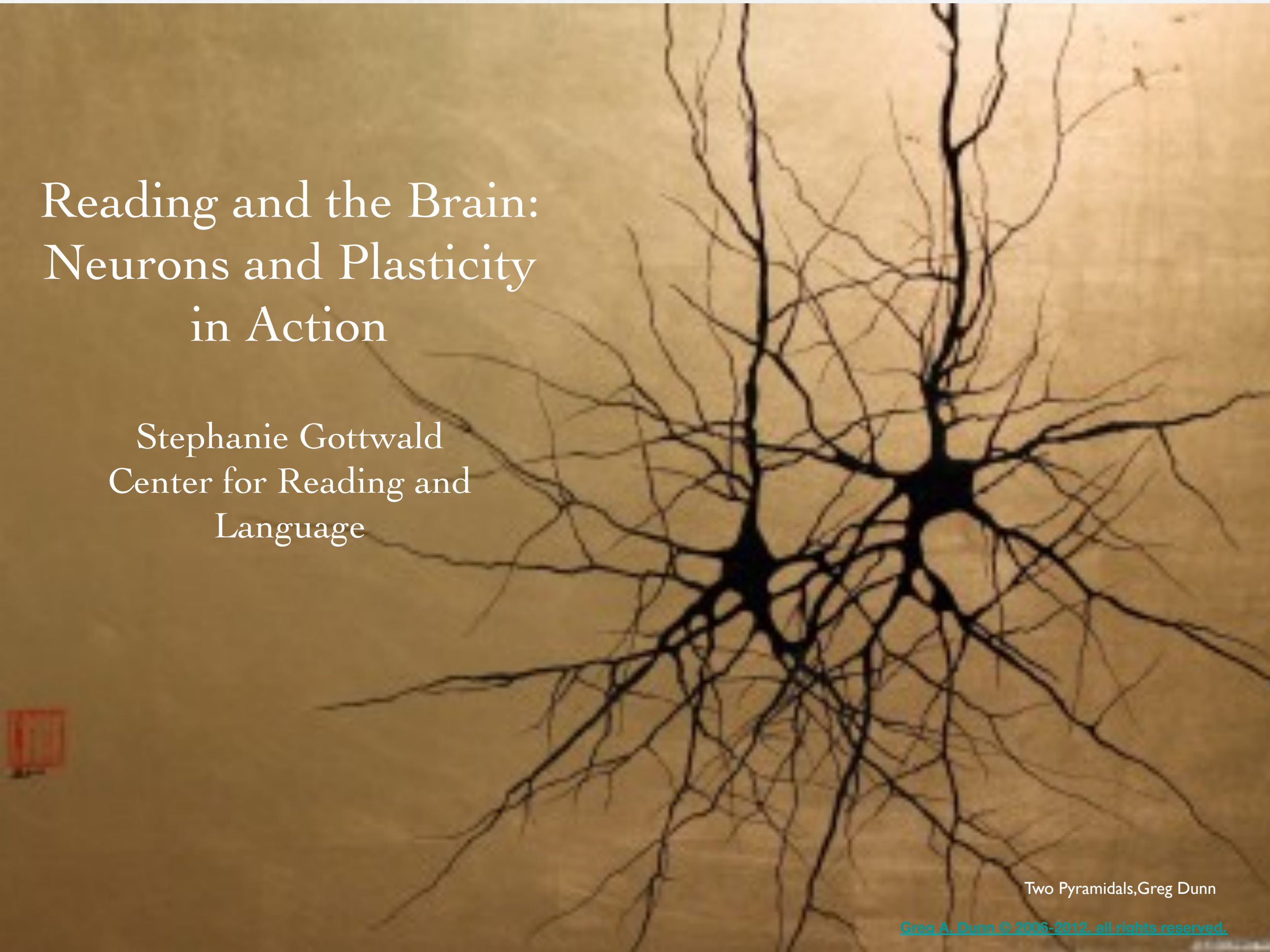
Reading and the Brain: Neurons and Plasticity in Action

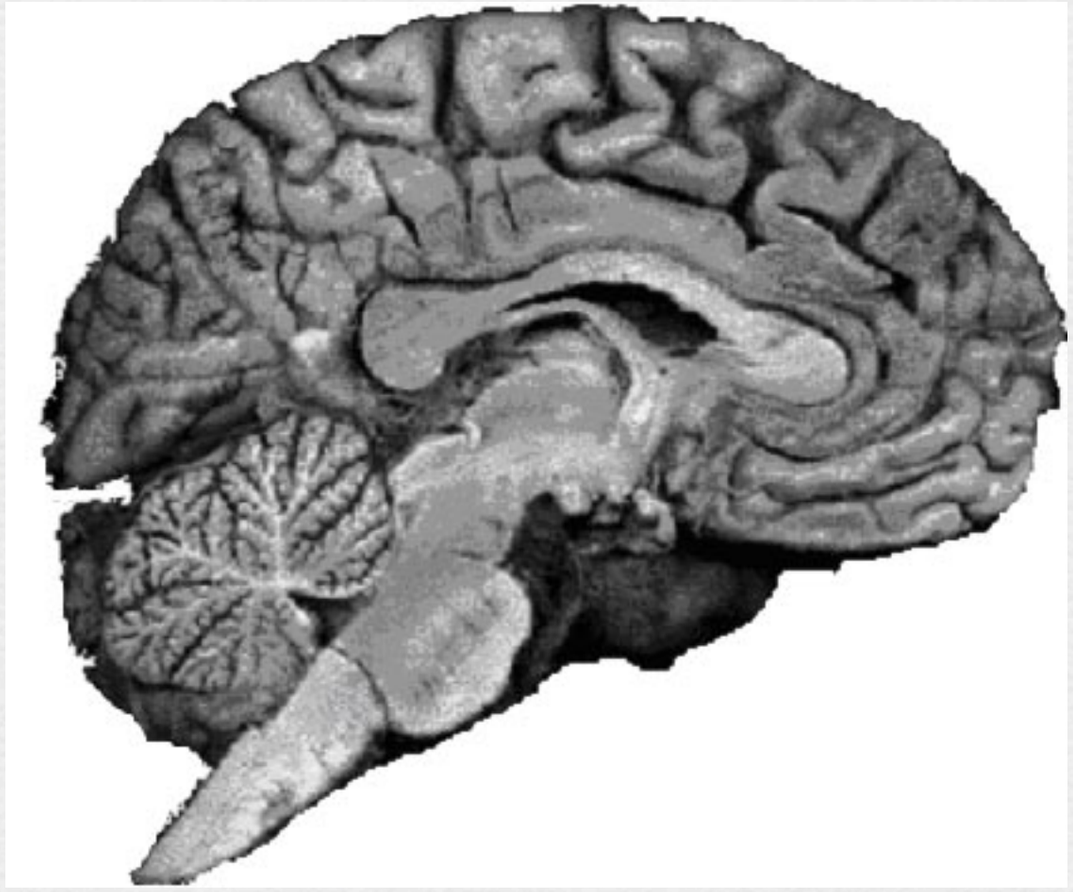
Stephanie Gottwald
Center for Reading and Language



Two Pyramidals,Greg Dunn

What do we know about the typical reading brain?

Are dyslexic brains different?



What can findings from neuroscience add to the practice of inclusive education?

CEREBRODIVERSITY

Caveat #1: The brain is still a mystery.

Most work analyzed only the upper layers (cortical layers) of functioning.

Many studies had small subject pools

Studies have focused on word identification or phonological skills, i.e. rhyming.

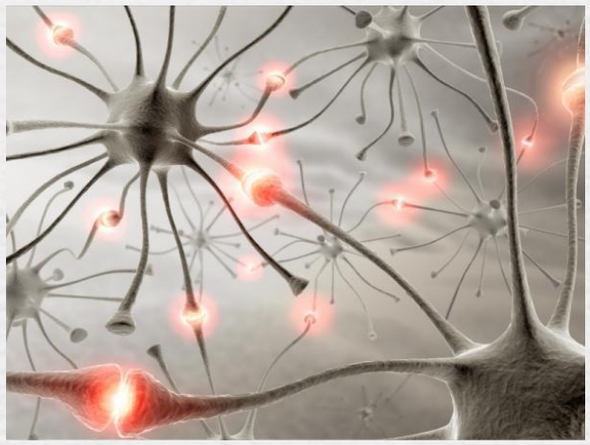
Caveat #2: Any experience "changes" the brain.

Brain development is "activity-dependent".

Every experience excites some neural circuits and leaves others alone.

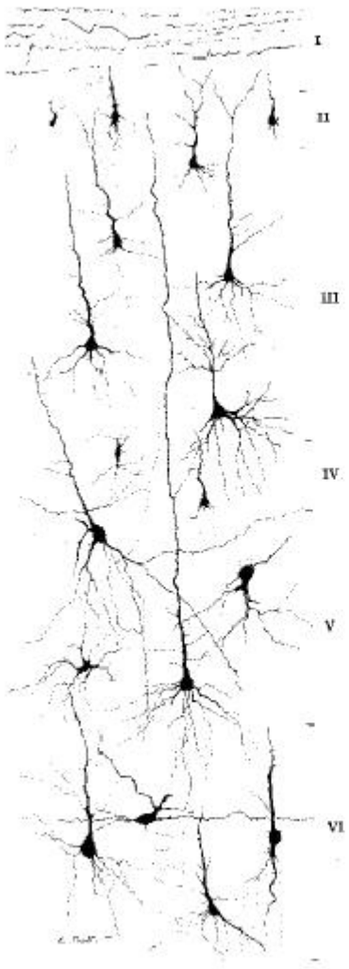
Neural circuits used over and over strengthen, those that are not used are dropped resulting in "pruning".

How does the brain learn anything?



- Overproduction of neurons and connections among neurons
- Selective reduction of neurons and connections among neurons
- Waves of intense branching and connecting followed by reduction in neurons
    - Before birth through 3-years-old
    - Again at 11- or 12-years-old

Birth to 2 Years--Synapses



Birth

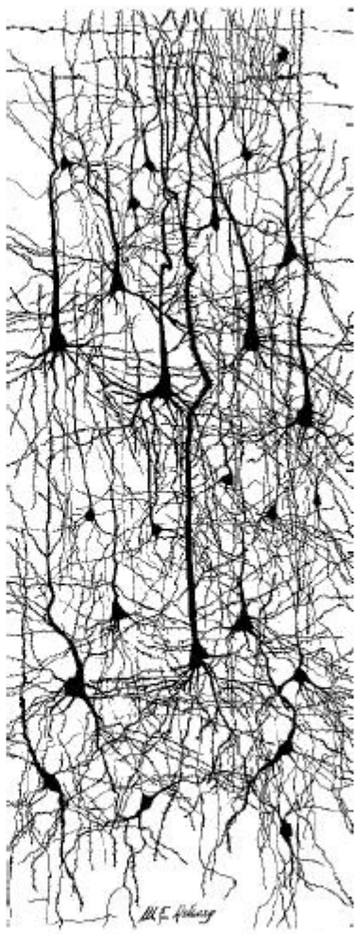


Fig. 92. Drawings from Golgi-Cox preparations

2 years

2 Years to 6 Years--Synapses

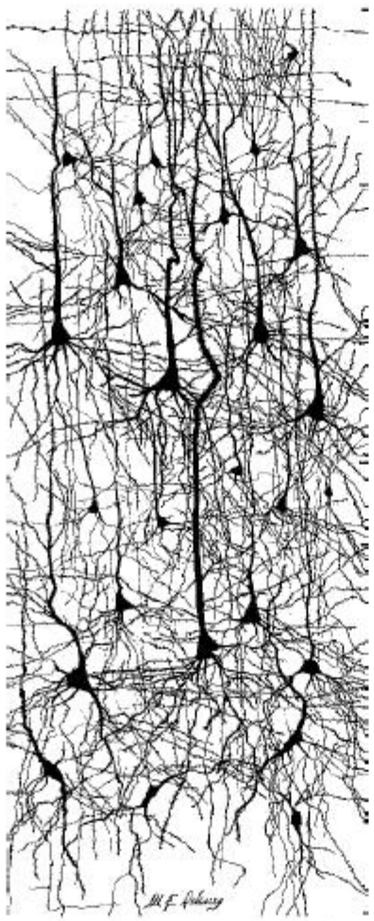


Fig. 92. Drawings from Golgi-Cox preparations

2 Years

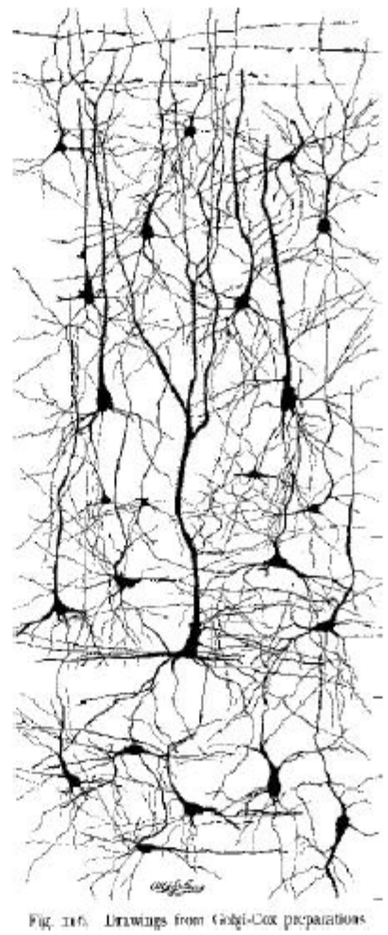
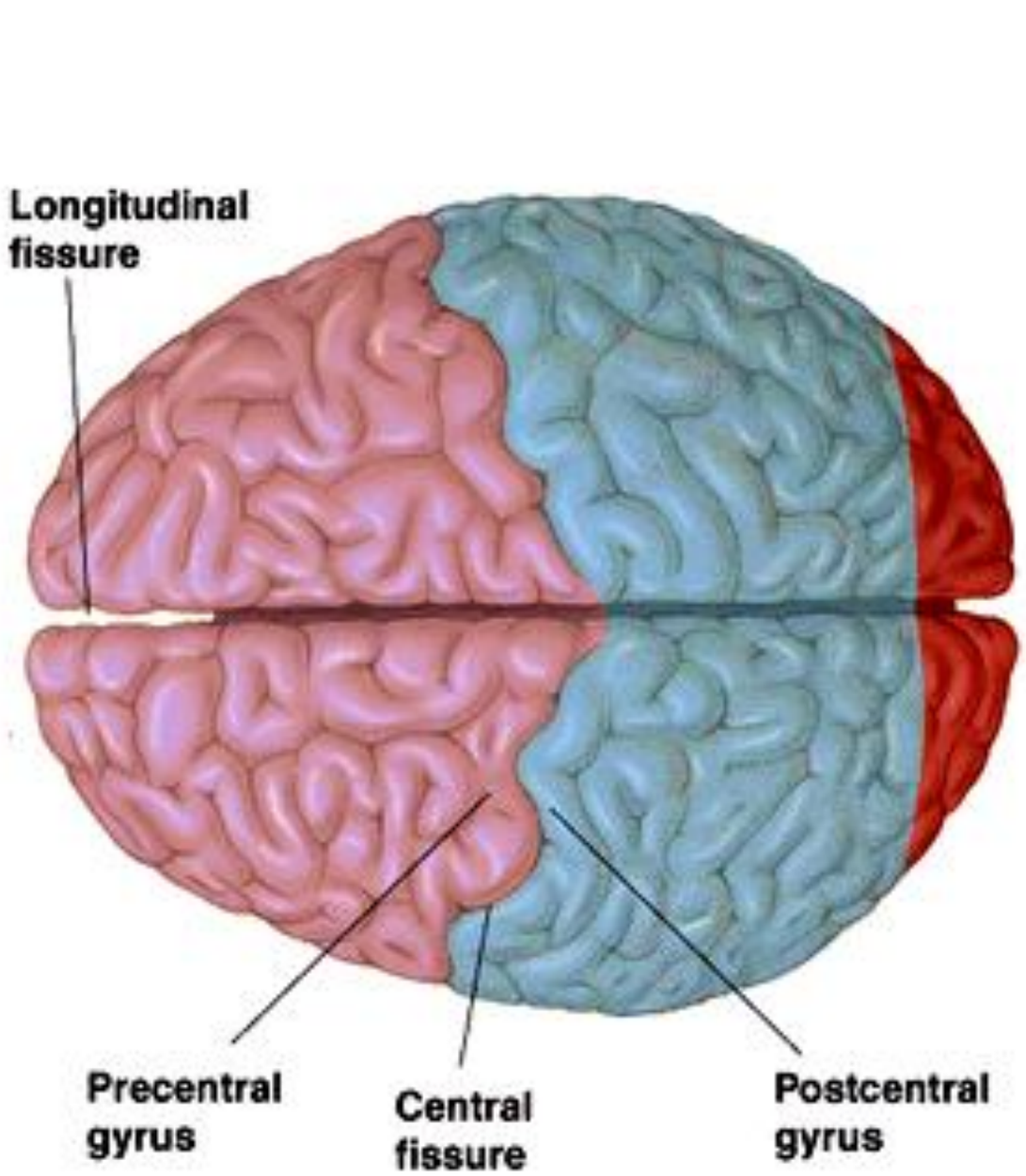
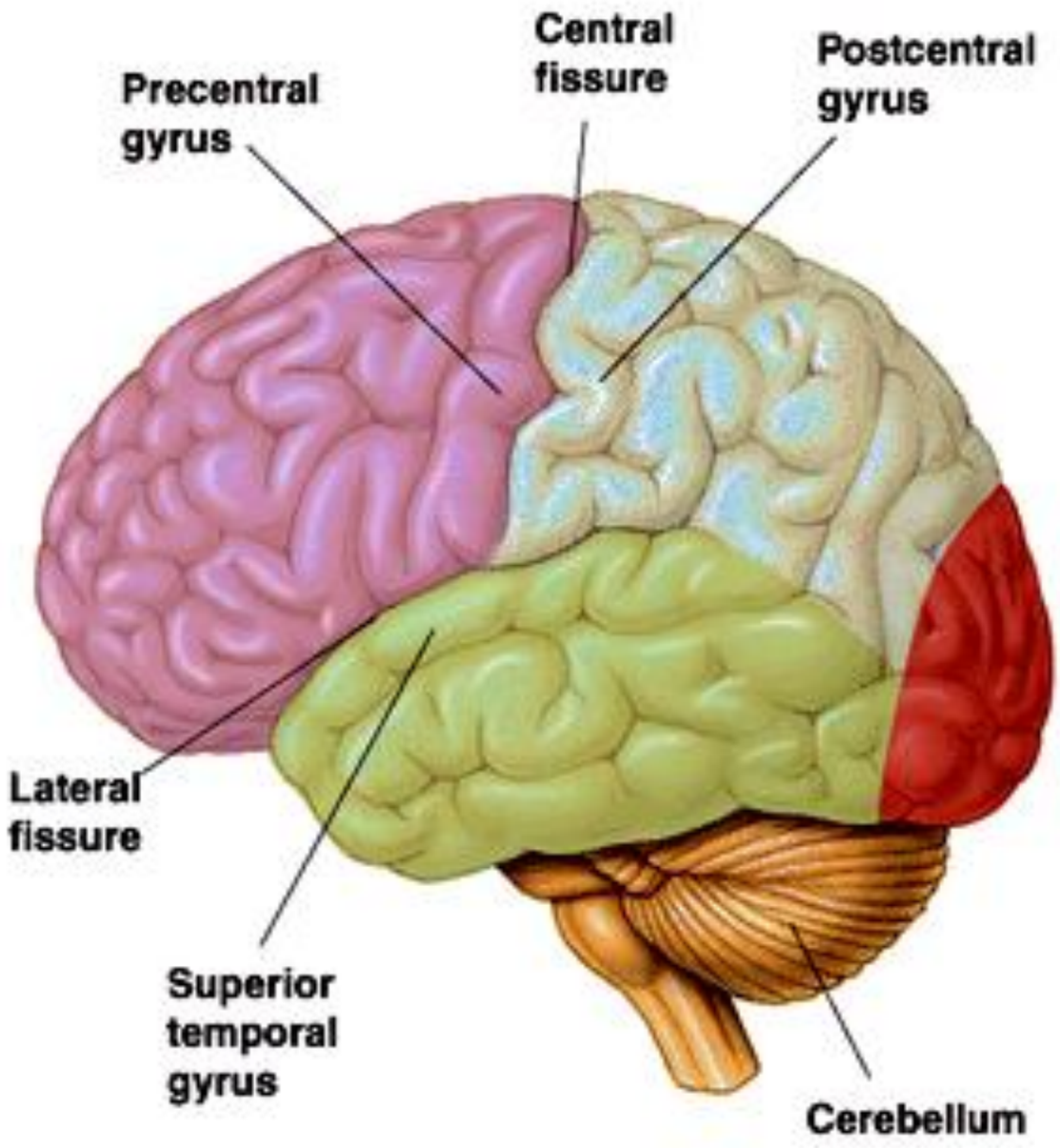


Fig. 116. Drawings from Golgi-Cox preparations

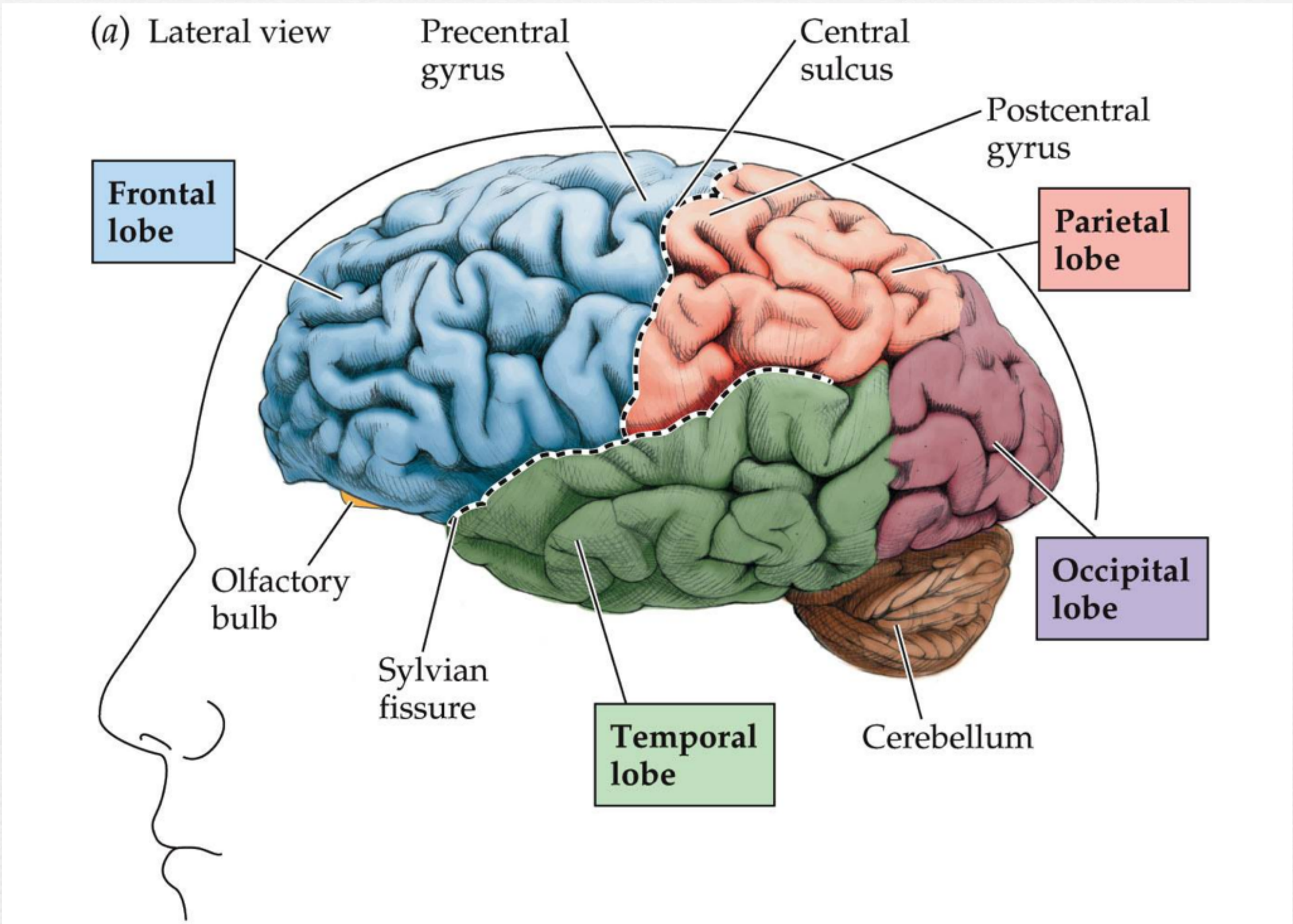
6 Years

► The Lobes of the Cerebral Hemispheres





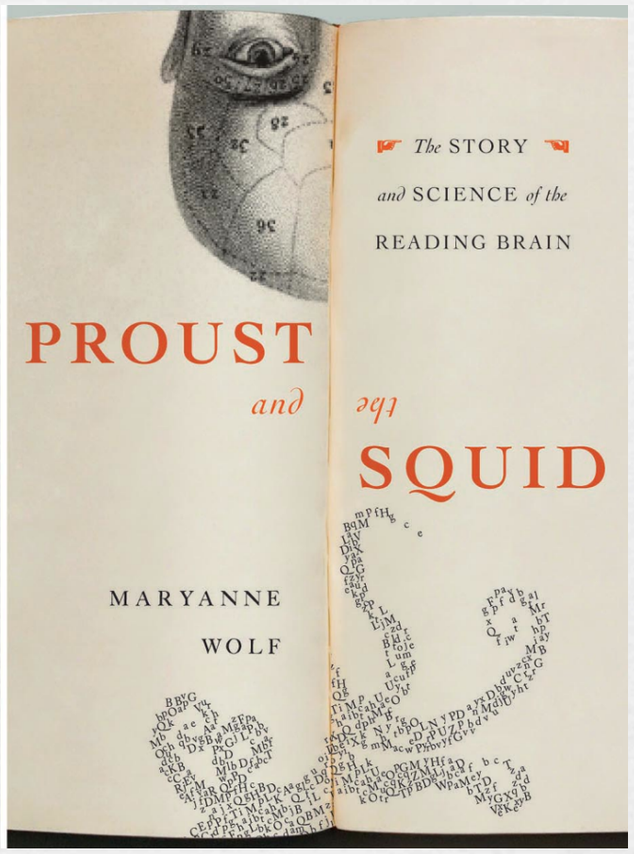
Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe

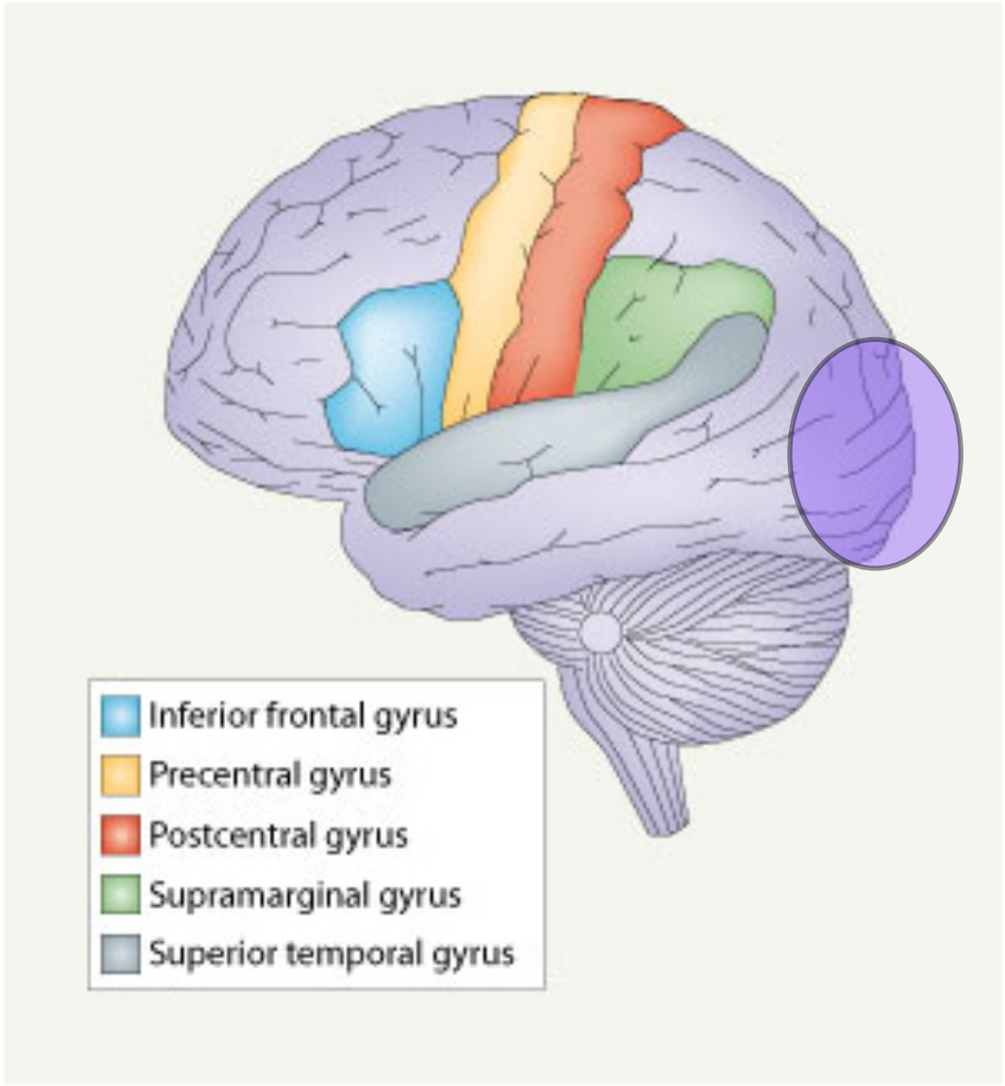


***Biological Psychology 6e*, Figure 2.12 (Part 1)**

We were never born to read.

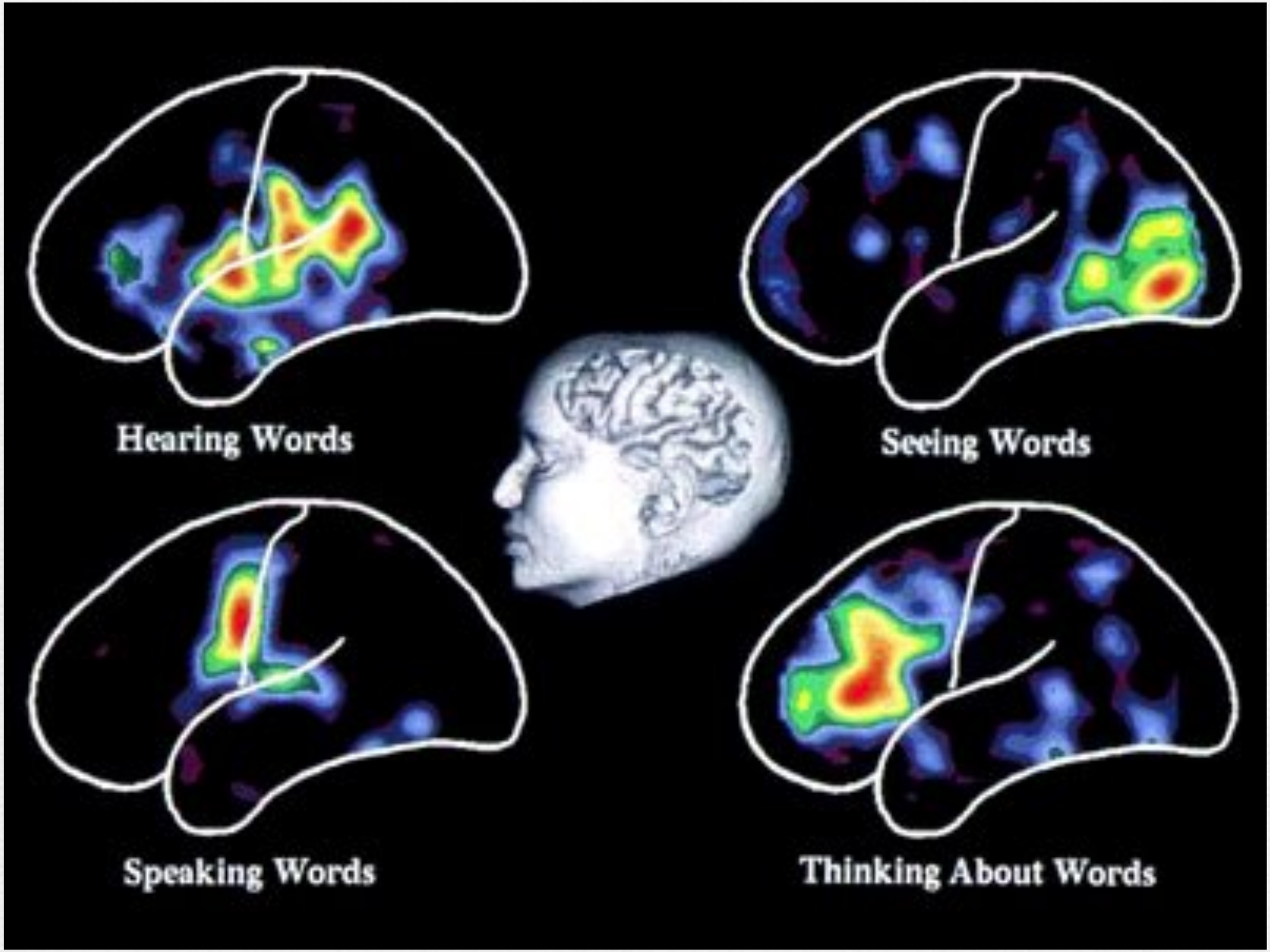
-Maryanne Wolf, Director
Center for Reading and Language Research

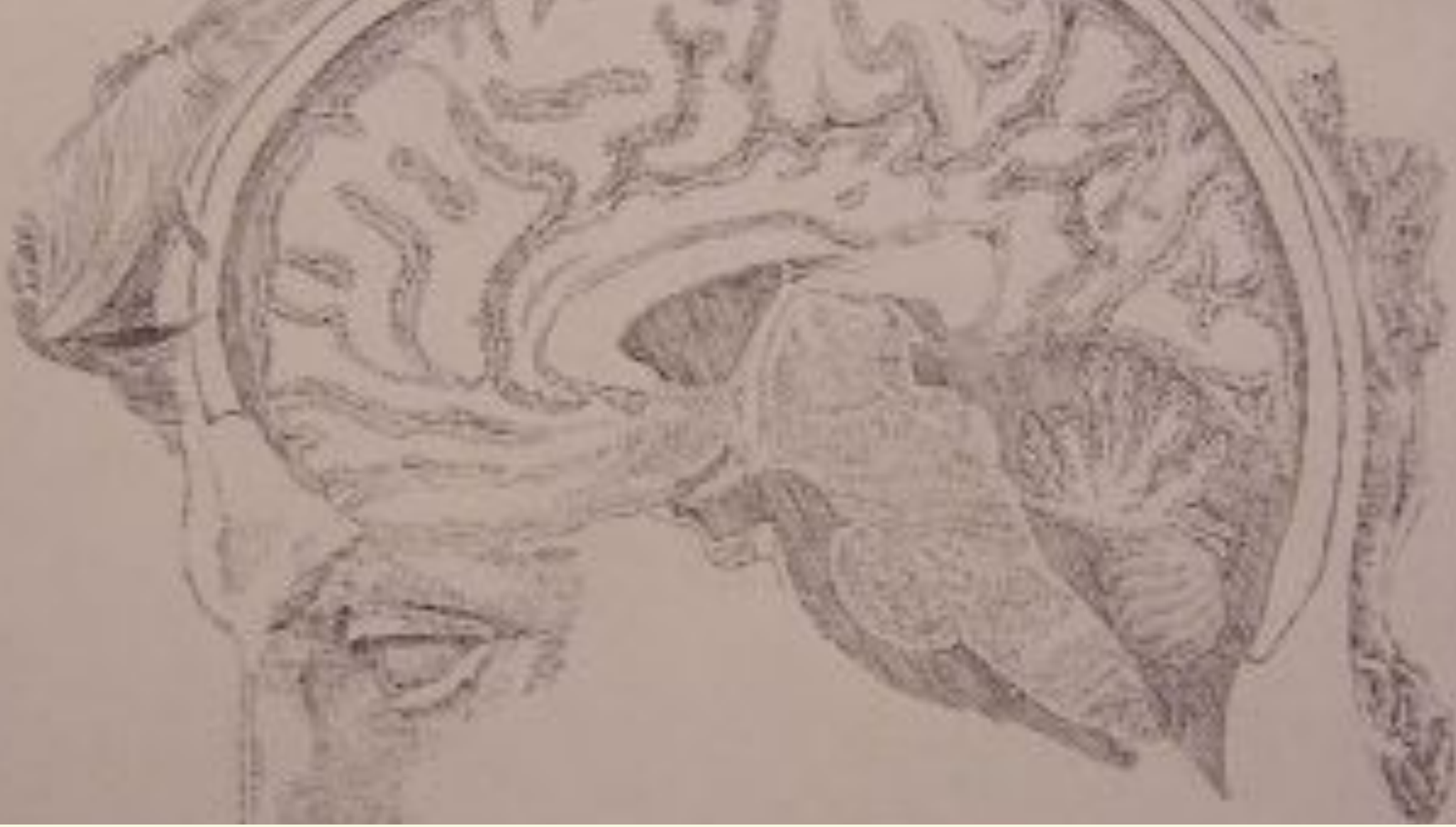




"Children are wired for sound, but print is on optional accessory that must be painstakingly bolted on."

-Steven Pinker

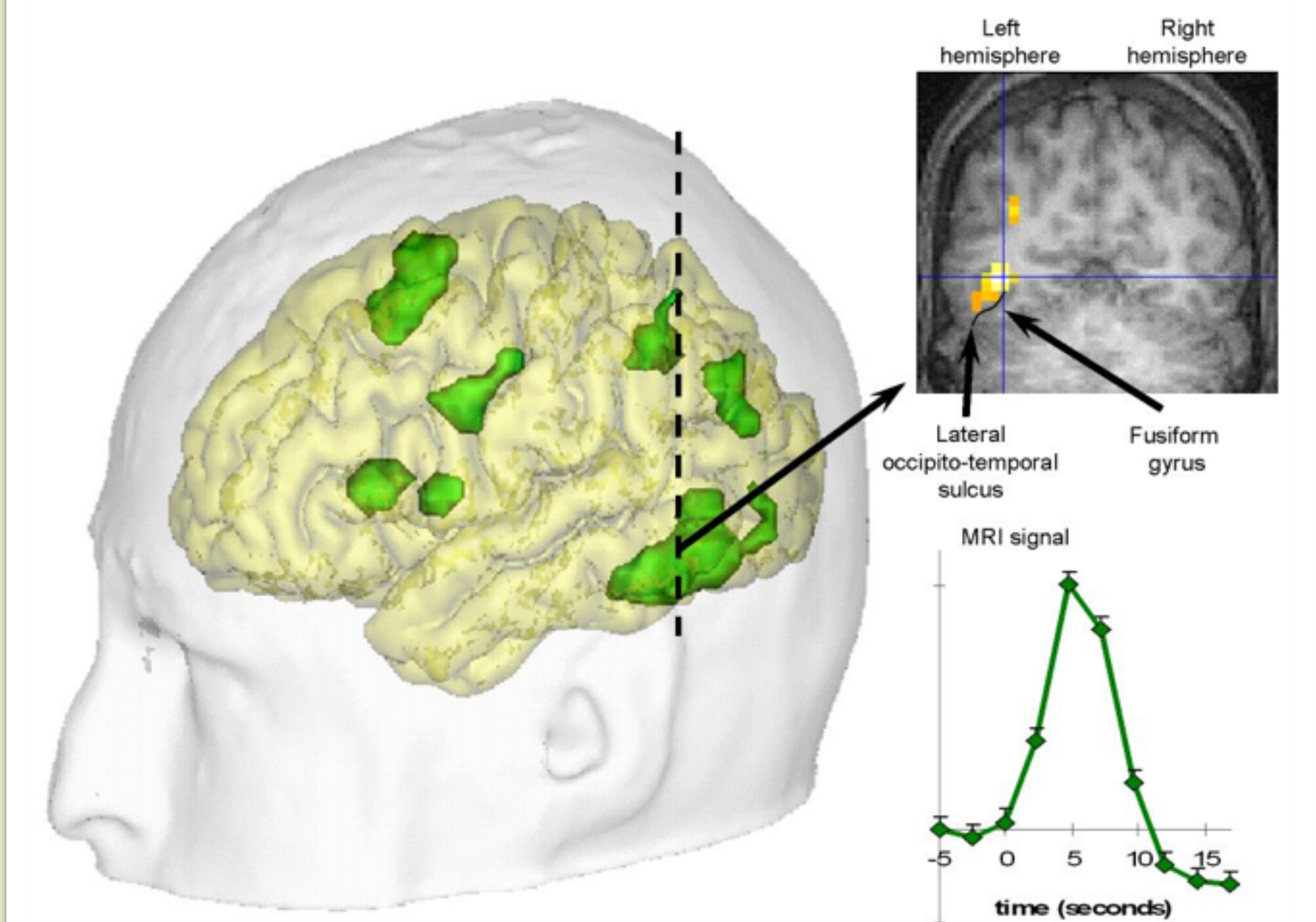

Hearing Words
Seeing Words
Speaking Words
Thinking About Words



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, 2009

“Neuronal Recycling” for Numeracy and Literacy

Understanding how the brain learn to read?

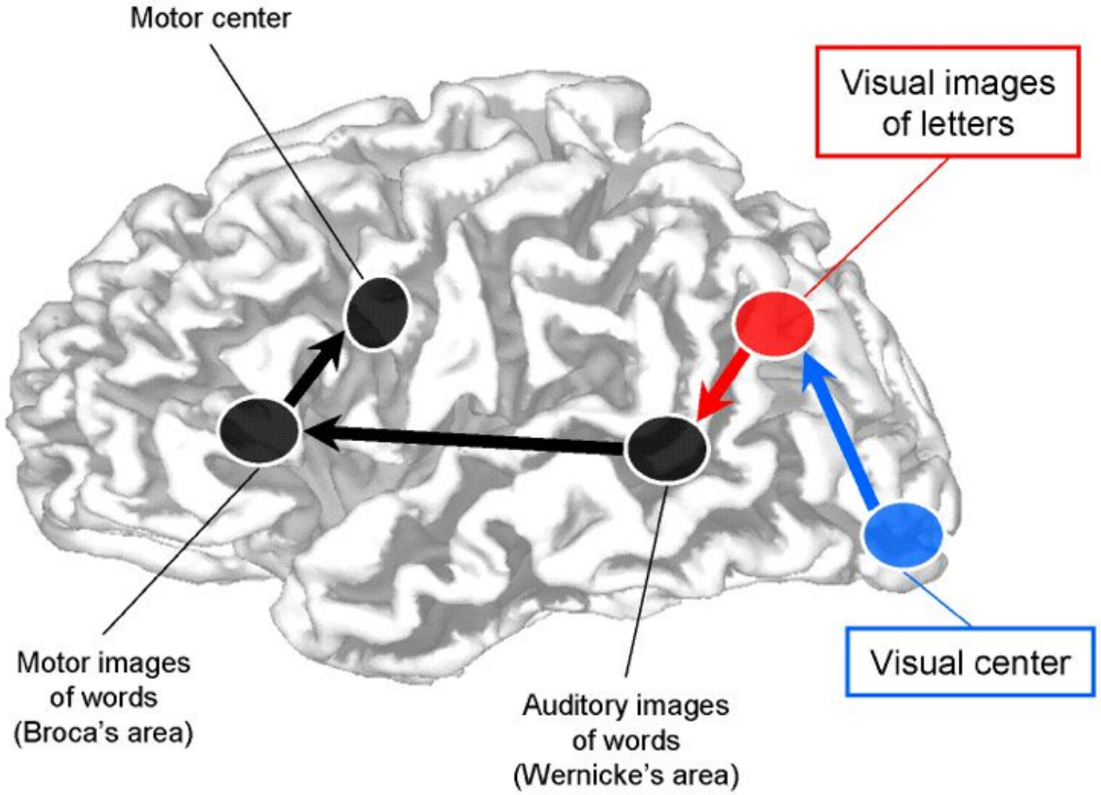
New Connections among Older Structures

Form "Working Groups"

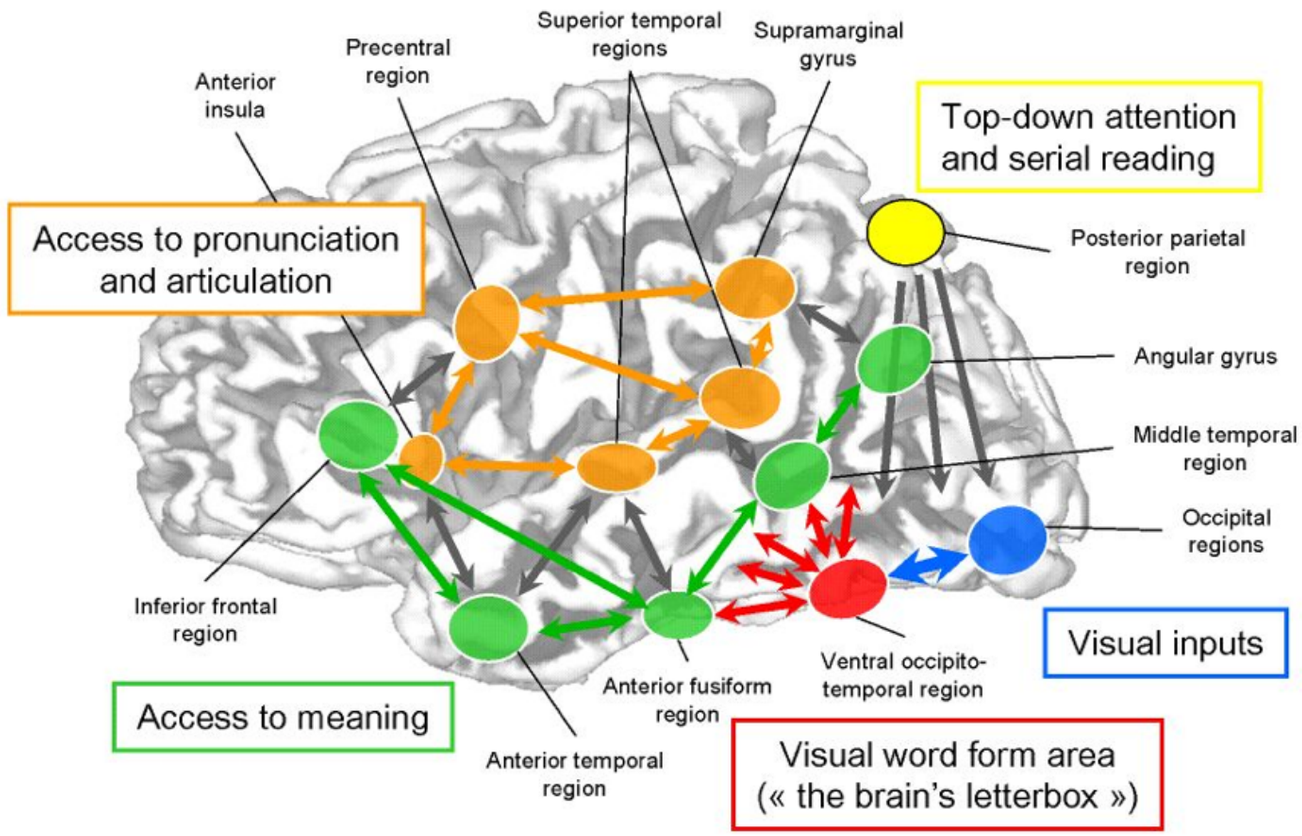
Automatic Circuits

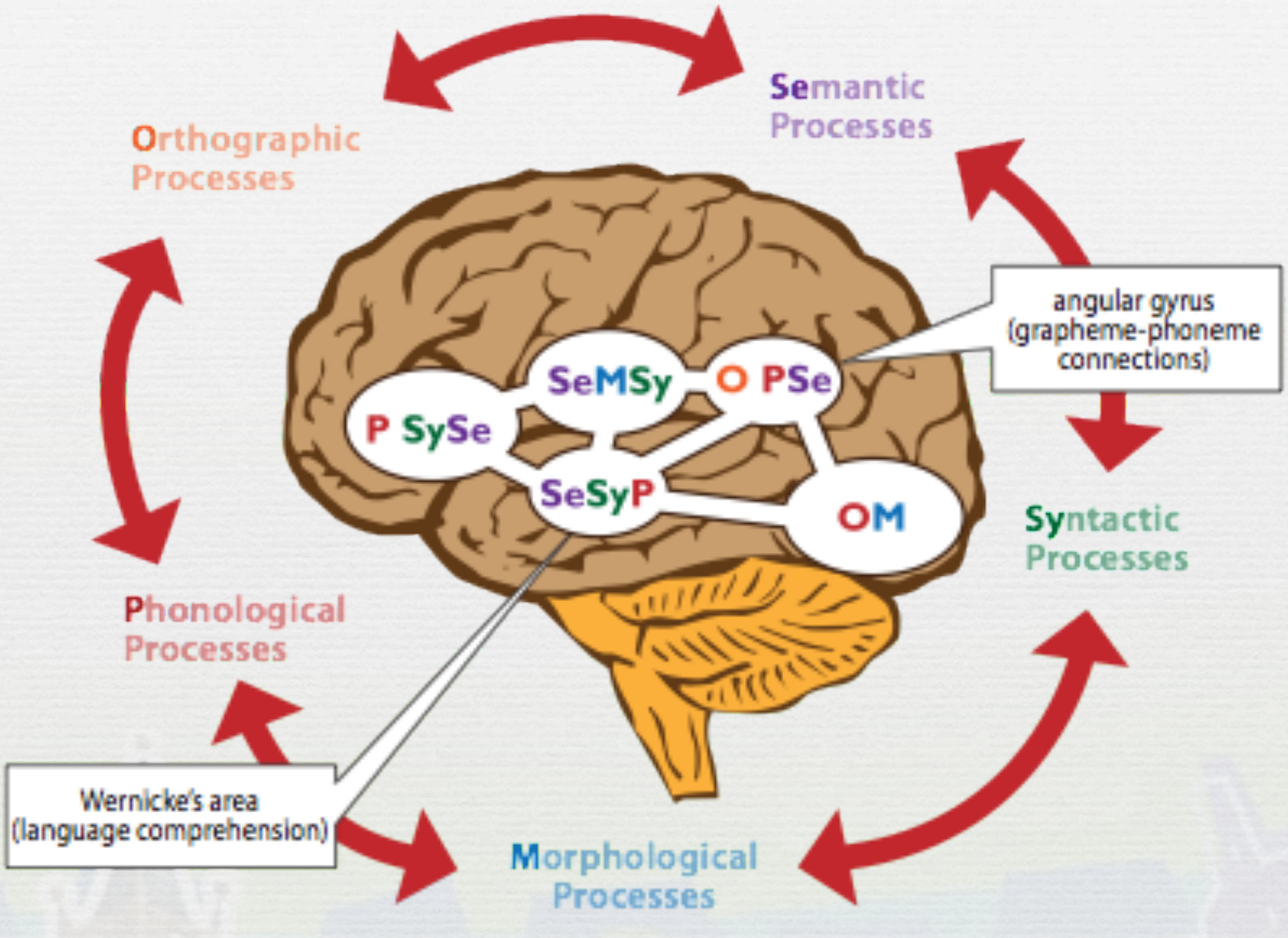
The old neurological model of reading

(After Déjerine, 1892; Geschwind, 1965)



A modern vision of the cortical networks for reading




Semantic Processes
Orthographic Processes
angular gyrus (grapheme-phoneme connections)
SeMSy
O PSe
P SySe
SeSyP
OM
Syntactic Processes
Phonological Processes
Wernicke's area (language comprehension)
Morphological Processes

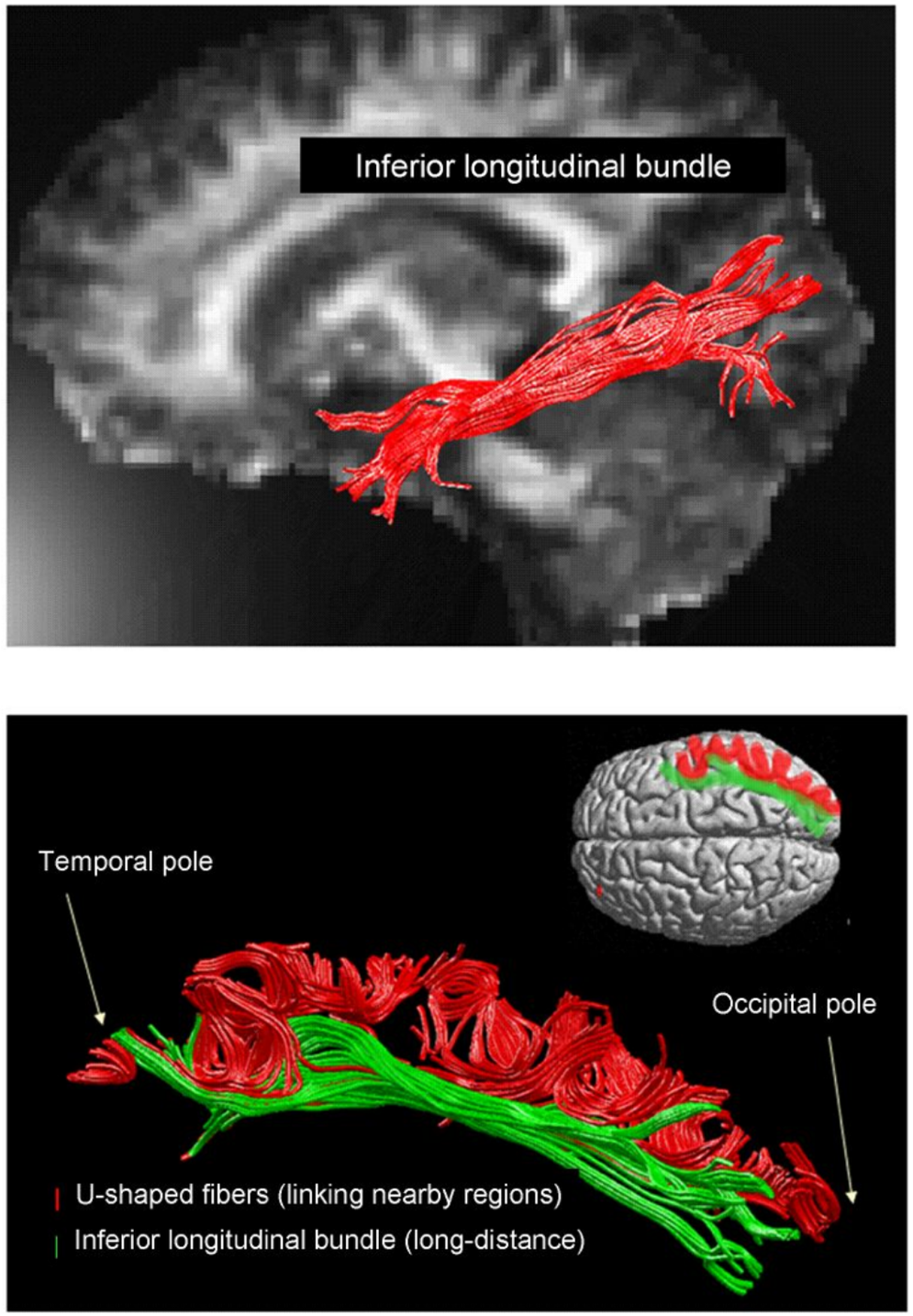
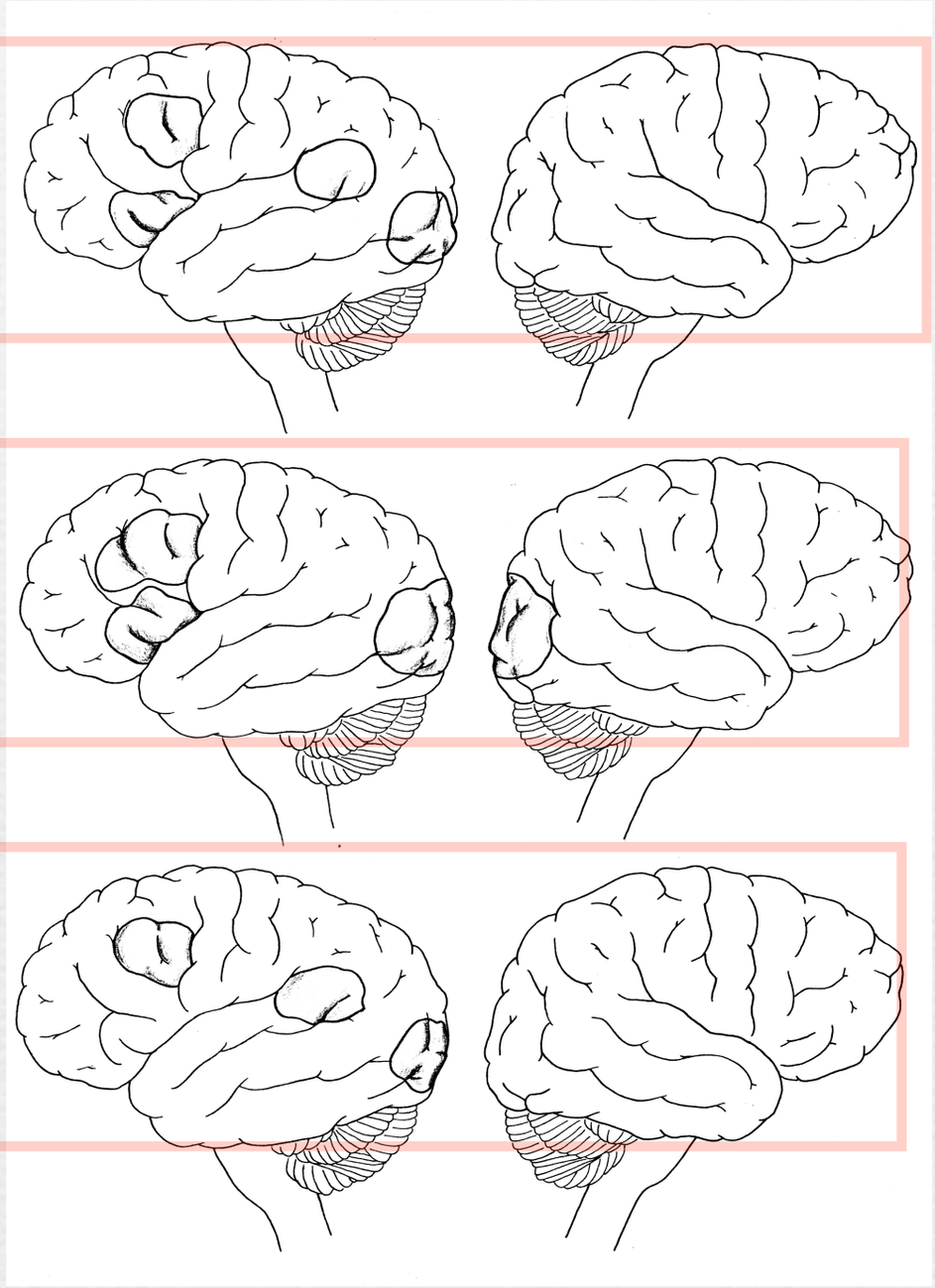


Figure 2.16. The left occipito-temporal region, at the back of the brain, analyzes written words and transmits the results to other distant areas through vast fiber bundles that can now be visualized with diffusion MRI. The image shows the reconstruction of a major anatomical pathway, the inferior longitudinal fasciculus, which projects towards the front of the temporal lobe. All along the cortical surface, numerous U-shape fibers also connect nearby regions step by step (after Catani et al., 2003).

English

Chinese & Kanji

Japanese Kana



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

Bulger, Perfetti, & Schneider

No Universal Reading Brain

What have we learned from brain studies so far?

- In typical readers, certain aspects of reading are reliably associated with certain brain areas
- There are brain differences between good and poor readers
  - But not all studies find them in the same place
- Structured reading instruction changes the brain
  - Caveat: we only beginning to understand the mechanism(s) of change. How can we use our understanding of what the brain is NOT doing in dyslexia to inform our intervention, particularly in phonology and fluency areas

So, what is dyslexia?

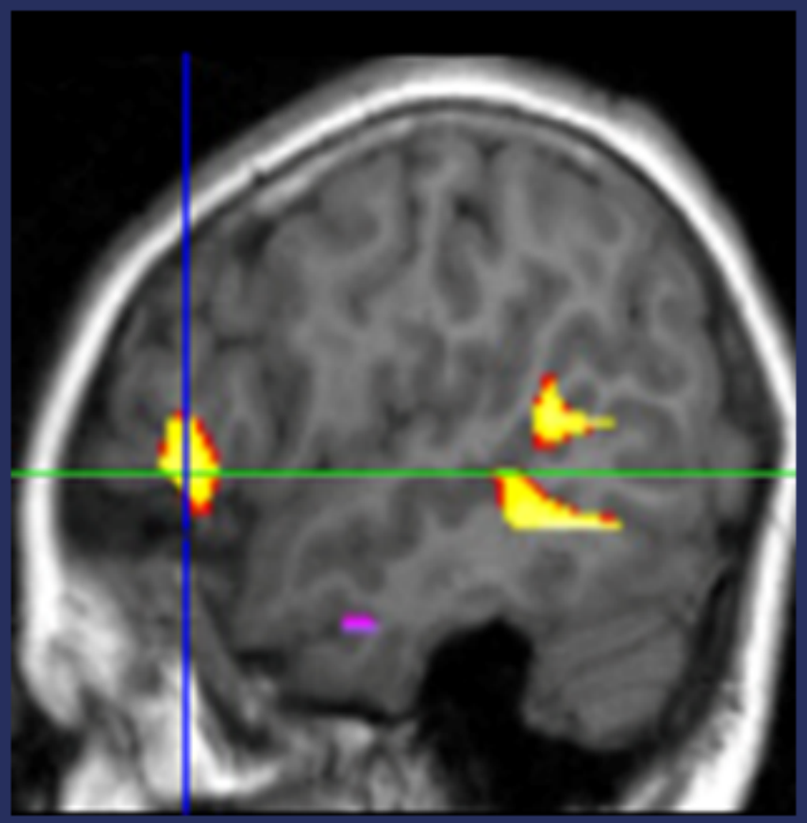
Dyslexia

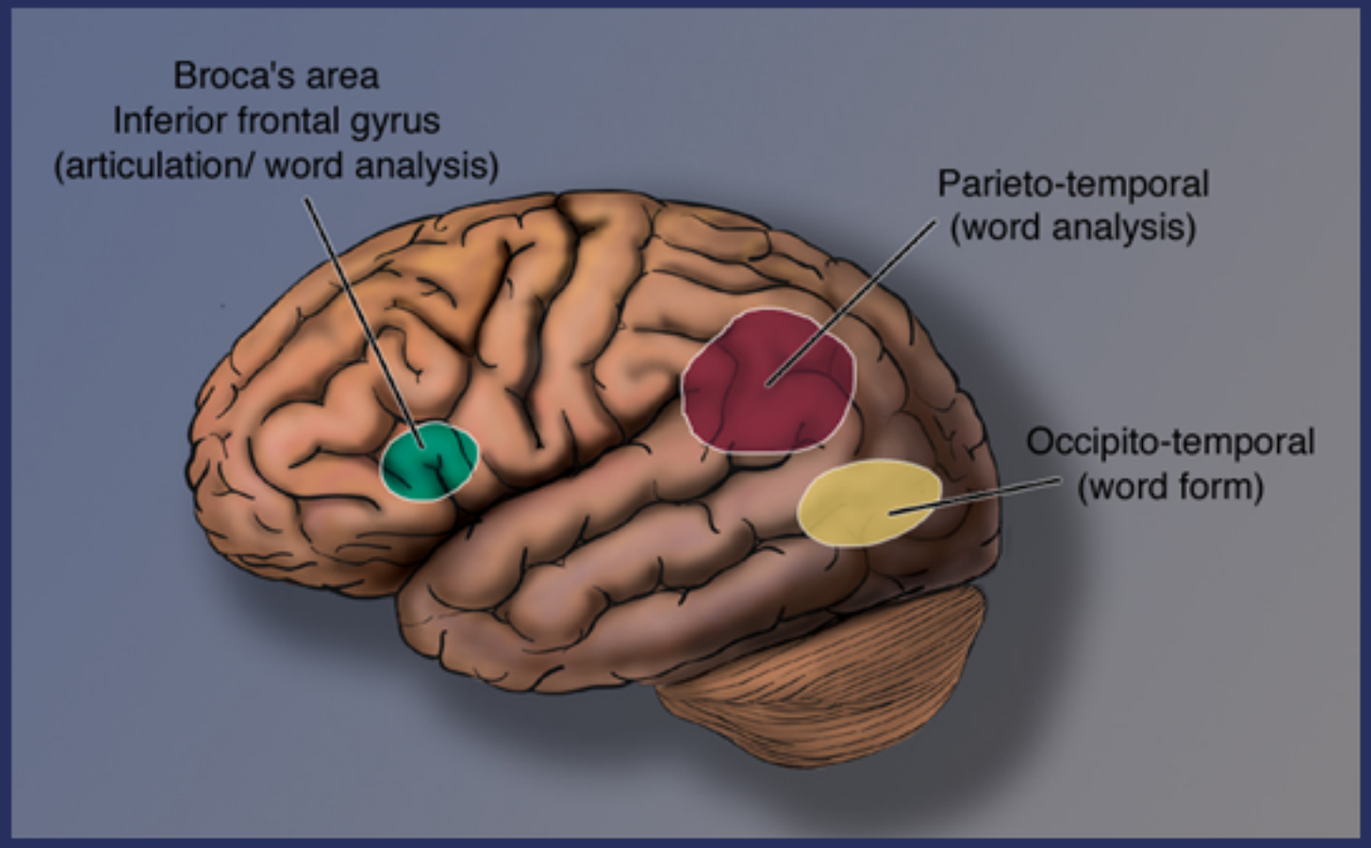
Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction.

(Lyon, Shaywitz, & Shaywitz, 2003, p. 2)

Neural Systems for Reading

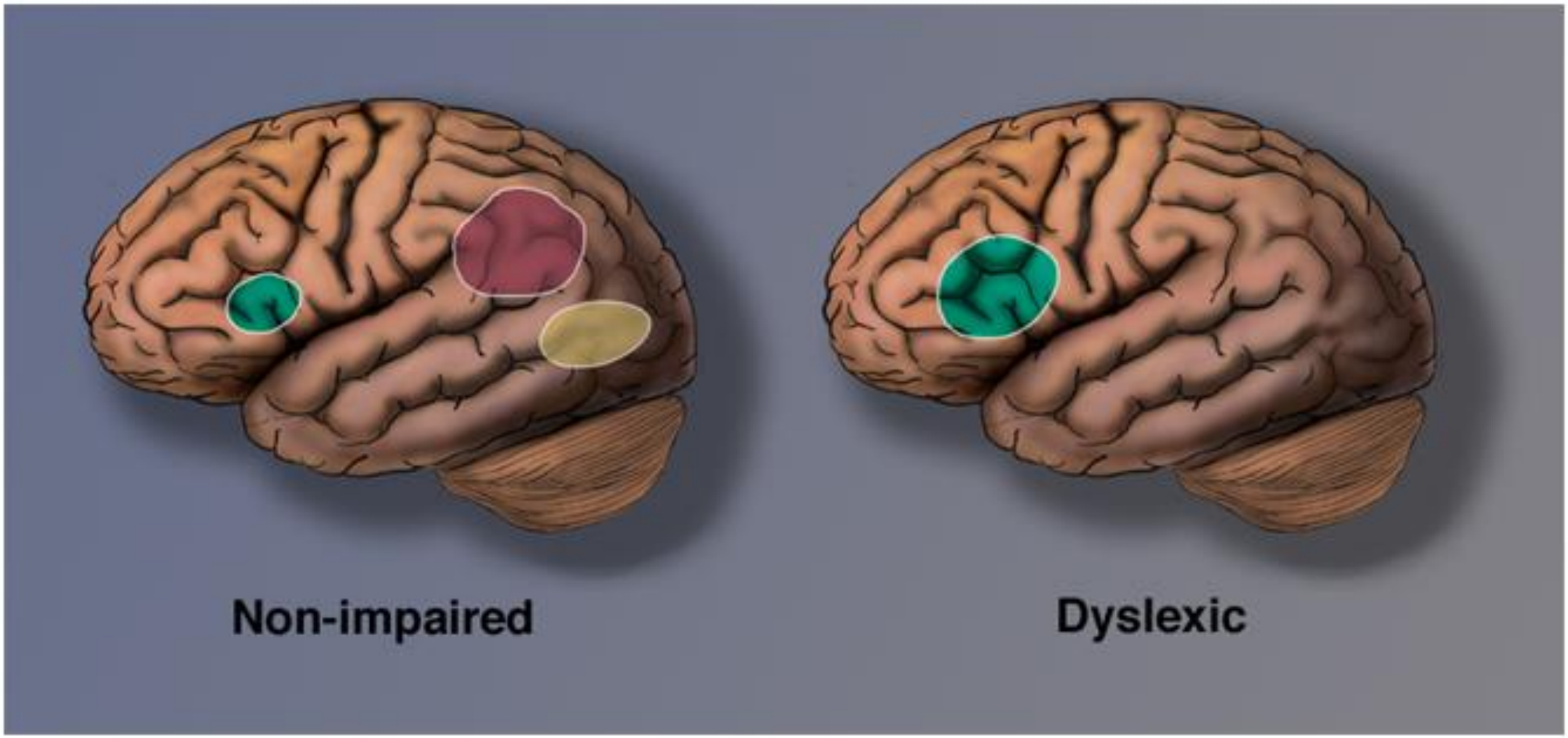
Typical vs Dyslexic Readers





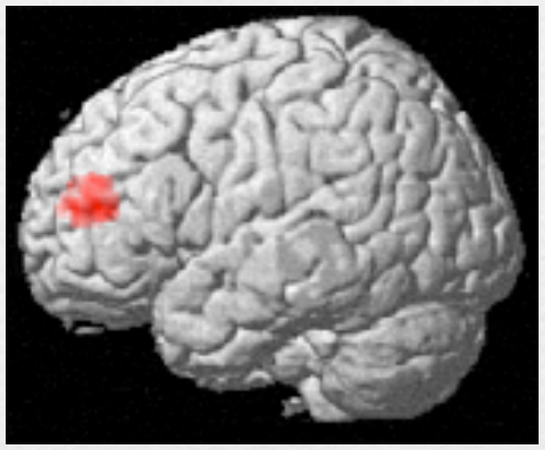
Neural Signature for Dyslexia:

Disruption of Posterior Reading Systems



Typical Readers

Ages 7-12, n=13

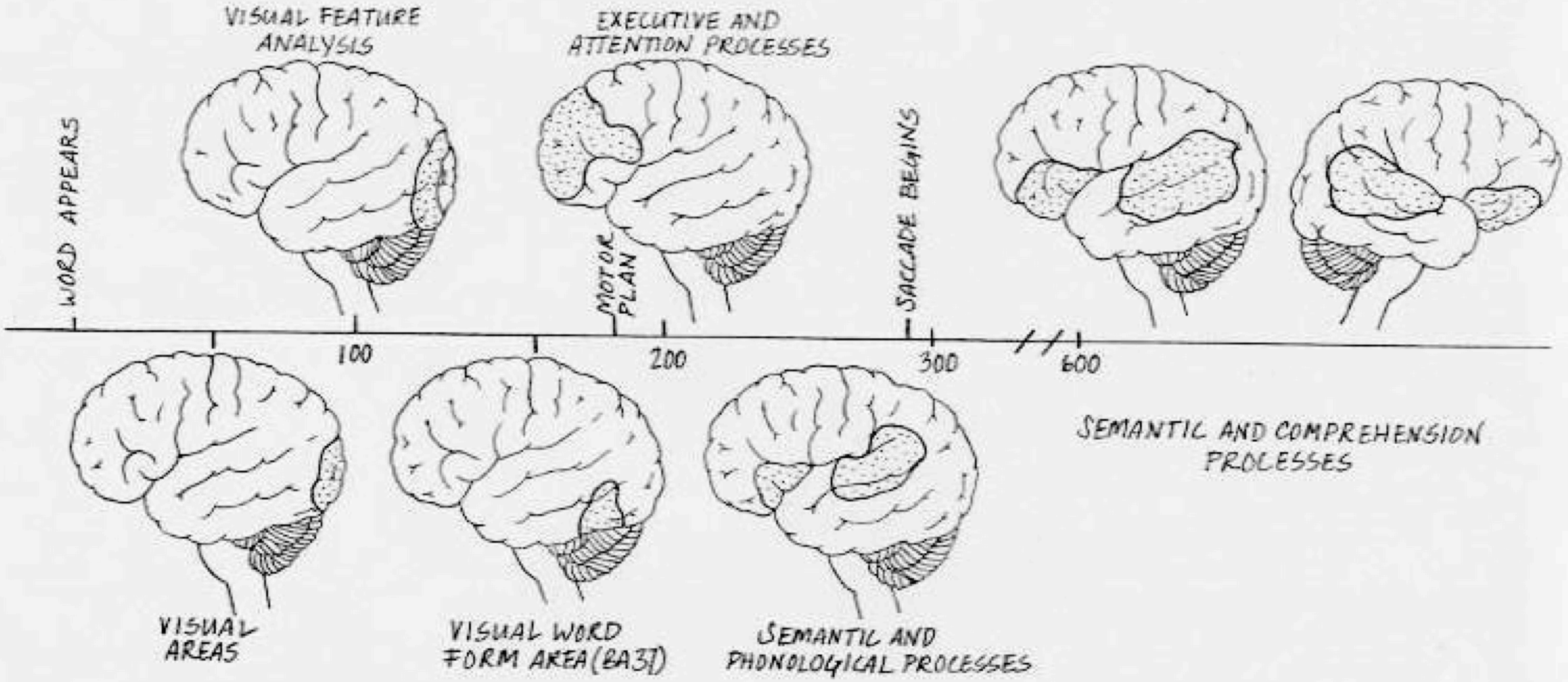


Children with Dyslexia

Ages 7-12, n=13

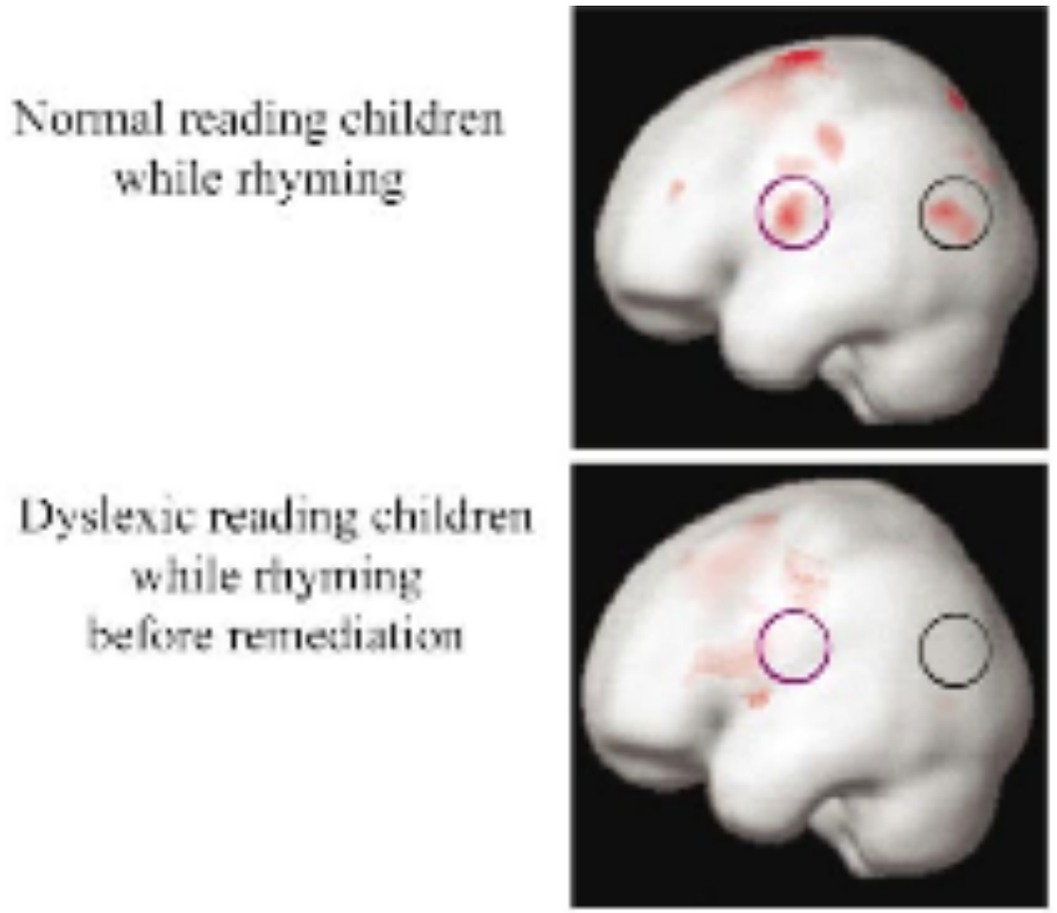
In dyslexia, widespread activation, particularly in RIGHT Hemisphere.

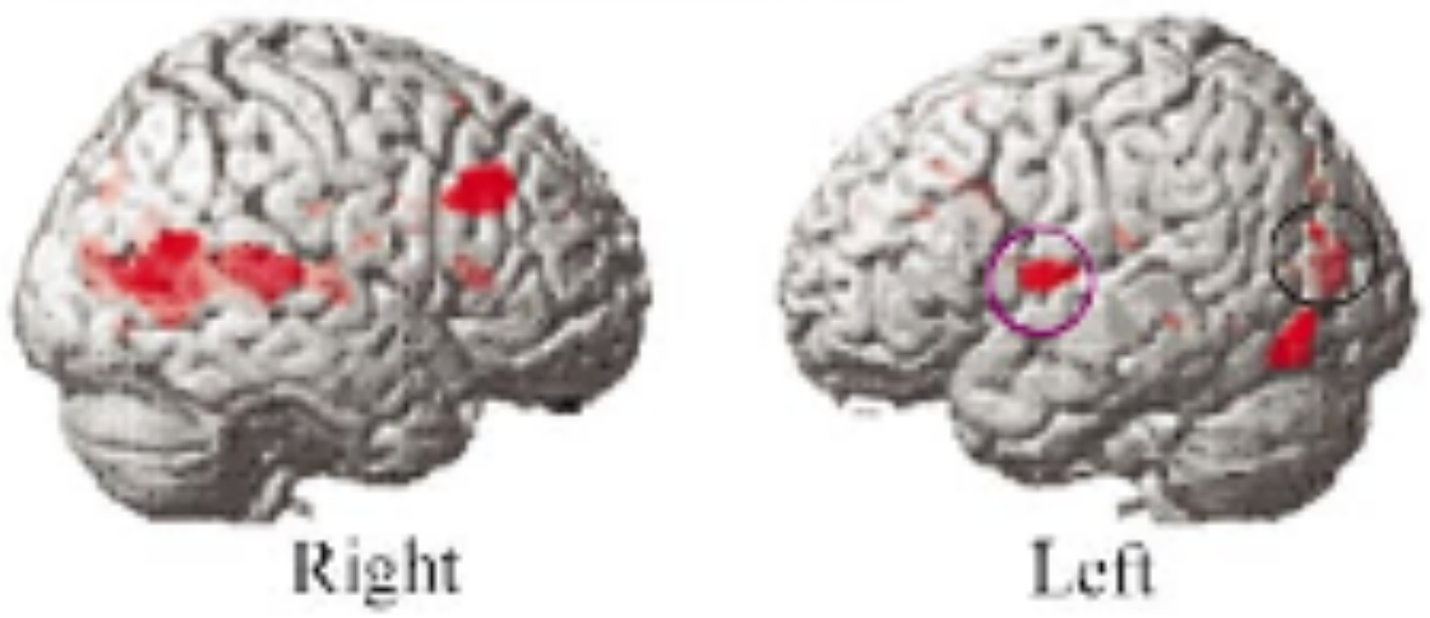
Kovelman, Norton, Wolf, Whitfield-Gabrieli, Gabrieli, et al, Cerebral Cortex, 2011



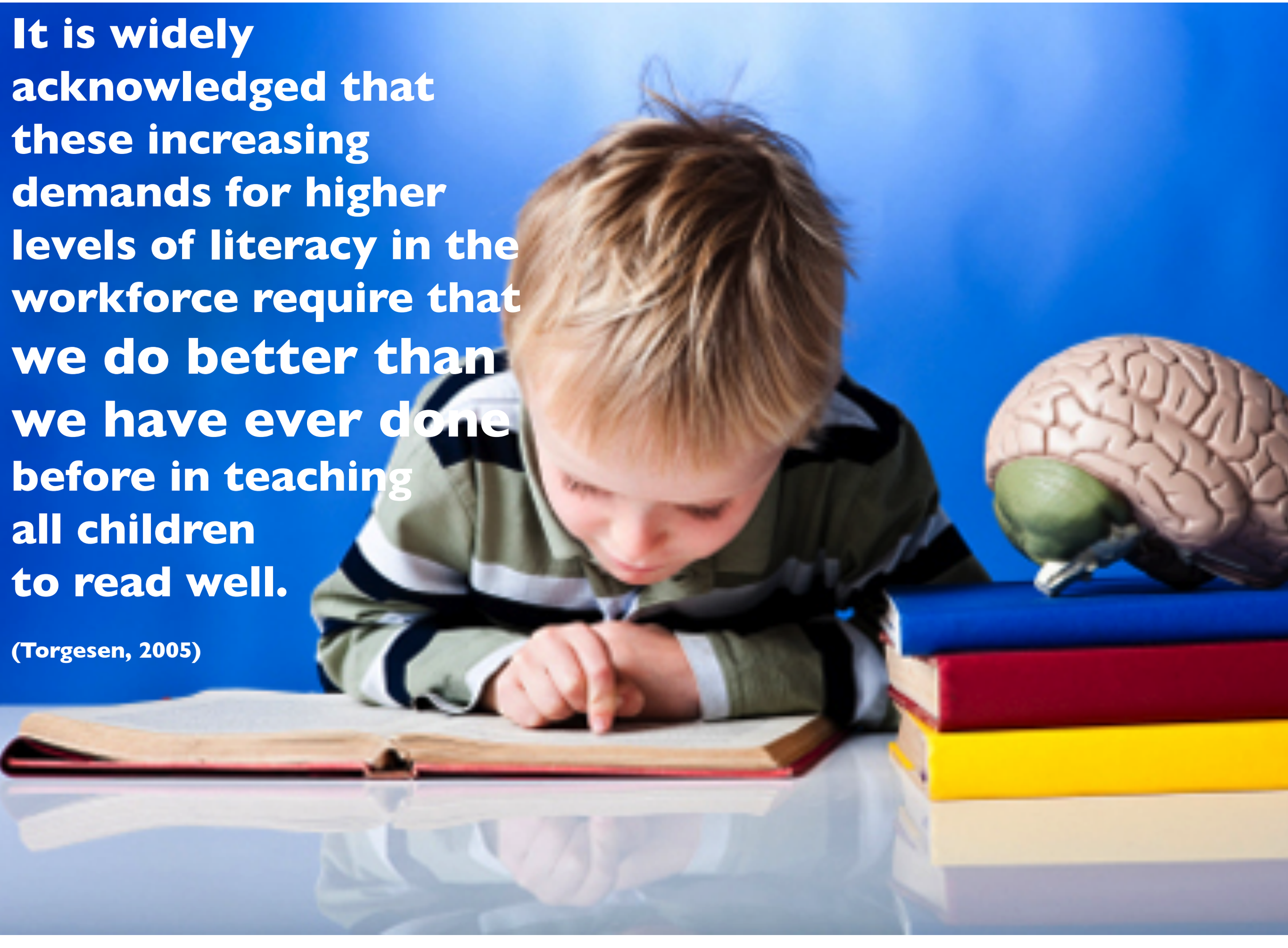
Dyslexics are 50-75 msec behind at every stage.

Dyslexia-
Postremediation



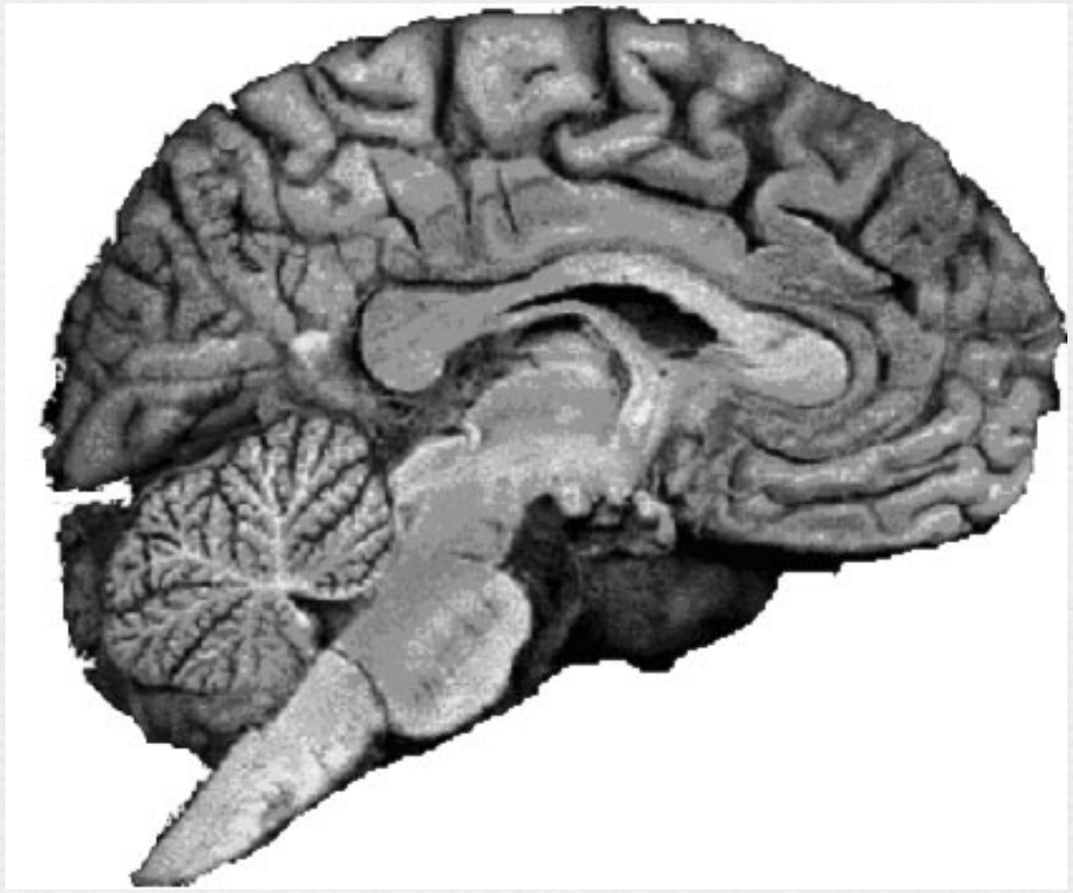


Temple et al., 2003


It is widely acknowledged that these increasing demands for higher levels of literacy in the workforce require that we do better than we have ever done before in teaching all children to read well.
(Torgesen, 2005)

Thank you.

steph.gottwald@tufts.edu



Questions unanswered during webinar due to time:

Please find questions asked by the audience members below and Dr. Gottwald's response to each. If you have additional questions or comments, please email webinars@voyagersopris.com.

Question 1

What about children who have a superior verbal IQ, but continue to struggle with on grade level reading fluency and basic sight word spelling? Ideas for instructional interventions?

Answer

Recent research has negated the influence of IQ on reading development. We can then assume that the major influence of IQ lies in the area of vocabulary. Children with superior IQs tend to have large and dynamic vocabularies. What we all know about words does at least indirectly contribute to the ability to retrieve information about words rapidly. Two published interventions that directly connect various levels of word knowledge and fluency are RAVE-O and Language!. RAVE-O is for elementary-aged children and Language! is for middle school to high school aged children. Both of those programs have shown remarkably efficacy for remediating fluency deficits.

Question 2

How do you provide quality interventions for children with an orthographic type of dyslexia that don't struggle with phonics?

Answer

There is little research on the independence of a diagnosis of orthographic dyslexia. Nevertheless, it is a frequently used term referring to children who have enormous difficulties learning to spell. While very few spelling interventions exist, there is evidence of the efficacy of systematic, rule-based spelling instruction for children with reading disabilities. I would look for guidance in the books Speech to Print by Louisa Moats and Unlocking Literacy by Marcia Henry

Question 3

Is there a neural circuitry benefit for students to tap out the phonemes of a word such as /m/ /i/ /p/ and then use a arm gesture that goes across the body as they blend the sounds into the word mip? Does this help build circuitry between the left and right hemispheres?

Answer

There is no data supporting those kind of physical movements to promote the connection between sounds and graphemes. However, that does not mean that those kinds of movements are not beneficial. The child is likely more engaged and has a more memorable experience with each learning moment when movement is involved. I would keep going with that. Kids love it.

Question 4

How can I help dyslexic students improve their fluency?

Answer

It is important to move away from the notion that fluency is based on speed alone. The speed of reading a text is only an index for how rapidly a child can access all the sound, grapheme, semantic, and syntactic knowledge of the word that is being activated. When any of this information cannot be activated quickly enough then the overall speed of identification is compromised. Keeping this in mind, it is important to teach words and vocabulary knowledge in an interconnected way and then allow children to practice their speed of activation. Children should be allowed to practice their fluency using texts they already know and can read and understand with ease.

Question 5

Can you send us references and resources regarding the various types of dyslexia -- research summaries and articles, books, etc. particularly relating to the double deficit idea?

Answer

I would recommend the following texts for information on dyslexia:
Overcoming Dyslexia by Sally Shaywitz
Proust and the Squid: The Story and Science of the Reading Brain by Maryanne Wolf
Reading in the Brain by Stanislas Dehaene
The Dyslexia Debate by Julian Eliot and Elena Grigorenko

Question 6

Can you recommend where to look for research on the relationship on language processing and math?

Here are some references I hope are helpful:
Martiniello, Maria (2008). Language and the Performance of English-Language Learners in Math Word Problems. Harvard Educational Review. 78(2).
Baroody, A. (1987). Children's Mathematical Thinking. New York: Teachers College Press.
Ginsburg, H. (1977). Children's Arithmetic: The Learning Process. New York: Van Nostrand.
Cathy

Question 7

I noticed in Shaywitz's definition that it referred to phonological processes. What about visual processes and rapid naming/fluency considerations?

Answer

You are right that Dr. Shaywitz's book does not mention research related to either visual processes or fluency. For an excellent overview of visual processes and reading I would recommend the first chapter of Reading in the Brain by Stanislas Dehaene. To find out more about fluency I would read Proust and the Squid by Maryanne Wolf.

Question 8

Are there specific tasks to encourage new pathway development for reading skills. For example, there has been a correlation between playing a string instrument for developing specific math skills. Are there any activities that may help to encourage components related to the brain's areas for reading?

Answer

If you want to help children learn to read, they should learn about words, about letters and sounds and try to read as much as possible. There is some evidence that rhythm related activities are correlated with phonemic awareness skills, but there is a great deal more work to be done in that area. Otherwise, there is no evidence that activities outside of reading or language help children learn to read.