Neuroscience of Learning
An Introduction to
Mind, Brain, Health, and Education

Section: Reading & Dyslexia

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The Nobel Prize & severe dyslexia

Baruj Benacerraf
1980 Nobel Prize for Medicine (Immunology)

Carol Greider
shared 2009 Nobel Prize for Physiology (telomeres and chromosomes)
Dyslexia & astrophysics
Neuroscience & the Classroom: Making Connections

A COURSE FOR K-12 TEACHERS

OVERVIEW
Insights drawn from neuroscience not only provide educators with a scientific basis for understanding some of the best practices in teaching, but also offer a new lens through which to look at the problems teachers grapple with every day. By gaining insights into how the brain works—and how students actually learn—teachers will be able to create their own solutions to the classroom challenges they face and improve their practice.

see video

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UNITS:
Introduction | Different Brains | Emotion & Thinking | Seeing Others | Different Learners | Neural Networks | Implications for schools | Conclusion

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http://www.learner.org/courses/neuroscience/
Using Technology to Break the Speed Barrier of Reading

New research suggests that one of humanity’s most important inventions can be improved

By Matthew H. Schneps on September 8, 2015
IQ and language development appear to be uncoupled in dyslexia

Ferrer et al., (2010); Shaywitz, Weiss, Saklofske, & Shaywitz (2015)
Dyslexic adolescents rated higher on creativity than typically developing adolescents.

![Graph showing comparison between dyslexic and non-dyslexic children and teenagers from BRUXELLES.](image)
Entrepreneurs with dyslexia

- Richard Branson: The Virgin Way
- "The Shark" Daymond John: Display of Power
- Steve Mariotti: The economics of one unit
Poll: What part(s) of the brain do we use to read?
The reading network

- Motor plans for handwriting: e.g., Exner’s area
- Auditory representations of phonemes: e.g., Planum Temporale
  \( /b/ \neq /d/ \)
- Motor plans for vocalisations: e.g., part of Broca’s area
- Lower-level visual areas
- Visual representations of letters: e.g., Visual Word Form Area (VWFA)
  \( b \neq d \)
Another look at the reading network

Dehaene, 2009
Poll: Can you lose your left occipital lobe and still read?

Lesion caused by a surgical intervention at the age of 4
YES! The brain can overcome...

At Age 11

**Normal volunteers**

**Patient**

$Z = -12$
Poll

• Do young readers use more cortex than skilled readers?
Typically, specialized language areas develop and lateralize over time based on experience.

- Longer/refined connections are more efficient (like well-formed highways rather than meandering trails)
- Right hemispheric regions are recruited in early learners but less and less as expertise grows

Age 11

Age 38
Poll

• Reading networks & dyslexia...
Reading networks are different in dyslexia

**Red** = Non-impaired reader > Dyslexic reader

**Blue** = Dyslexic reader > Non-impaired reader

A. Young readers

B. Older readers

NI > DYS (positive)
DYS > NI (negative)
Connectivity is different in typical versus dyslexic readers

**Red** = Non-impaired reader > Dyslexic reader

**Blue** = Dyslexic reader > Non-impaired reader

Finn, 2013
Connectivity differences are seen in children at risk for dyslexia before 18 months of age

Axonal tracts of the arcuate fasciculus (connecting Broca’s area with Wernicke’s area) have decreased white matter in FHD+ infants.
Why are there such differences in these networks?
Words are processed as whole words or phonologically
Long route taxes working memory: the phonological buffer

https://classconnection.s3.amazonaws.com/173/flashcards/21173/png/psyc11339595879773.png
What are the implications of this heavy working memory load?
Dyslexia is variable: A few possible root causes

- Magnocellular theory (visual processing atypicalities)
- Impaired visual attention
- Impaired auditory processing

A PHONOLOGICAL DEFICIT is a core component in most forms of dyslexia

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How the visual system works (oversimplified)
Dorsal stream = location...”where” pathway
Ventral stream = thing...”what” pathway
VWFA is in the ventral stream

When we learn to read, we retrain part of the face area (FFA) into one that specializes in letters.
There is a cost... Illiterate adults are better are recognizing faces than literate adults

Dehaene, 2010
What does the VWFA do?

It and the networked regions before and after enable “...the rapid recognition of strings of letters and their translation into sequences of sounds.”

Why does the VWFA matter in dyslexia?
“RD [Reading Disability] often has a genetic basis and has been associated with a common neurobiological marker—the failure to develop a functionally specialized visual-word form area (VWFA)…”
Magnocellular theory
Visual magnocellular system dominates dorsal visuomotor pathway - directs visual attention & eye movements.
Magnocellular theory: Visual atypicalities

“... Reading can be disrupted in patients with 20/20 vision [because]... reading is a complex task that involves an interplay among vision, eye movements, attention, and linguistic processing.”

Fig. 1—When reading does not work.
Magnocellular theory: Visual atypicalities

“... Reading can be disrupted in patients with 20/20 vision [because]... reading is a complex task that involves an interplay among vision, eye movements, attention, and linguistic processing.”

What are the possibilities for intervention?
Impaired visual attention
Dorsal attention network

Table 1: Attentional control networks, their associated areas and function.
(Adapted from Shine et al. 2011; images from Spreng et al. 2010)

<table>
<thead>
<tr>
<th>Dorsal Attentional Network</th>
<th>Voluntary orienting</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dorsolateral prefrontal cortex</td>
<td>• Cognitive information processing</td>
</tr>
<tr>
<td>• Posterior parietal cortex</td>
<td></td>
</tr>
<tr>
<td>• Corpus striatum</td>
<td></td>
</tr>
</tbody>
</table>
Impaired visual attention may involve the VWFA

The VWFA has stronger connections to the dorsal visual attention network than to the reading network.
What are the implications of a VWFA traffic jam on the development of the reading network?

- Hint #1: Practice makes permanent.
- Hint #2: The mind is made by the work of the hand.
The auditory processing network

Impaired auditory processing

Decreased ability to hear clearly as sound intensity changes over time (think of a classical music piece that goes from piano to forte...rise time)

Goswami, 2015; Hämäläinen, et al., 2012
Impaired auditory processing

- Trouble with rise-time (the upward moving part of amplitude) is predictive of future reading difficulty

- Behavioral evidence of rise-time difficulty:
  - Impaired musical rhythm
  - Timing differences in syllable production

Poll

Symptoms of dyslexia
What do you think would help?

https://dyslexickids.wordpress.com/2013/06/26/dyslexia-mind-map/
Dyslexia interventions

- Repeating Reading: Some small evidence
- Spelling Mastery: Some small evidence
- LindaMood Phoneme Sequencing: Moderate evidence
- Orton Gillingham: Not much evidence
- FastForward: Mixed evidence
- Computer training: Growing evidence
Motor practice may improve visual attention

First, motor movements may direct attention to the stimuli being learned, resulting in a more robust visual representation. Second, after a motor movement is learned, a motor program is established that may directly connect to the visual cortex during perception, increasing its recruitment. Third, the act of writing a letter may result in visual information that adds to, or augments, a representation of the visual form that is re-activated upon subsequent perception. The first hypothesis, that motor
And the apps!

**ER Browser - $0.99**
Compatible with iPhone, iPad, and iPod touch. Requires iOS 7.1 or later. This app is optimized for iPhone 5.
This app is a web browser that allows the user to change the style of web pages to make them easier to read. The user can change the background color, fonts, text size, and more.

https://itunes.apple.com/app/er-browser/id552868356

*Lower Elementary*
*Operating System/Platform: iPhone*

**Learn to Read, Write and Spell - Free**
Compatible with iPad. Requires iOS 4.3 or later.
This app teaches advanced reading and spelling skills to children and adults who struggle in those areas.


**SightWords**
SightWords free and printable materials are designed to promote learning in the classroom and also at home. They have recently introduced a great new curriculum for teaching Phonemic Awareness (also called Pre-Phonics) to children.

**Dictaphone Business**

**Intro to Letters, by Montessorium**

**Phonics Genius**

**Dyslexia Quest**
MIT & compassionate tech
Case study: Brett Burlison

Stories of e-readers and dyslexia...

Read how Brett Burlison, an attorney with dyslexia, discovered how reading on an iPhone helps, and how this lead to his writing a novel, a passion he thought was out of reach. Read how he did it here.

How iPhone Unlocked My Dyslexia

Here’s a sentence I never thought I’d write: I just published my first novel. Being a writer seemed elusive not because I couldn’t tell a good story, but because reading was so difficult. Seriously.

I’m severely dyslexic. Here’s the story of how I got here, and the tech that helped forge the way.
E-reader

Read Your Way.
Pause, rewind, change speed.
Change font, size, spacing, color for optimal readability.
Highlight and take notes.
Speed-read.
Set a sleep timer. Or put on your headphones, lock the screen and go for a walk.

Synchronized Highlighting.
Seeing the words smoothly synchronized with speech improves comprehension and knowledge retention. Auto-scrolling and full-screen, distraction-free view helps the reader focus.

truth is so well fixed in the minds of the surrounding families, that he is considered the rightful property of

186 Voices.
30 Languages.
You will find a perfect instrument.

Try Acapela voices
Try Ivona voices
Try NeoSpeech voices
Press on a word for a second to bring up bookmarking menu.

Pinch the screen to enter Focused Reading Mode.

Tap with two fingers to scroll to the text being read out loud.

Double tap on a word to start reading from there.

Gestures
Is it cheating to use an E-reader?
Case study: Holly

“I thought I was illiterate. I found essay writing really hard. There was nothing more frustrating than knowing what you wanted to write, methodically constructing a logical plan, ticking all the relevant check points and then the final essay to be somewhat unrepresentative of what was initially intended.”
Case study: Holly

What helped in HS:
  o Technology
  o Tests: a reader, scribe, and more time

What helped in college:
  o A university mentor
  o Two months extra time for her dissertation
  o A laptop with assistive technology software

Holly recently graduated from college with a degree in Physical Education
Case study: Tom

- 8 years old
- Can’t construct CVC words
- Can’t recall sight words
- Reads q for y
- Sounds out dress as b r s s
- Frustrated
Case study: Tom

Intervention plan

• Memory (auditory and visual, to include sequential memory)
• Developing a sight word store
• Securing phoneme-grapheme correspondence
• Alphabetic knowledge

...What’s missing???
Case study: Grace

- Trouble with visual scanning, processing, and working memory.
- Difficulties with spelling and sequencing for problem solving.
- Strong verbal skills and artistic abilities.
- Learns well with color and when her hands are occupied.
- Struggles with note taking (due to difficulties with spelling and visual scanning as she switches from the front of the room to her paper)
- Difficulty keeping up with lecture (gets “lost”)
- Looks like she’s daydreaming...

http://dyslexiahelp.umich.edu/professionals/students-strengths-and-interests/case-studies
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What are the possibilities?
Case study: Grace

• **Not Daydreaming**: Desperately wants to blend in with her peers (so she looked to them to see what she was supposed to be doing)

• Able to follow along in books that she could highlight and make doodles and notes in the margins during the lecture; this freed her attention to focus on the lecture and gave her notes to refer to later
Case study: Amy

• Enjoys creative writing, fashion, and art
• Extremely bright and has a strong memory
• Benefits from rule-based instruction. If you tell her a rule once, she will be able to recite it to you the next time you see her.
• She delights in being able to be the teacher and teach the rules herself or correct others’ errors.
• Amy’s stories often jump around without any cohesion or plot
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What are the possibilities?
Case study: Amy

- Visual/editing approach to stories
- Work on her story daily
- Use a multi-sensory model to illustrate the parts of a story (character, setting, initiating event, internal response, plan, and resolution)
- Amy drafted stories about glamorous people and enjoyed illustrating their wardrobes
- Amy revised her stories (with guidance) using the story tool
- After several revisions, she produced a well-developed story and colorful illustration that was framed and displayed.

http://dyslexiahelp.umich.edu/professionals/students-strengths-and-interests/case-studies
Case study: Ryan

- Diagnosis of PDD-NOS that affects his language, social, and literacy skills
- Struggles with anxiety.
- Interests: pirates and treasure, cooking, watching his favorite TV shows, and drama
- Strong memory
- Conveys a great deal of social knowledge when he is acting or drawing
- Protests and shuts down when he has to read or write
Case study: Ryan

- Diagnosis of PDD-NOS that affects his language, social, and literacy skills
- Struggles with anxiety
- Struggles with reading and following directions, asking for clarification, and comprehending and using abstract vocabulary
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What are the possibilities?
Case study: Ryan – Social anxiety reduction

- Watched shows that taught lessons about friendship or had a “moral to the story”
- Took some of those themes and stories and modified them into his own story that included kids from his school and himself as characters
- Illustrated his story and made it into a short book.
- Therapist suggested that Ryan make his story into a play, and that he could be the director
- Role-plays done with therapist to help with social anxiety: greetings, turn-taking, active listening, problem solving, and flexibility for handling unforeseen circumstances
- He invited a peer to act in his play; Has since directed four plays and written countless others
- Five of his peers have come and acted in his plays. (It has become a “cool” thing to do in Ryan’s social circle)
- Gained confidence in relating to his peers and in his strength of writing and directing plays
Case study: Ryan – Sequencing & directions

- **Baking projects**: required him to locate the directions on the package, sequence and follow each step in a sequence, and determine the meaning of new vocabulary
- This contextual learning increased his attention and removed all anxiety
- Built on his strengths for baking
- Learning in context allowed him to remember the meanings of abstract vocabulary
- Ultimately he brought his baked treats to others thus receiving more positive social feedback
Case study: Ryan-Reading practice

- **Scavenger hunts** to boost reading for directions and vocabulary skills
- Enjoyed the challenge of complex directions because there was an element of surprise and adventure
- Clear consequence if he incorrectly followed the directions (creating the opportunity for Ryan to ask for directions or seek clarification)
- Context-based learning (i.e., he was looking at a fire extinguisher when he was reading the word for the first time) was easy to remember
- Many conjunctions (but, therefore, so, if) and sequence words (when, at the same time, before, after, next) were targeted multiple times, which led to mastery
Julia’s Top Recommendations

• Bountiful early exposure to oral language (including music, rhymes, and poetry) from humans who care
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• Let the parent’s know it’s not their fault! But, they can make a difference

• Focus on the positives! Let them know that everyone has challenges/gifts (name yours) and everyone finds strategies to work with them...everything is workable.
Good luck with your work!

Grad students, remember to complete the 3-2-1!