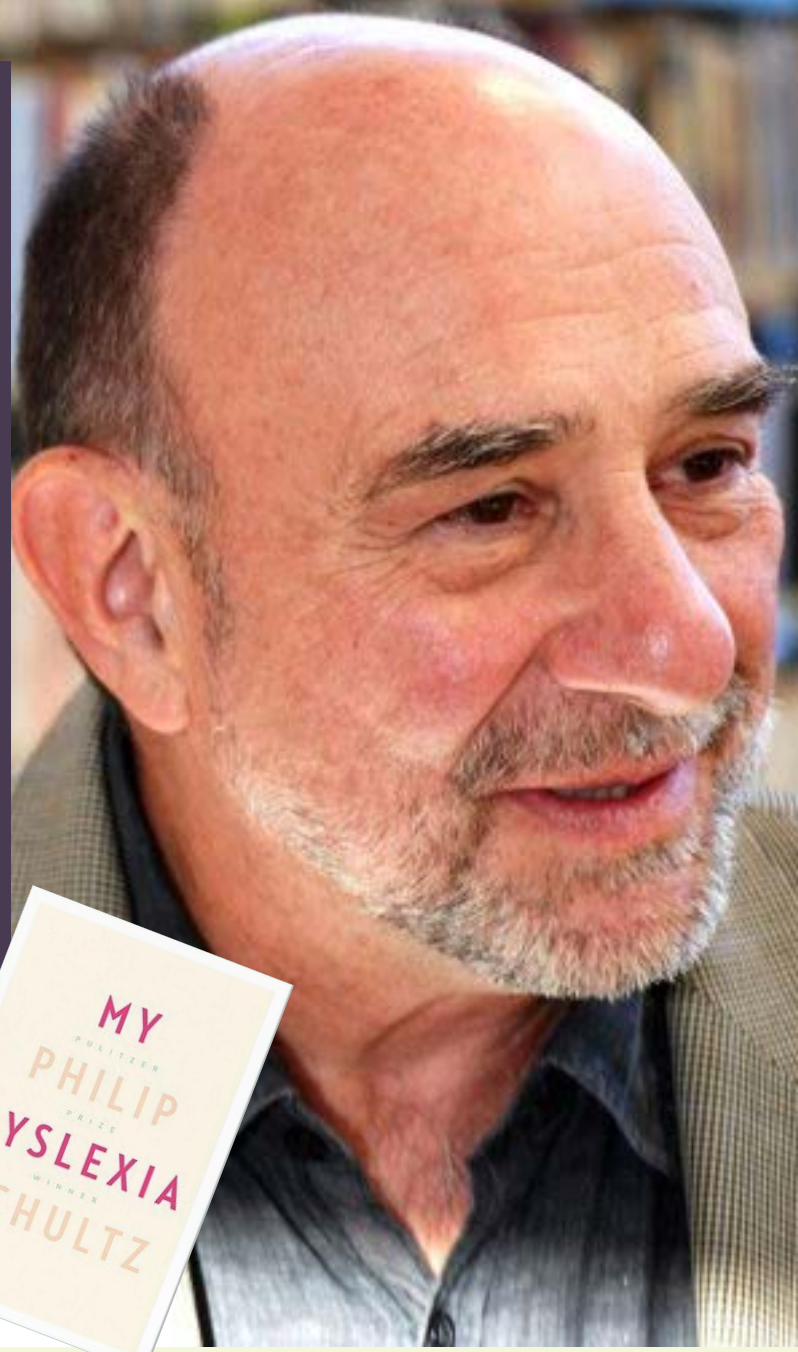
**o a d s d p o a p s**

## PART 2: Cerebrodiversity and Dyslexia

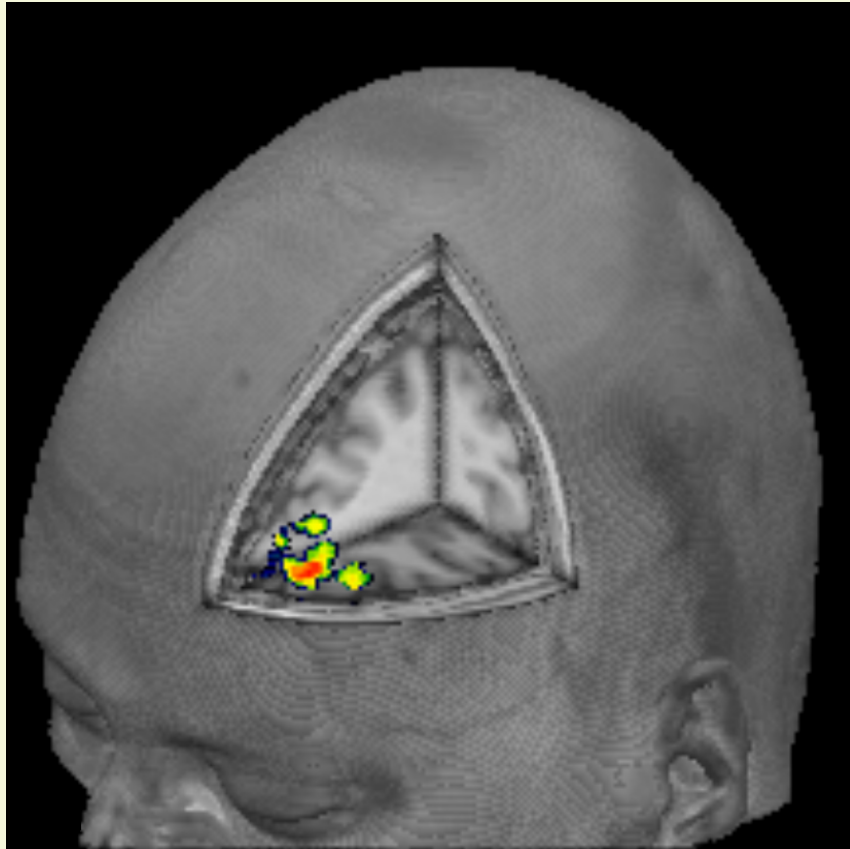


The Implications of the Reading Brain Circuit  
for a new view of Dyslexia and its Intervention

“For a long time I couldn’t imagine my life amounting to anything...I didn’t know there was something wrong or different about how my brain processed information and language; I believed there was something wrong with ME. I still, on occasion, believe this. Perhaps I always will.”



# Phonology Differences: Rhyming



Young Readers



Children with Dyslexia

# Typical Readers

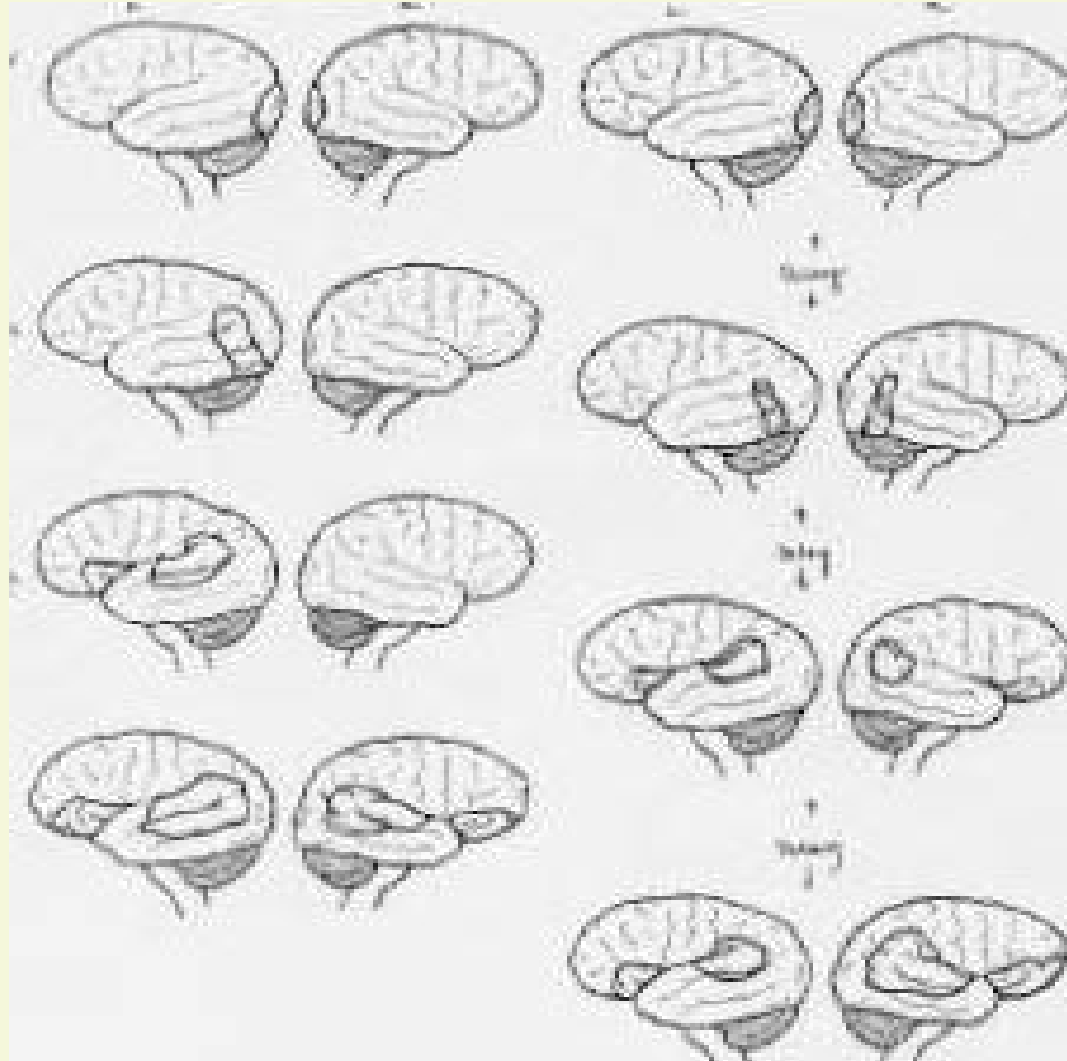
# Dyslexic Readers

Visual  
Recognition  
0-100 MSEC

Word Specific  
Activation  
150 MSEC

Phonological  
Processing  
180-300 MSEC

Semantic  
Processing  
200-500 MSEC



**Delay**

**Delay**

**Delay**

**Delay**

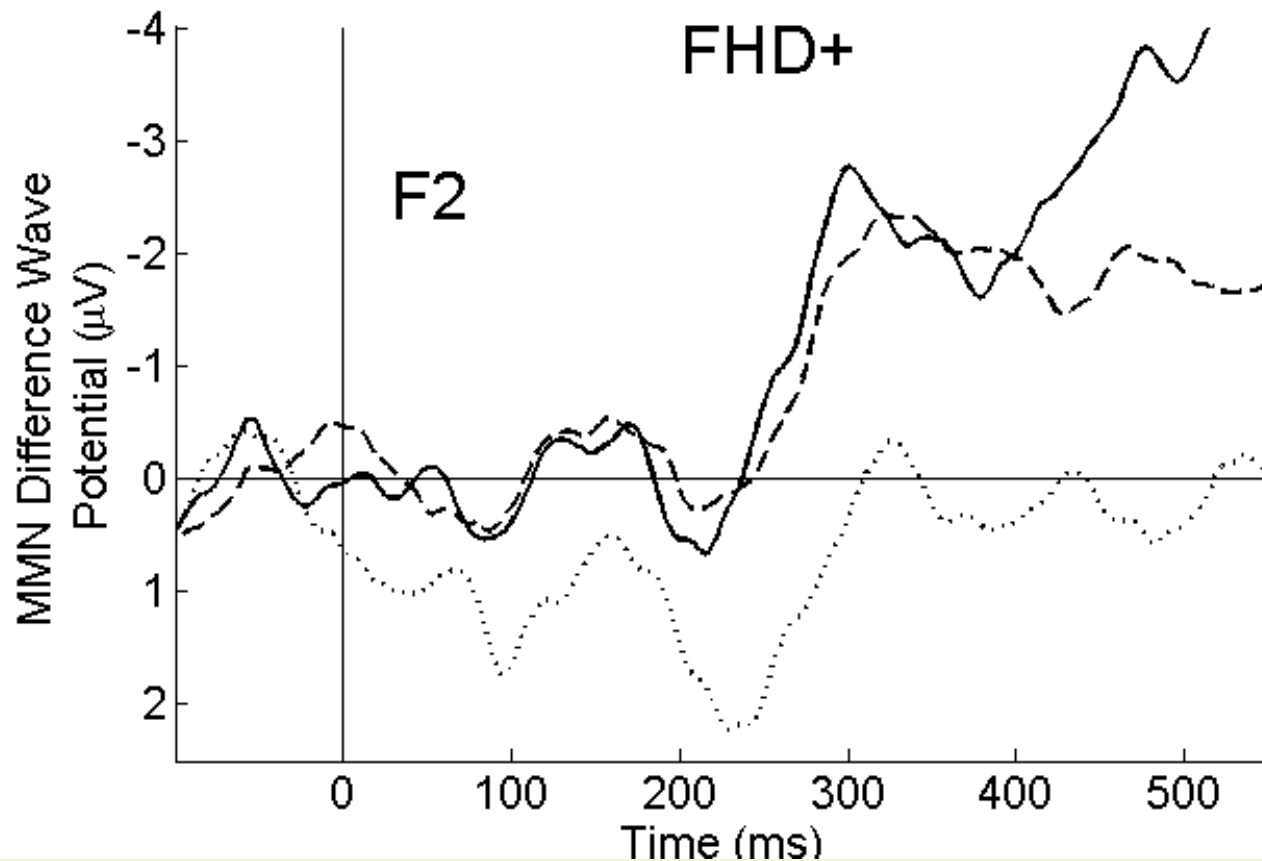


“So does this mean I’m more creative because I use this right hemisphere more than other people and my right pathways got strengthened that way?

Or does it mean that dyslexics are just born with more creative brains from the start? “

-Ben Wolf Noam

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



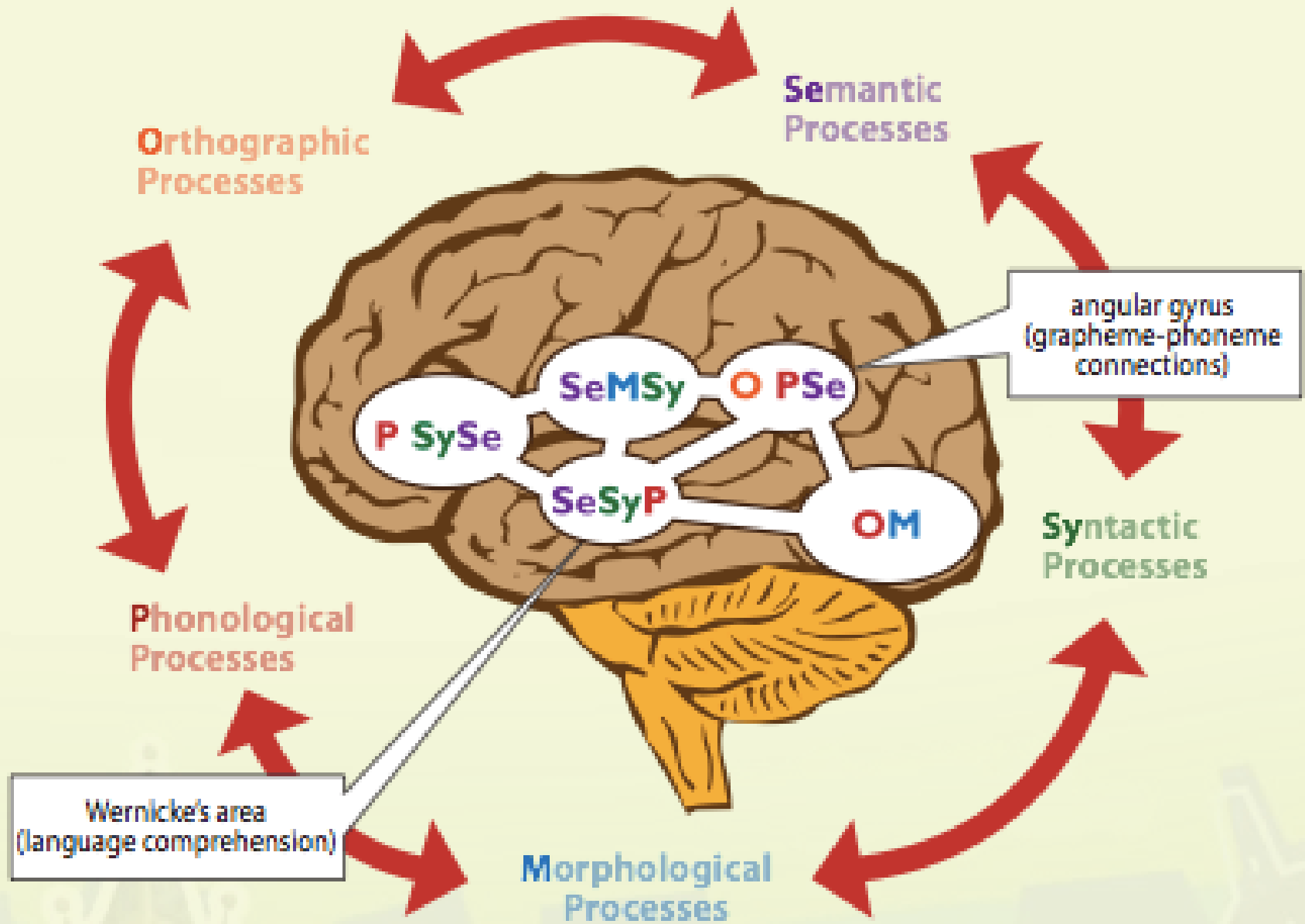
Home Literacy  
—— High  
--- Medium  
..... Low



Implications of  
Reading Brain  
For Instruction  
and Intervention

Develop: **each**  
**Component**  
Their **Connections**  
**Automaticity**  
Time to think **new**  
**thoughts**

# Both Reading Circuits: Basis of Intervention



# Principles of Instruction

Equal weight in instruction on **accuracy and speed**

Explicit instruction in all components of linguistic knowledge: that is, emphasis in instruction on **phonology, orthography, semantics, syntax and morphology**

Explicit emphasis on **comprehension strategies and reader's own thoughts**

# **NICHD Grant: Legacy of Reid Lyon- HD 30970**

## **Co-Principal Investigators**

**Robin Morris, Atlanta**

**Maryanne Wolf, Boston**

**Maureen Lovett, Toronto**

# Program Components

**PHAB** -Phonological Analysis and Blending Emphases

**PHAST**- Phonological,Morphology,and Metacognitive Strategy Training

**RAVE-O**-Reading, Automaticity, Vocabulary, Engagement, Orthography (the Circuit)

**CSS**- Classroom Survival Skills

**MATH**- Math/Direct Instruction

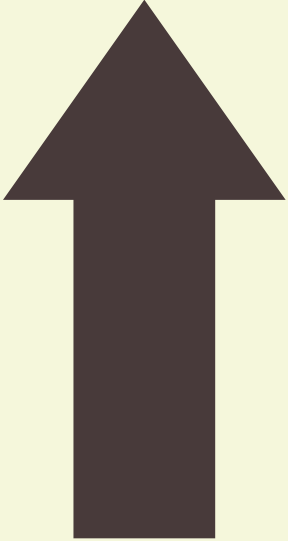
**ALL GIVEN IN 70 1 HOUR SESSIONS  
by Project Supplied Research Teachers**

# RAVE-O Characters



Metacognitive  
Strategies  
Embodying  
Circuit

# RAVE-O Intervention: Reverse Engineering of Reading Brain



Systematic emphases on all aspects of **words--- their recognition, access, and retrieval (POSSuM).**

Rate and accuracy emphases for **text reading and “deep reading” comprehension.**

Provides a foundation for learning **key principles** of English language.

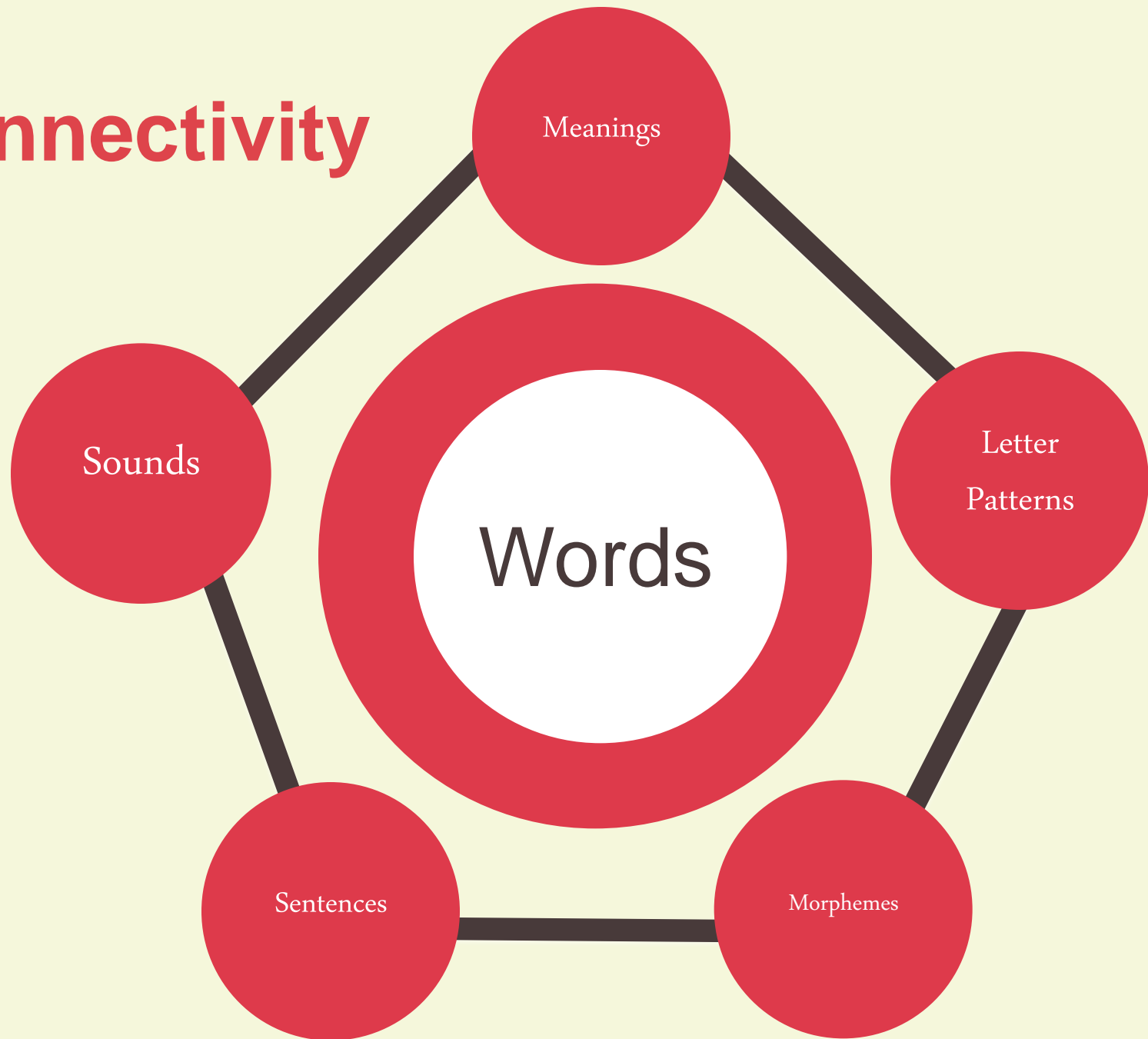
# What RAVE-O is NOT:

**NOT a “Silver Bullet”**

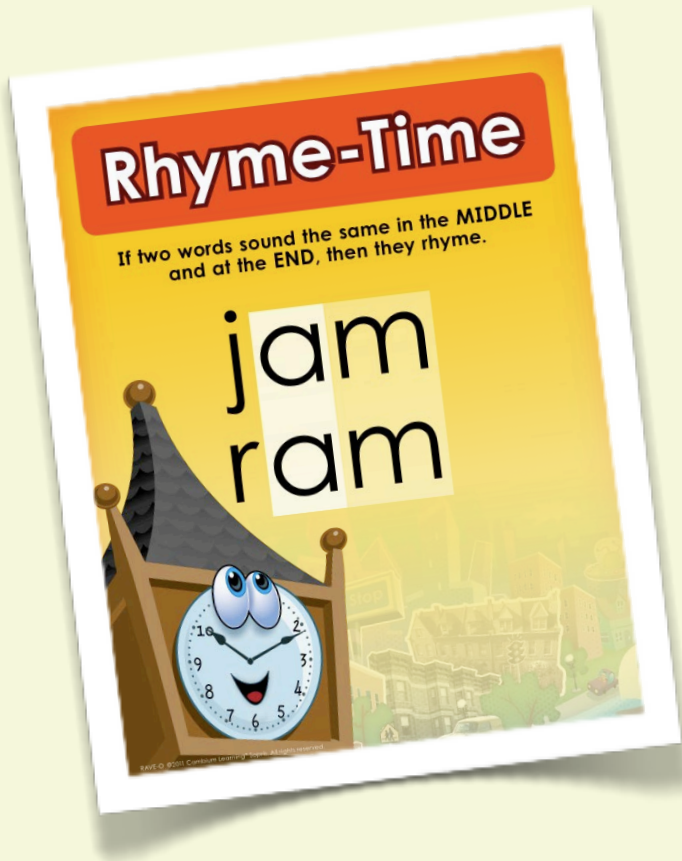
**Complements and extends existing explicit  
decoding programs**



# Connectivity



# Phonology Emphases: Words are Connected by Sound



How do I analyze  
what I know  
about words?

# Strategies for semantic skills



Many  
Interesting  
**Meanings**

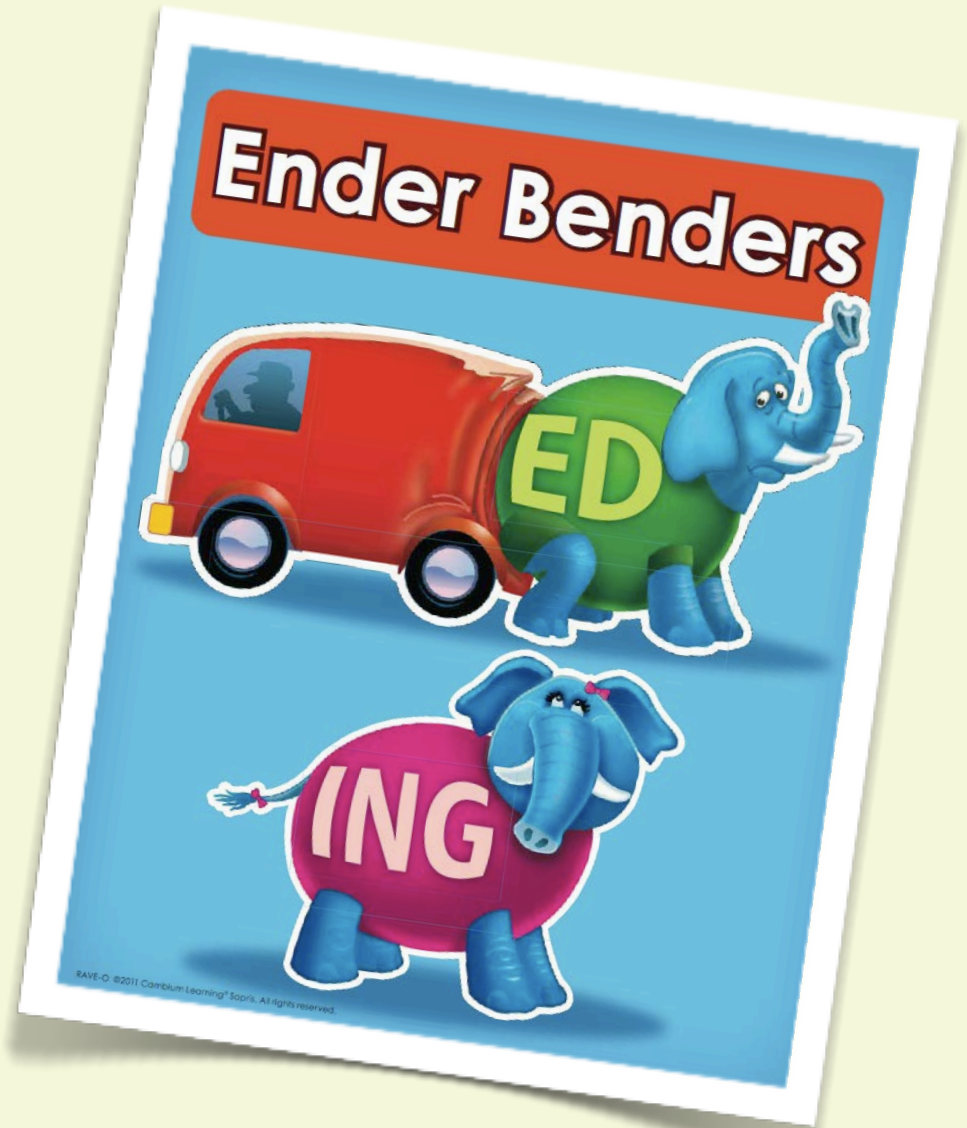
Many  
Interesting  
**Connections**

# Morphological Analysis Skills

j am s

j am m ing

j am m ed



# Think Thrice

You are a thoughtful reader when you ...

Think Ahead!

Think Back!

Think for Yourself!



Comprehension,  
Deep Reading,  
and “Thinking  
Outside the Box”

Facts

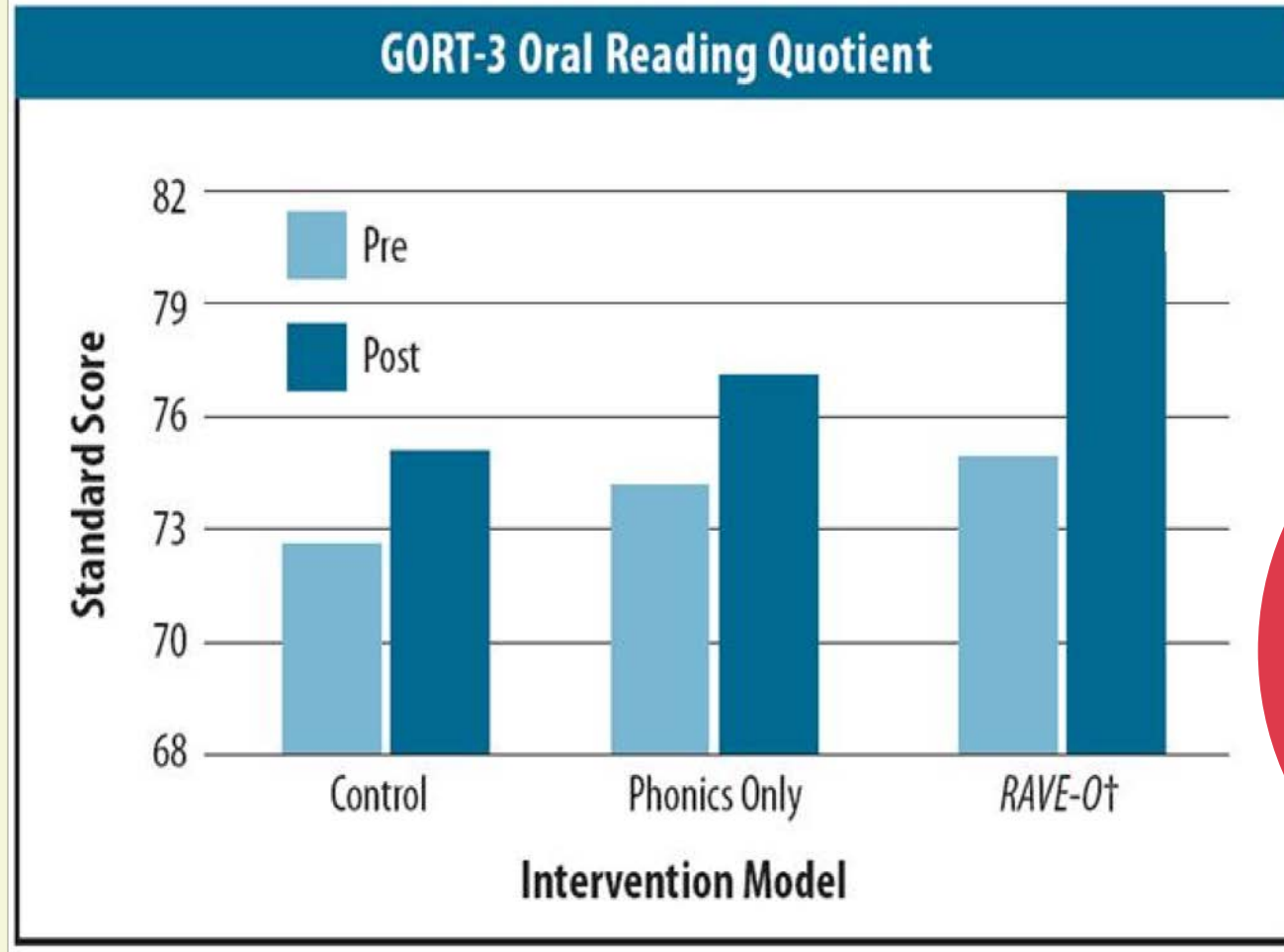
Predictions

Inference

Analysis

## Gray Oral Reading Test-3: Fluency and Comprehension

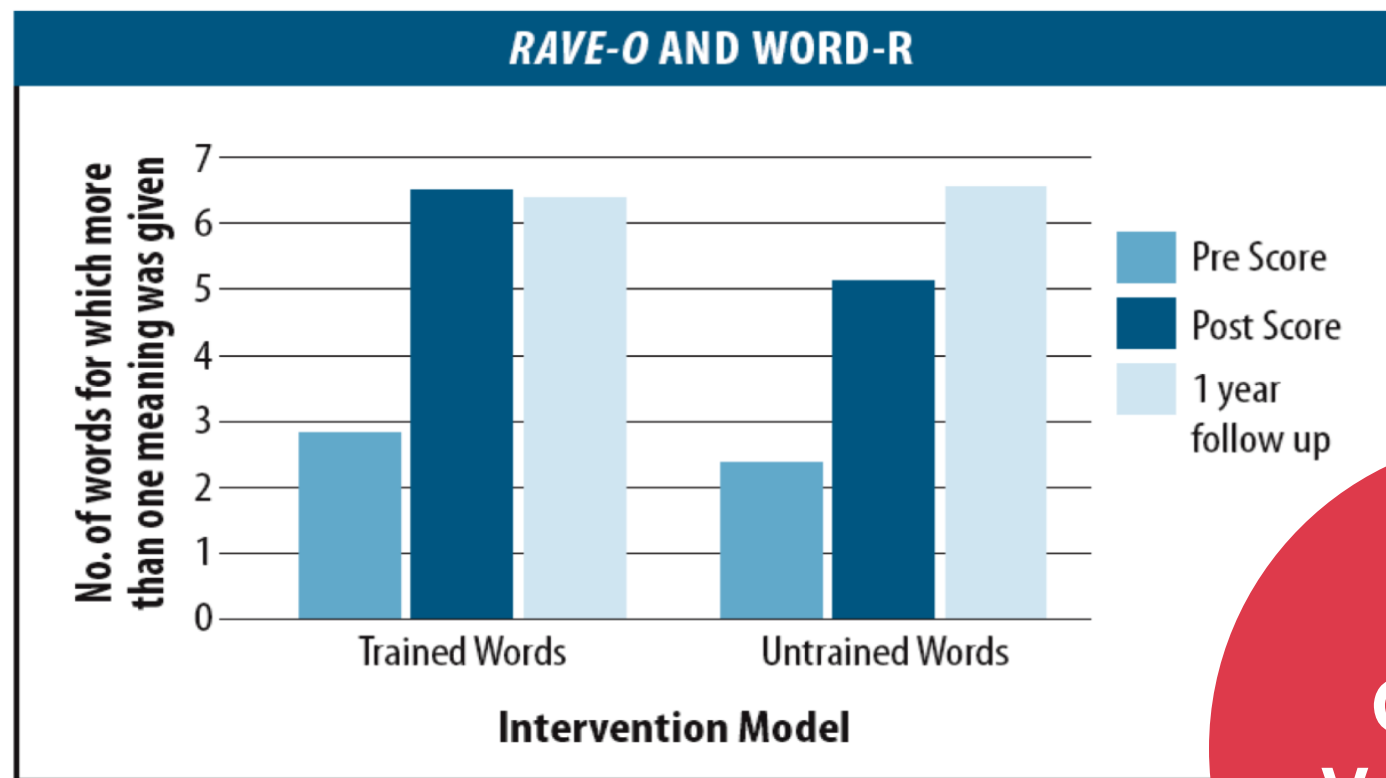
Changes in Oral Reading Quotient (fluency + comprehension) Standard Scores on Gray Oral Reading Test-3 after 70 one-hour instruction sessions.



**Gains in  
Text  
Reading &  
Comprehension**

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

**Gains in  
Vocabulary**

# 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.

# Interventions In MULTIPLE Educational Settings

- Second and third graders (7-9 years old)
- Three types of intervention
- School-day pull-out (NICHD; Atlanta, Boston, and Toronto; ten years)
- Summer School (RFBD; 4 hours/day, 4 weeks)
- After-School (IES; Phoenix & Boston; 1 hour/ day, 3 days/week)



# SUMMER SCHOOL

- Prevent Regression
- Provide Intensive Instruction in small group settings
- Promote a sense of achievement through Effort
- Change relationship to Reading

# Impact on Educational Culture:



- Changing “CULTURE” of classroom and School
- Professional Development/Teacher Preparation

# Motivational Strategies

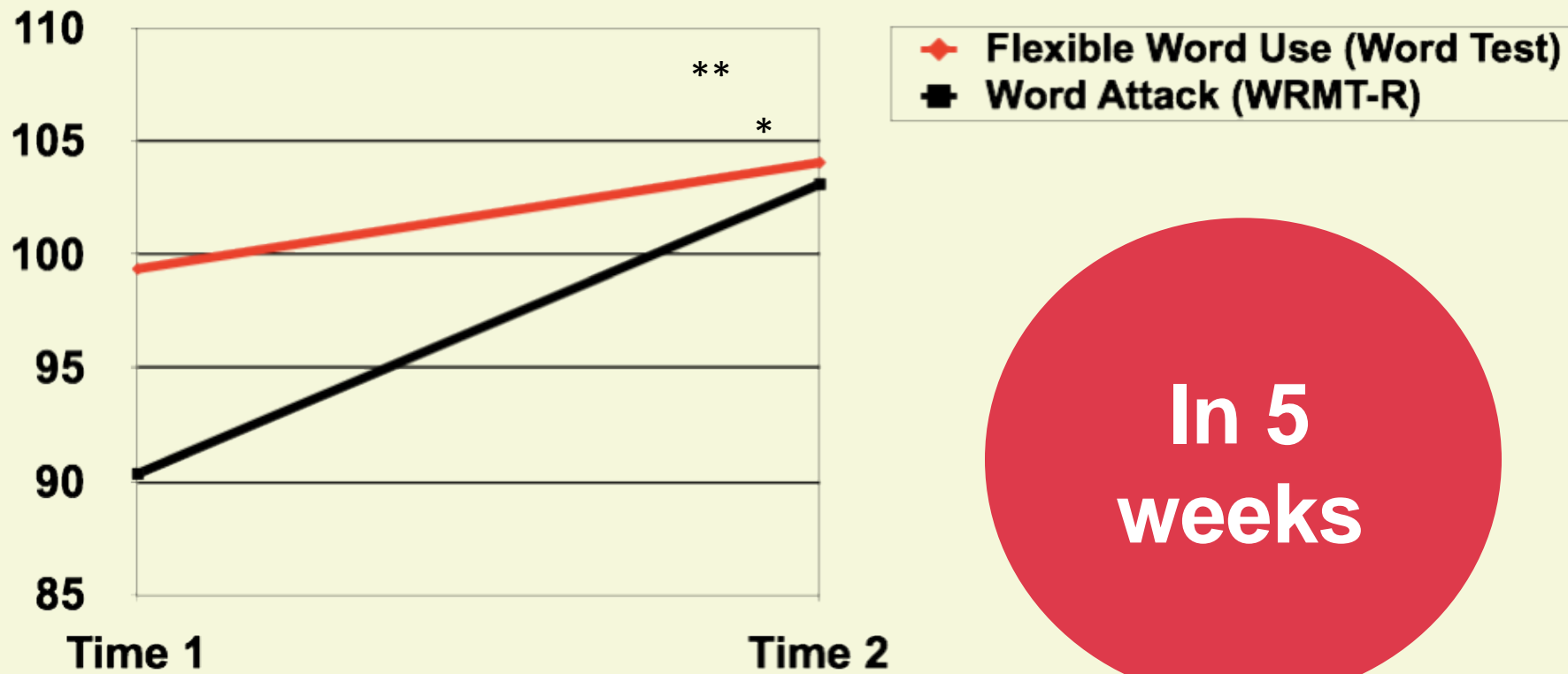
**Belonging**  
Supportive  
community of  
learners

**Competence**  
Taking on  
challenges &  
Coping with  
failure and  
errors

**Autonomy**  
Voice &  
Choice in the  
classroom

# Tufts Summer Reading Program

Significant Gains in Reading Ability (Orkin, 2013)

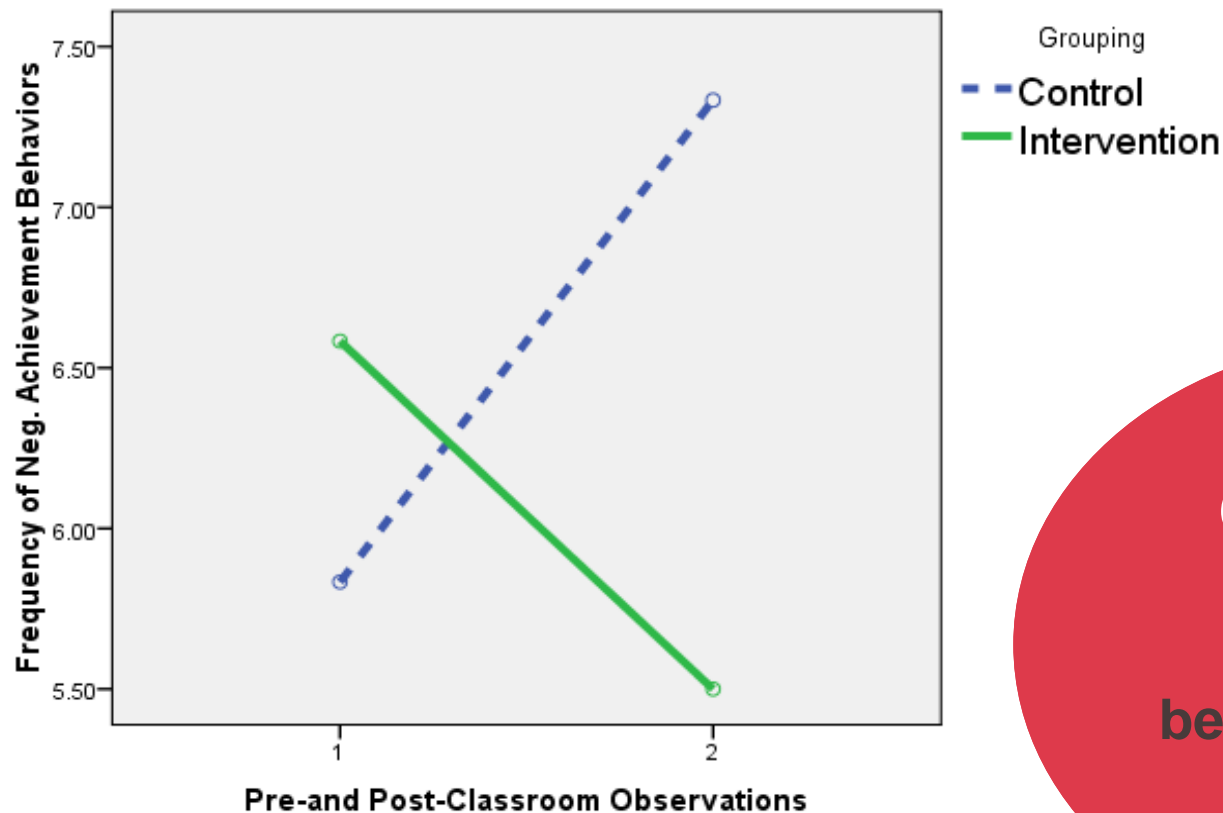


\* Significant at the  $p < .05$

\*\* Significant at the  $p < .01$

# Tufts Summer Reading Program

## Reduction in Avoidance Behaviors (Orkin, 2013)



**CONTROL**  
Increased  
disruptive  
behaviors & task  
avoidance

# GAINS IN READING AND ENGAGEMENT AND PERSONAL RELATIONSHIP TO READING





## PART 2: Implications of Reading Circuit for Reading in a Digital Age



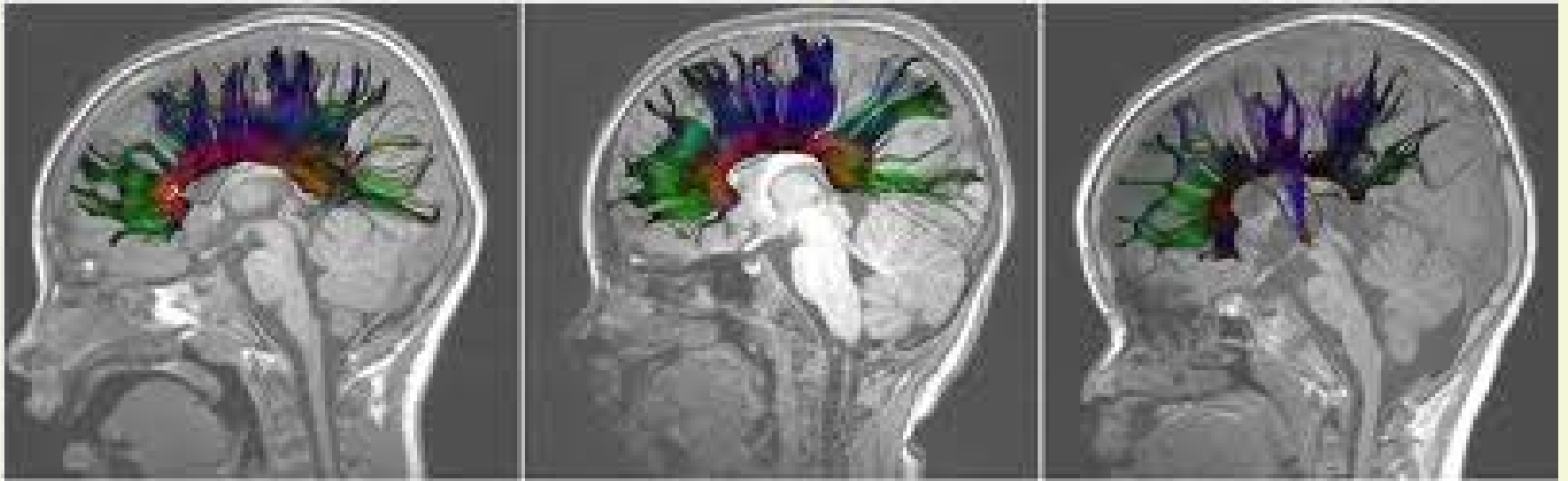
What we know...

Each circuit reflects the demands of **language** and **medium**



**Reading Brain is tabula rasa**

We know...



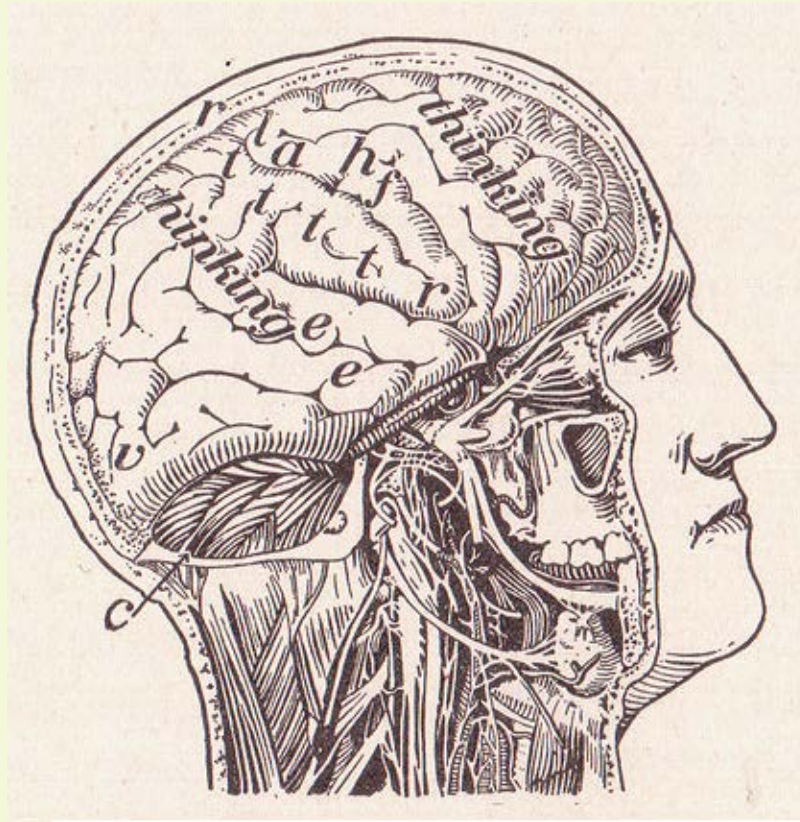
... each reader must build a new reading circuit.

We know...



... this reading circuit is plastic and influenced by the specific emphases of different writing systems and mediums

## We know...



... that the present reading brain is capable of both  
the most superficial and the deepest, integrated  
forms of reading, feeling, and thought



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

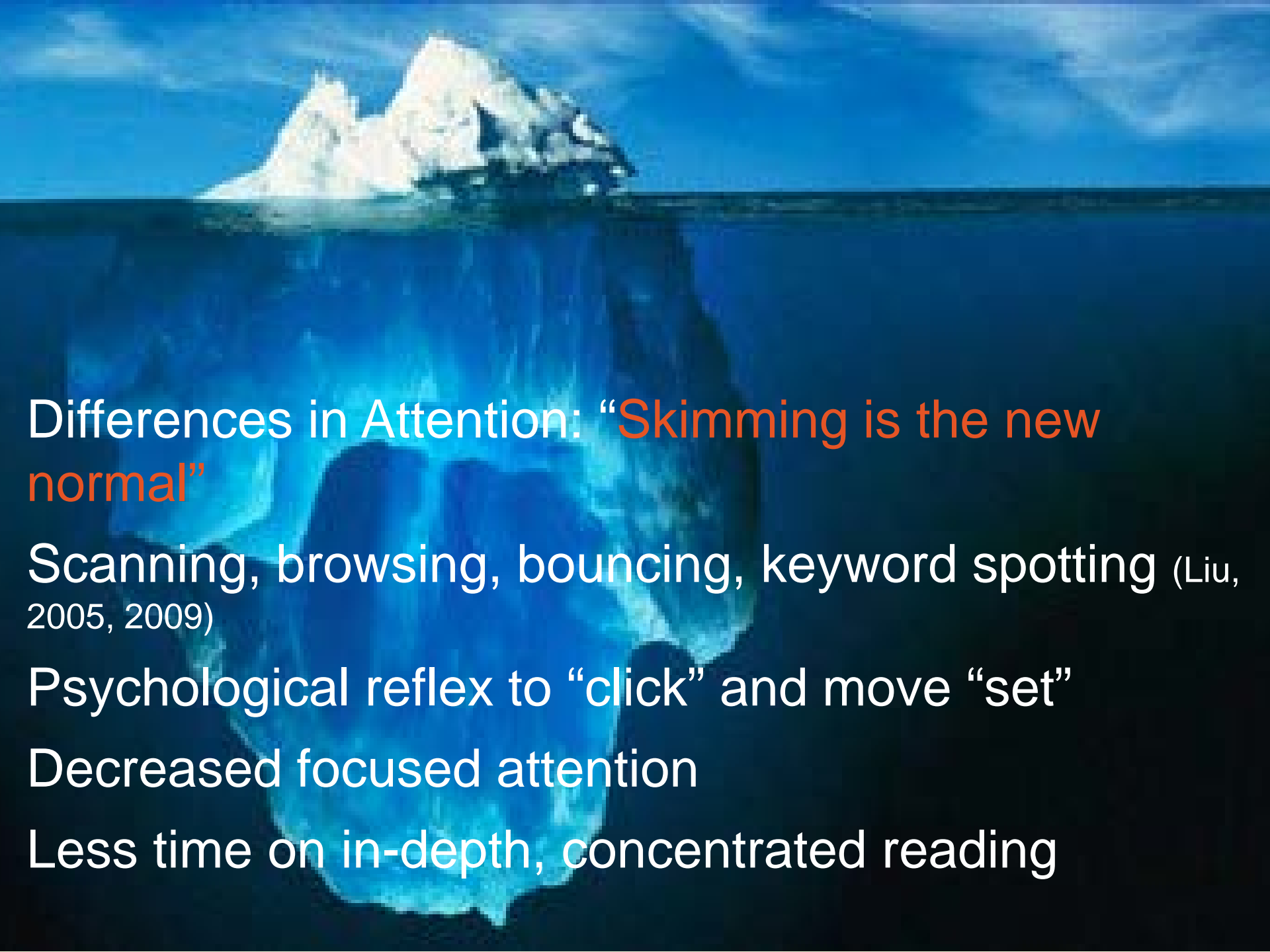
# Characteristics of on-line reading in the young reading brain



Continuous **partial** attention  
with skimming and skipping  
reading styles

Demand for **immediacy**

Efficient **multi-tasking** of  
diverse sets of information



Differences in Attention: “Skimming is the new normal”

Scanning, browsing, bouncing, keyword spotting (Liu, 2005, 2009)

Psychological reflex to “click” and move “set”

Decreased focused attention

Less time on in-depth, concentrated reading



## Digital Reading Brain

- **M**assive information processing and production
- **S**peed and efficiency
- **M**ulti-tasking and interactive communication

# Threats to Deep Reading

One of the greatest impediments to this form of reading is the “**busy mind**” that skips from one thought to the next without the capacity to enter the hidden depths of words that require both **receptivity** and the **quiet focusing of attention**.

-E Bianchi



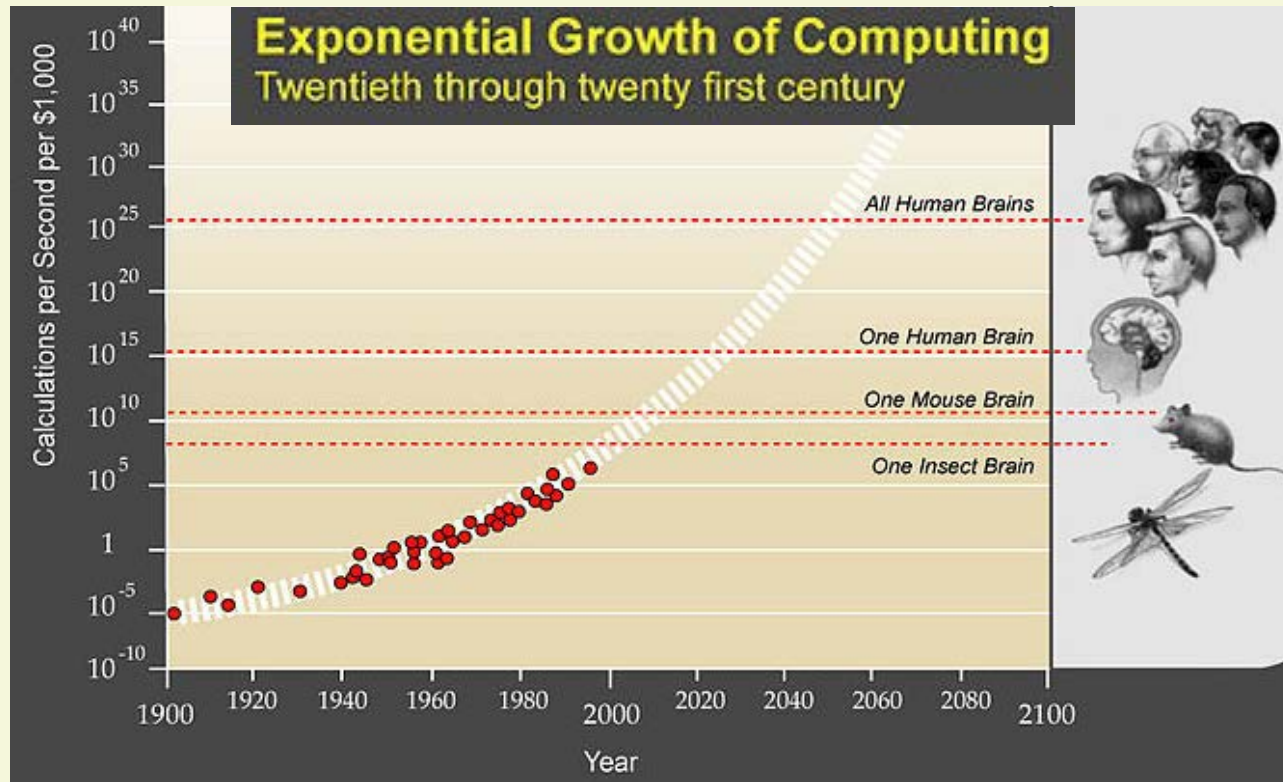
“It would be a shame if brilliant technology were to end up threatening the kind of intellect that produced it.”

- Edward Tenner



What we do not know...

We do not know...



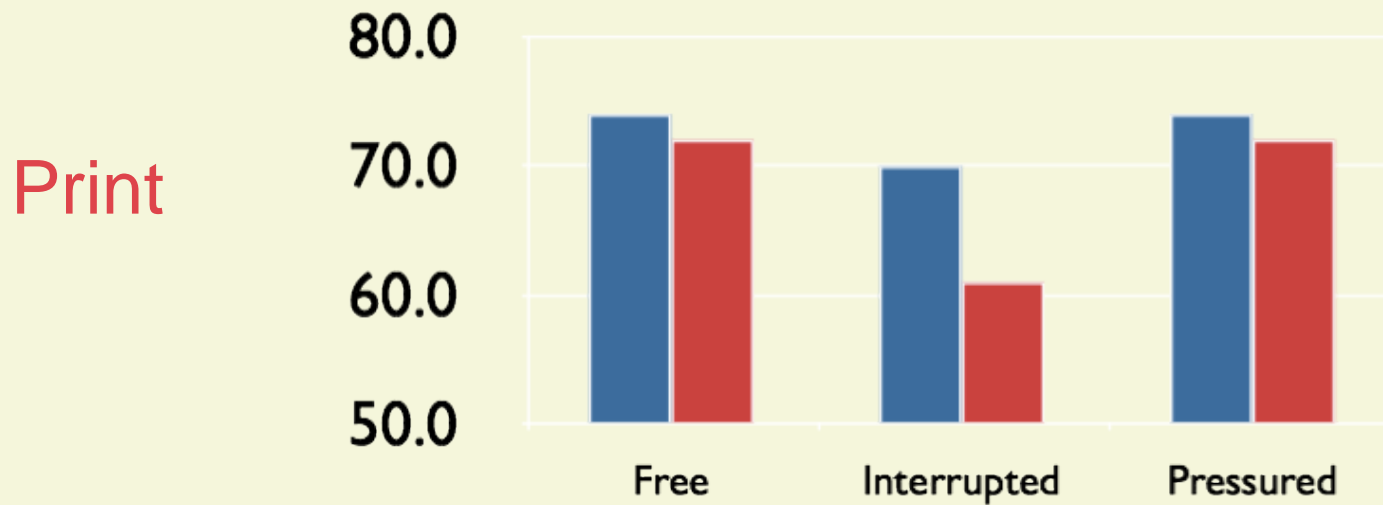
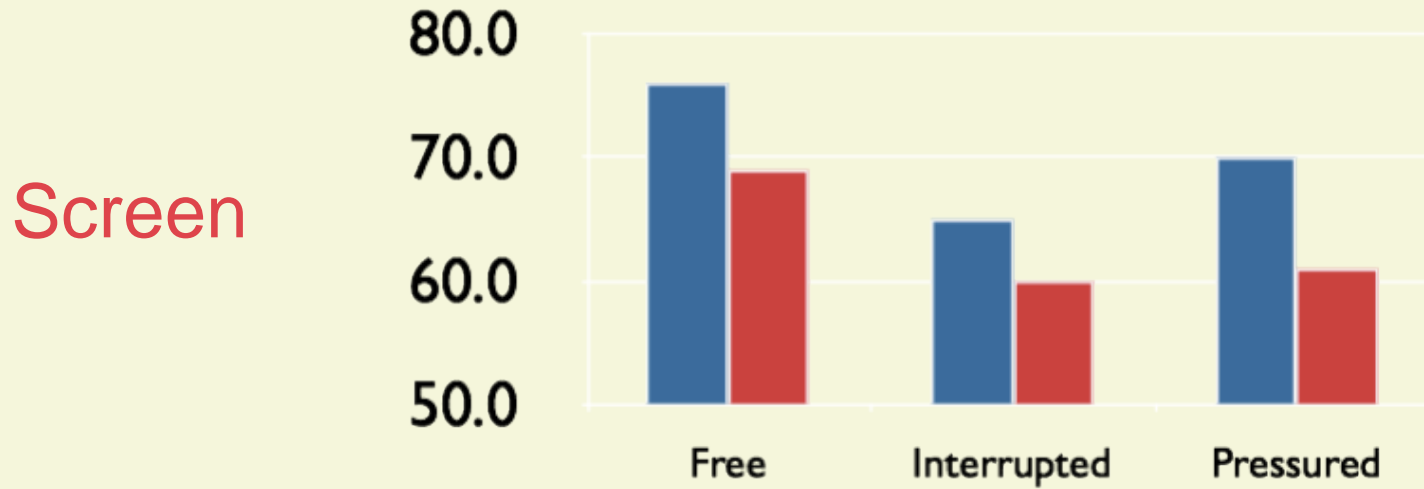
... but we can predict that information will accelerate at rates that will make completely new demands on every person in the next generation.

We do not know...



... if the immediate access to this increasing amount of external information in the young will deter from the formation of “**Deep Reading**” processes or the desire to probe more deeply into its meaning or to go beyond it.

# Comprehension for On-Screen vs. Print



(Ackerman & Lauterman, 2012)

POP Test Score

We **do not** know...

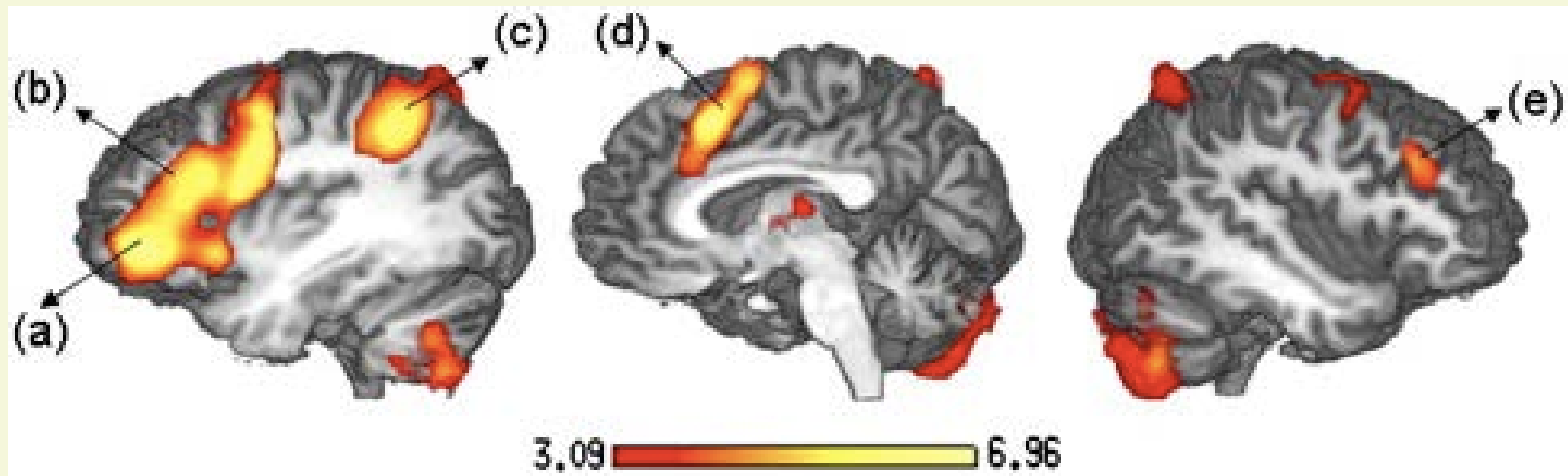


Fig. 6 Cognitive Demand: Regions of the brain activated as a function of high relative to low cognitive demand (C-H & D-H > C-L & D-L) in the (a) left ventral lateral prefrontal cortex (BA 44/45), (b) left dorsal lateral prefrontal corte...

... if such changes in internalized knowledge will result in a very different set of cognitive capacities to synthesize, infer from information, and go beyond it in very different, and more innovative ways than before, and that are more appropriate for the digital culture.

# Can Digital Reading become a “Deep Reading” Brain?

- Can the thing itself redress its own weaknesses?
- Can we teach from the start:
  - Analogical Thinking and Inference
  - Critical Analysis and Deliberation
  - Insight and Epiphany
  - Contemplation
- Bi-Literacy as Goal



How can we create the conditions for **new readers to develop a bi-literate brain and to know when to skim and when to dive deeply and leap beyond the text?**

A photograph of a rural village with thatched huts and two children in the foreground. The scene is set in a dry, hilly area with sparse vegetation. In the background, there are several traditional huts with steeply pitched, thatched roofs. Two young children are standing in the foreground on a dirt path. The child on the left is looking towards the camera, while the child on the right is looking away. The overall atmosphere is one of a remote, rural community.

**72  
Million**  
Children with  
no school

**Can all  
children  
become  
literate?**



**Can we create an experience on a tablet that can help children learn to read who have no schools or teachers in remote parts of the world?**

MIT Media Lab



# Global Literacy Collaborative



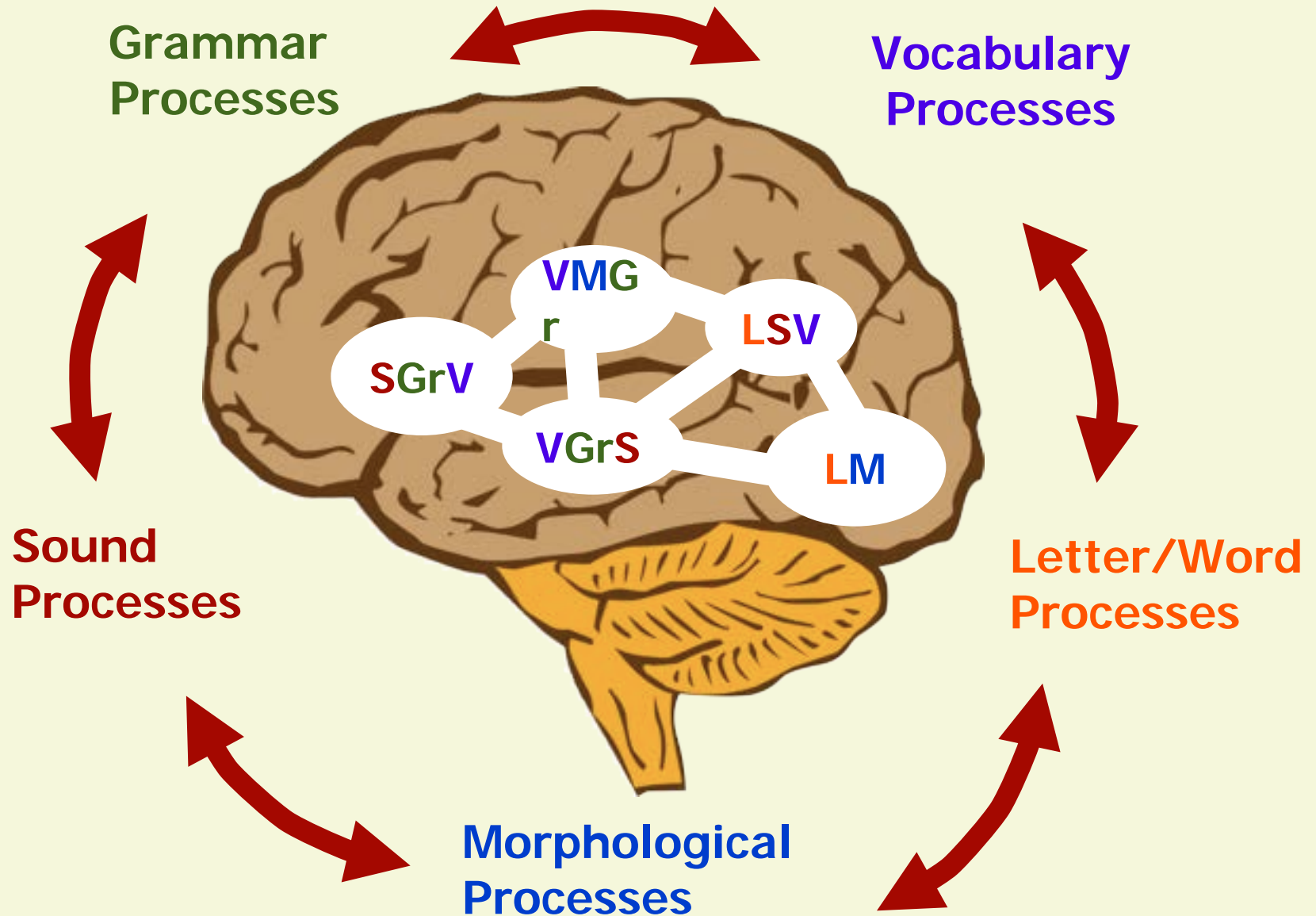
THE DALAI LAMA  
CENTER  
FOR ETHICS  
AND TRANSFORMATIVE VALUES



Solar charging hut the community built for this project in Wonchi Lake site. The solar recharging equipment is inside. It also gives the children a place to gather and use their tablets together and learn from one another.



# Reading Brain Circuit: Basis of Approach to Content





**“I got Mine On! I’m a lion!”**



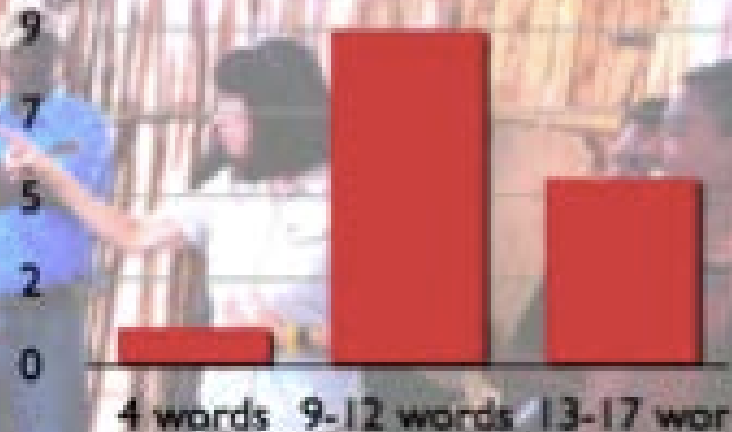


# Ethiopia Results

## Results from 1-year assessment: Kindergarten level skill for top performers

- Letter name and letter sound recognition
- Writing letters from memory
- Oral words
- English word recognition

Words in Vocabulary



Words in Vocabulary





# Global Ethics Literacy

The background of the slide features a stylized globe with green continents and blue oceans. Several hands of different skin tones are reaching up from the bottom, with their fingers touching the surface of the globe, symbolizing global unity, collaboration, and shared responsibility.

Promotes

- **collaboration and support**
- **positive leadership**
- **global connections** among children
- **perspective** taking & cross-cultural understanding
- **empathy and compassion**
- **social justice**

# The Future of Literacy: What may we hope in Iceland?

How do we **add** to the repertoire of the expert reading brain without **diminishing** it?

How can we best instruct each **new reader**, including boys and children with dyslexia-**-everywhere?**

How can we provide teachers with **the best of training for literacy** at every age, for every child?



The Future of Literacy

# For more information on Reading Instruction:

- Contact [Steph.Gottwald@tufts.edu](mailto:Steph.Gottwald@tufts.edu)
- Visit our website:  
<http://ase.tufts.edu/crlr>
- [To learn more about the](#) Global Literacy Project, visit [globallit.org](http://globallit.org).