THE READING BRAIN:
“We Were Never Meant To Read”
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- 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?

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

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

Bulger, Perfetti, & Schneider
Development of Insights into Written Language by the Species

2000 years

Symbolic representation

Symbols for language and concepts

Symbol for each sound
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.
Early Reading Brain: Everything Matters in the Development of the Reading Circuit
Concepts in first language are essential platform for concepts and vocabulary in second language.
Language Development

- Phonemes
- Orthographic Patterns
- Semantics
- Syntax
- Morphology
Phonemes Matter

Phoneme Awareness

Explicit Emphasis on Manipulation of Sound
Orthography Matters

Letters & Letter Patterns

Conventions of Print

Left to Right Scanning
Sticker Story: Horses

I like horses. Horses have other horse friends. Horses like carrots. You wouldn't think they could, but they can put their legs straight up. Horses make you feel good. My dad wants a horse but my mom says no, when I am 16 or 20 I will buy my own horses.
Semantic Development

Vocabulary

Semantic Depth & Breadth

Polysemy and Semantic Flexibility
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).
“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
<table>
<thead>
<tr>
<th>Morphological Development</th>
<th>jam</th>
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<tbody>
<tr>
<td></td>
<td>jams</td>
</tr>
<tr>
<td></td>
<td>jamming</td>
</tr>
<tr>
<td></td>
<td>unjammed</td>
</tr>
</tbody>
</table>
The more you know about a word ... the faster you will read and comprehend that word.

- Phonological processes
- Orthographic processes
- Syntactic processes
- Semantic processes
- Morphological processes
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
Going beyond the wisdom of the author
The Reading Circuit: Basis of Understanding Development, Disruption, and Instruction

Orthographic Processes

Semantic Processes

Phonological Processes

Syntactic Processes

Morphological Processes

Wernicke's area (language comprehension)

angular gyrus (grapheme-phoneme connections)
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
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).
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
- Low achievement
- Lowers student’s interest in learning
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).
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

- Sounds
- Meanings
- Letter Patterns
- Sentences
- Morphemes

Words
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

jam s
jam m ing
jam m ed
Comprehension, Deep Reading, and “Thinking Outside the Box”

Think Thrice
You are a thoughtful reader when you...

Think Ahead!
Think Back!
Think for Yourself!

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.

GORT-3 Oral Reading Quotient

<table>
<thead>
<tr>
<th>Intervention Model</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>73</td>
<td>82</td>
</tr>
<tr>
<td>Phonics Only</td>
<td>76</td>
<td>81</td>
</tr>
<tr>
<td>RAVE-O†</td>
<td>79</td>
<td>82</td>
</tr>
</tbody>
</table>
Gains both short- and long-term in vocabulary knowledge and semantic flexibility after 70 one-hour instruction sessions.

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

**RAVE-O AND WORD-R**

<table>
<thead>
<tr>
<th>No. of words for which more than one meaning was given</th>
<th>Trained Words</th>
<th>Untrained Words</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Score</td>
<td>Post Score</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>7</td>
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<tr>
<td>6</td>
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</tbody>
</table>

**Intervention Model**

Trained Words = RAVE-O Core Words  
Untrained Words = Word-R Test  
(All results significant at p ≤ .001 level.)
## Study Population GAP

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SES</td>
<td>50% High- 50% Low</td>
</tr>
<tr>
<td>Race</td>
<td>50% CA - 50% AA</td>
</tr>
<tr>
<td>IQ</td>
<td>50% Average- 50% Below Avg.</td>
</tr>
</tbody>
</table>

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)

In 5 weeks

* Significant at the p < .05
** Significant at the p < .01
Tufts Summer Reading Program
Reduction in Avoidance Behaviors (Orkin, 2013)

INTERVENTION
Reduced disruptive behaviors & task avoidance

CONTROL
Increased disruptive behaviors & task avoidance

Grouping
- Control
- Intervention

Frequency of Neg. Achievement Behaviors
Pre-and Post-Classroom Observations
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

- Massive information processing and production
- Speed and efficiency
- Multi-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)
We do not know...

... 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?
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?
Global Literacy Collaborative
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

Grammar Processes

Vocabulary Processes

Sound Processes

Letter/Word Processes

Morphological Processes
“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

![Bar chart showing vocabulary words in different categories](Image)
Global Ethics Literacy

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
- Visit our website: http://ase.tufts.edu/crlr
- To learn more about the Global Literacy Project, visit globallit.org.