The Science of Dyslexia: An Overview of the Science

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Read Washington
June 5, 2021

Thanks to Dr. Jack Fletcher for the use of some of his slides.

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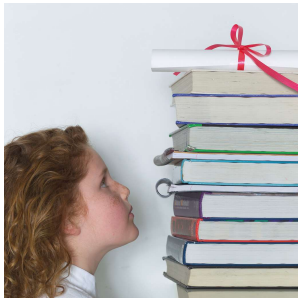
What is Dyslexia?



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What is Dyslexia?

- Dyslexia is a **word reading disability**.
- The primary characteristic is difficulty ***reading and spelling single words***, especially when presented in lists.
- It leads to problems reading text, but is not a text-level disability.

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Voices of Students (Middle School)

"Sometimes when students in my class read, they might know how to say simple words okay, but they will skip over the big words. They look around to see if anyone is even listening to them. But they don't fix them; they just keep going. They stumble over words, trying to sound them out. Sometimes they don't even know they made a mistake, and when they finally figure out the words, they don't have a clue what it all means. They just keep going."

McCray, Vaughn, & Neal, 2001

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What is Dyslexia?

- **A language-based disorder, *not* caused by vision problems.**
- **Primary underlying cause**: Poor phonemic awareness, NOT "seeing backwards"

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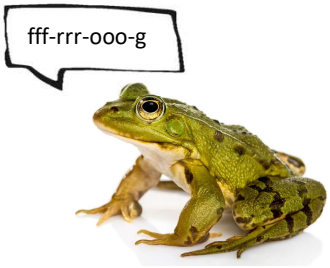
Phonemic Awareness is the ability to recognize, identify, and manipulate the individual sounds in spoken words.



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What is Dyslexia?

(definition adopted by the International Dyslexia Assn.)

"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. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge."

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A Complex Picture

- Many students with dyslexia also have problems in addition to word reading difficulties.
- Many also have ADHD (25-40%) (but these are two separate/different conditions).
- Anxiety is common.
- Written expression and reading comprehension are often impaired (lack of reading experience limits vocabulary and background knowledge).

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Causes of Reading Disabilities, including Dyslexia

- **Genetic**
- **Environmental**
- **Neurological:** Affected by *the interaction of* genetic and environmental influences

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A Genetic *Predisposition*

- Genes account for about 50-80% of the variance in reading outcomes in different genetic studies
- Among children who have a parent with dyslexia, as many as 35%-45% have dyslexia
- No *specific* genes for poor reading have been identified (e.g., no "dyslexia genes")

"Biology is not destiny"

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Environmental Factors

- Economic disadvantage (access to health care, preschool education opportunities, exposure to lead, etc.)
- Early print exposure, parental literacy habits
- Oral language usage in the home and community
- Time spent reading to the child and talking about books
- Reading instruction that fails to meet the needs of the student

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Dyslexia and the Brain

The way the brain functions when doing reading tasks is different in people with dyslexia (and in children at-risk of dyslexia and other word-reading disabilities) and normally functioning readers.

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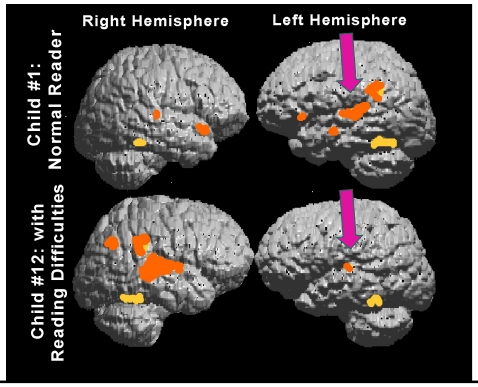
Brain Function in Dyslexia (Simos et al., 2001)



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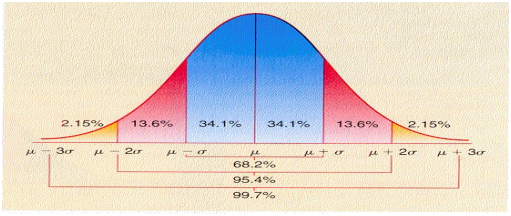
Reading difficulty and disability/dyslexia…

- Is variation on normal development (like high blood pressure, not the flu or a broken leg)
- May be mild, moderate, or severe



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What is the Prevalence of Dyslexia?

- We don't know *exactly* how many people have dyslexia
- It depends on the methods and cut-off scores used for identification.
- Most estimates are about 7%-15% in the general population.
- We do not know how to reliably distinguish dyslexia from other word-reading disabilities.

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Identification of Students with Dyslexia

- There is no "dyslexia test" that will validly identify someone with dyslexia.
- Dyslexia is best identified through assessments of reading and spelling skills, *and* tracking students' response to high-quality reading intervention.

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Screening for Dyslexia

- Rapid triage that should not burden the teacher
- Screening may produce "false positives"—students who seem to be at-risk for dyslexia but are not.
- Goal is to determine who needs more assessment
- WHY? Sufficiently intensive, consistent early reading intervention can *prevent* the word reading difficulties associated with dyslexia or *reduce their severity.*

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Dyslexia Assessment

- Students identified through screening need additional reading assessment.
- Assess phonemic awareness, phonics, word reading, text reading.
- Identify students as at-risk for reading difficulties or disabilities and provide strong, consistent, research-based intervention.
- Monitor student progress with repeated assessments.
- Students with weak response to strong intervention may have dyslexia.

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Interventions for Students with Dyslexia

Where's the magic bullet????

- Physical exercises?
- Colored overlays?
- Eye exercises?
- ADHD medication?

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Physical Exercises

- "There is currently insufficient evidence that exercise or movement-based therapies are effective in remediating dyslexia.
- Early theories of brain disorganization, lack of hemispheric dominance, and perceptual-motor deficits have been discredited, and therapies based on these theories lack scientific evidence to support them."

Denton (2011)

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Vision Treatments and Dyslexia

"Scientific evidence *does not support* the efficacy of eye exercises, behavioral vision therapy, or special tinted filters or lenses for improving the long-term educational performance in these complex pediatric neurocognitive conditions."

American Academy of Pediatrics, 2009

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What is "scientific reading research"?

High-quality scientific research controls for sources of bias or competing explanations for the findings so that you can trust the conclusions.

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Experimental Research: The "Gold Standard"

- Hypothesis testing
- Random assignment to groups
  - "Treatment"
  - An alternative treatment or "Typical Practice" (NO Placebos!)
- Large samples representative of the population
- Fidelity to treatment (really doing what you say you are testing)

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The Convergence Insufficiency Treatment Trial-Attention and Reading Trial (CITT-ART)

- Convergence Insufficiency (CI): A specific vision condition; the eyes have difficulty converging and tend to drift outward when looking at near objects.
- CI has been associated with symptoms that could interfere with reading: double vision, blurred vision, tired eyes, eye discomfort, headaches, difficulty working up close.

CITT-ART Investigator Group, 2019

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CITT-ART Study

- Office-based vision therapy (eye exercises) has been found effective in treating CI
- But does this therapy improve reading in children with CI?
- Randomized clinical trial that evaluated the effects of office-based CI therapy
- Multi-site study (9 sites in 7 states)

CITT-ART Investigator Group, 2019

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CITT-ART Study

310 Children **with Convergence Insufficiency**
Reading Ability Varied
Grades 3 to 8

Randomly assigned

Office-Based
CI Vision Therapy
N = 206

Placebo Therapy specifically designed NOT to stimulate convergence and focusing
N = 104

16 Weeks of Treatment

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Convergence Insufficiency Study: Results

- The CI therapy improved students' CI (vision) significantly more than the Placebo therapy
- The groups did not differ significantly on any reading outcome at posttest.
- CI vision therapy improved students' vision, but it did not improve their reading more than the placebo therapy

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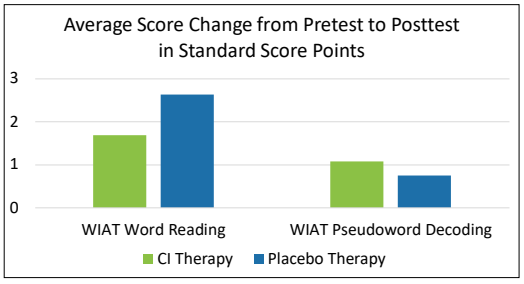
NO Effects on Skills Related to Dyslexia
(Word Reading and Decoding)



WIAT = Wechsler Individual Achievement Test

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Convergence Insufficiency Eye Exercises

- Are likely to improve vision in children with CI
- May make reading more comfortable
- Are NOT likely to improve word reading or decoding, the underlying difficulties in persons with dyslexia

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Risks of Ineffective Treatments

"Serious harm could…be caused by *delaying potentially more effective interventions* as children with dyslexia engage in months of ineffective treatment, since children with impaired reading become farther and farther behind …They may also suffer the serious emotional consequences of repeated failure."

Denton (2011)

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Does ADHD treatment improve reading outcomes for students with both ADHD and RD?

- The ICARD Study: Interventions for Children with ADHD and Reading Difficulties
- Funded by the National Institute of Child Health and Human Development, National Institutes of Health
- 2010-2016, Houston and Cincinnati-Area Schools

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Children with Both ADHD and Reading Difficulties (RD)

- ADHD and reading difficulties/disabilities (RD) are two different conditions
- From 25% to 40% of children with ADHD also have RD, and vice versa

Image credit: #92284297, Credit: Leah-Anne Thompson, iStock, Getty Images

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As a group, children with both ADHD and RD have…

- More severe reading difficulties than with children with RD alone
- More severe attention difficulties than children with ADHD alone
- More severe academic failure and lower grades
- More severe social impairment than children with ADHD alone
- Poorer long-term social and occupational outcomes

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Treatments for ADHD and RD

- Well-validated interventions exist for each condition.
  - ADHD symptoms: medication + behavioral therapy (MTA, 1999)
  - RD: intensive reading instruction
- Less is known about optimal treatment approaches for children who have *both* ADHD and RD

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Our Questions…

When children have both ADHD and serious word-reading difficulties…

- What is the effect of just treating the ADHD?
- What is the effect of just providing intensive reading intervention?
- Is there an added impact if you treat both conditions at the same time?

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Participants

- 216 students in grades 2-5.
- All met formal criteria for ADHD (combined type or inattentive type).
- As a group, they were *severely impaired word readers*: Average pretest word reading and decoding scores were in the 3rd to the 5th percentiles.
- Attended 73 schools located in 22 school districts in the Houston and Cincinnati areas.
- Mostly male (60.6%), African American (72.1%), and economically disadvantaged (76.1%)

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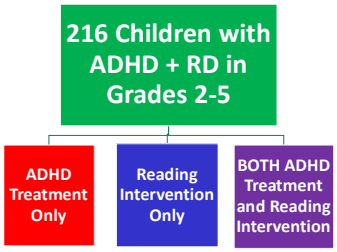
Children Were Randomly Assigned to 1 of 3 Groups



16 Weeks (not counting school holidays)

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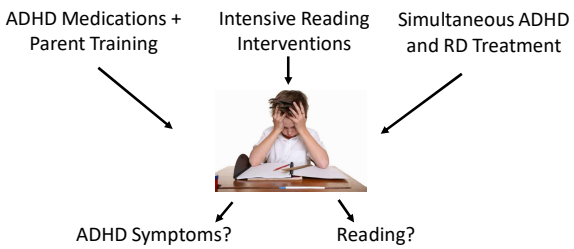
Purpose of the Study



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ADHD Treatment

- *Carefully-Monitored* Medication
  - Saw the study doctor weekly at first, then monthly
  - We collected ratings of performance and side effects from *parents and teachers* before each clinic visit
  - Doctor changed medications and dosages until child did well, and this was continuously monitored
  - 4 possible medications to choose from
- Parent Classes taught by a psychologist: Parenting a Child with ADHD

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Evidence-Based Reading Intervention

- Used programs and approaches supported by research evidence for students with reading difficulties
- Explicit, systematic instruction in word reading, decoding, and fluency; less emphasis on comprehension instruction
- Extended opportunities to practice; many hands-on practice activities
- Daily time spent reading books and stories with teacher support and feedback (both decodable and non-decodable text)

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Intensive Reading Intervention

- Four days per week for 45 minutes, for 16 weeks, at school.
- 1:1 or in groups of 2
- Provided by highly-trained teachers who were part of the research team

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Results

Tamm, Denton, et al. (2017).
Denton, Tamm, Schatschneider, & Epstein (2020).

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Improving Word Reading and Decoding

- *Intensive reading intervention* resulted in significantly better outcomes than ADHD treatment alone.
- Adding ADHD treatment to reading intervention was *not better* for enhancing word reading or decoding outcomes.

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Improving Reading Comprehension

- Providing ADHD treatment resulted in better *reading comprehension outcomes* than intensive reading intervention.
- Probably because the medication improved students' focus, attention, and self-regulation, which are very important for reading comprehension.

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Results

Intensive Reading Intervention

Improved Word Reading, Decoding, and Reading Fluency

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Results

ADHD Medication + Parent Training

ADHD Symptoms

Reading Comprehension

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Implications

When children have both ADHD and serious reading word-reading difficulties (including dyslexia):

- For improving ADHD symptoms: Treat the ADHD.
- For improving word reading and decoding: *Teach them to read.* Provide intensive, consistent, evidence-based reading intervention.
- For improving reading comprehension: ADHD medication may help improve reading comprehension.
- Combining the treatments doesn't seem to give additional benefit, but it is efficient.

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Please Note That…

- Children in the study remained impaired on all reading measures after 16 weeks of treatment
- Consistent small-group reading intervention is typically required for children with serious reading difficulties or disabilities for months, or even years.

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Effective Interventions for Students with Dyslexia and Other Word-Reading Difficulties

- In (nearly) every scientific study, *non-instructional treatment strategies have **not** been shown to be effective.*
- The same approach works for students with word-reading difficulties and those with diagnosed dyslexia

What *is* effective?

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The Power of Instruction

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Prevention vs. Remediation

Early intervention is effective for many students:

- Many children at-risk for dyslexia *can be taught to read in the average range* with early identification and intervention.
- Dyslexia may be *much less severe* for students who receive intensive early intervention.

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Prevention vs. Remediation

Remediation of dyslexia and other reading disabilities after Grade 3 is more challenging.

- It requires *consistent, intensive reading instruction*, usually over an extended period of time.
- Fluency often remains impaired.

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Early Intervention Can Be Effective

Prevention studies show that 70- 90% of at risk children (bottom 20%) in K- 2 can learn to read words in the average range.

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Early Development of Reading Skills: A Cognitive Neuroscience Approach

(Jack M. Fletcher – PI)

Grade 1 Multi-Tiered Intervention
Funded by NSF

Patricia Mathes and Carolyn Denton: Early Reading Intervention (Mathes et al., 2005; Denton et al., 2006).

A. Papanicolaou, P. Simos: Brain Activation Patterns (Simos et al., Neuropsychology, 2005; 2007; JLD, 2007)

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Grade 1 At-Risk Students

- Screened all students in 6 schools at the end of K or beginning of 1st Grade
- Assessed with measures of phonemic awareness and word reading
- Identified all students at-risk for reading difficulties in the schools
- School populations were economically disadvantaged

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The Interventions

Tier 1: Enhanced Classroom Instruction

- Whole grade screening and progress monitoring
- District provided extensive professional development and new materials

Supplemental Instruction: Two interventions tested

- Some children also received an additional 40 min of daily small group instruction for 30 weeks
- Two approaches: Proactive Beginning Reading; Responsive Reading Instruction
- Both provided explicit phonics instruction, but with different approaches and different emphasis on time spent reading text vs. practicing letters and words in isolation

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Proactive Intervention

- Explicit instruction in synthetic phonics, with emphasis on fluency.
- Integrated decoding, fluency, and comprehension strategies
- 100% decodable text
- Prescriptive intervention based on a carefully constructed scope and sequence

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Responsive Intervention

- Explicit instruction in synthetic phonics (blending) and analogy phonics (word families)
- Taught decoding, using the alphabetic principle, fluency, and comprehension strategies in the context of reading and writing
- Lessons planned based on ongoing assessment; teachers responded to student needs
- Hands-on practice with manipulatives
- Leveled text, not phonetically decodable

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Responsive Intervention Daily Routine

- Fluency Work (Repeated Reading) and Assessment: 8-10 minutes
- Word Work/Phonemic Awareness/Phonics: 10-12 Minutes
- Supported Reading:
  10-12 Minutes
- Supported Writing:
  8-10 Minutes

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Double Dose of Instruction for Struggling Readers

Enhanced Classroom Reading Instruction + ***Intervention: 40 minutes, 5 days per week***

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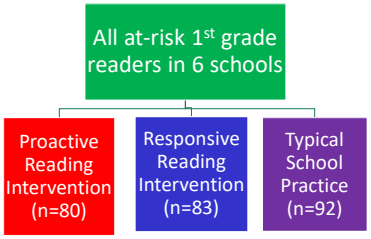
Children at Each School Were Randomly Assigned to 1 of 3 Groups



All got Enhanced Classroom Reading Instruction (Tier 1)
In 4 schools, the Typical Practice group ONLY got Tier 1.

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Research Results

Students in both interventions performed significantly better than at-risk students in the same schools who did not receive the interventions on measures of phonological awareness, word reading (timed and untimed), spelling, and oral reading fluency

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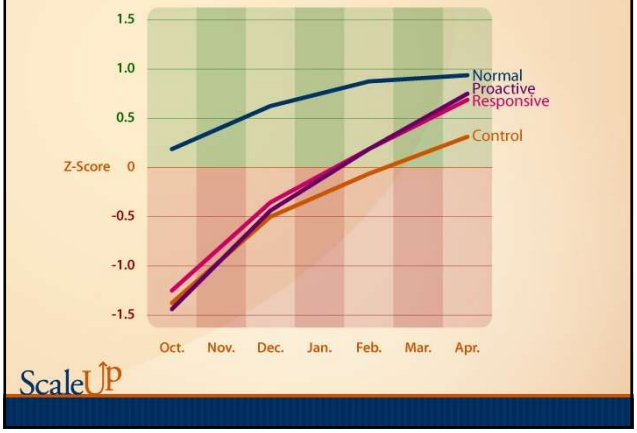
Growth in Word Reading by Intervention Group



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What percentage of at-risk children did NOT respond adequately to intervention?

(Woodcock-Johnson Basic Reading Score < 30th percentile)

Enhanced Classroom Instruction Only (Tier 1): 16%

Enhanced Classroom Instruction + Supplemental Intervention (Tiers 1+2): 4%

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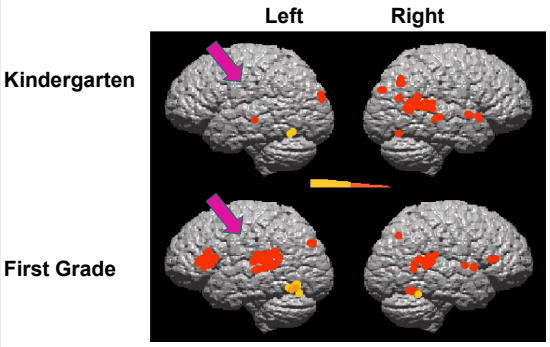
At Risk Reader Before and After Intervention



Simos, Fletcher, Sarkari, Billingsley, Francis, Castillo, Pataraia, Denton, & Papanicolaou (2005).

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The "Tier 3 study": Highly Intensive Reading Intervention Changed Brain Functioning

- Students in Grades 2-3 with persistent reading problems despite receiving previous reading intervention (some from our 1st grade study)
- "Tier 3" Intervention: Phonological processing and decoding 2 hours/day for 8 weeks, followed by oral reading fluency 1 hour/day for 8 weeks
- Scanned a subset of students before and after intervention
- Brain processing during word reading became more like that of "typical readers"

Denton et al., 2006; Simos et al., 2007

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What about Older Students with Severe Dyslexia?

Does the pattern of brain activation change in response to intervention?

- 8 students with severe dyslexia
- 8 week intense phonologically- based intervention
- *1:1 in a reading clinic* (during the summer)
- *2 hours a day* = up to 80 hours of instruction

Simos et al., *Neurology*, 2002

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Demographic Information and Word Reading Scores

Child	Gender	Age (years)	Pretest (%ile)	Posttest (%ile)	IQ	Medication
1	M	15	13	55	103	Adderal
2	M	10	2	59	95	Ritalin
3	M	10	2	38	110	Ritalin
4	F	8	3	55	105	Ritalin
5	F	7	2	50	110	Ritalin
6	M	7	18	60	101	__
7	M	11	1	38	98	Ritalin
8	M	17	1	45	102	__

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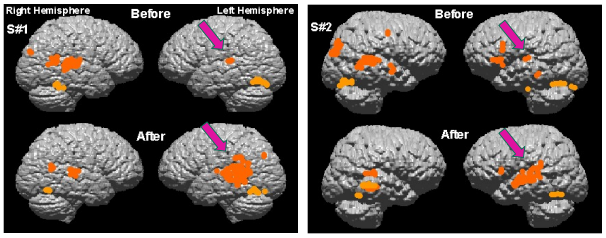
Neural response to intervention; (Pseudoword Task; Simos et al., 2002)



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Instruction Has the Power to Rewire a Student's Brain!

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The Challenge…

Students who are performing below grade level will only close the gap with their classmates if they learn ***FASTER*** than other students!

More *Instruction*
Efficient *Instruction*
More Practice

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Effective Instruction for Students With or At Risk for Dyslexia & Other Word-Reading Disabilities

- Teach Phonics and Phonemic Processing
- Provide Systematic, Well-Organized Instruction
- Provide Clear, Explicit Instruction
- Provide Extended Practice with Feedback
- Teach Effective Word Identification *During* Reading
- Monitor Learning

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Over **30 years** of scientific research has consistently shown that:

Students at-risk for *or* with word-reading difficulties and disabilities, *including dyslexia*, need explicit, systematic instruction in phonemic processing, phonics, and word study.

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Provide Systematic, Well-Organized Instruction

- Daily lessons follow consistent routines
- Follow a carefully planned scope and sequence
  - Go from *easy to hard*
  - Teach required pre-skills
  - Build in frequent reviews
- *Disconnected "mini-lessons" are not sufficient.*
- The EASIEST way to do this is to use an evidence-based instructional program that is designed to provide structured, systematic instruction!

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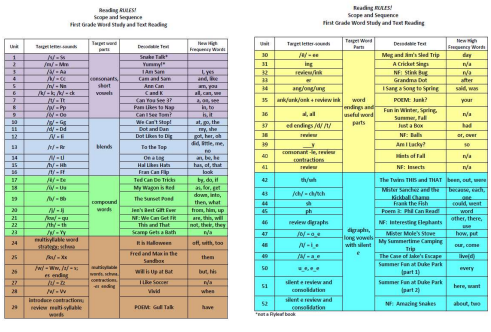
Follow a Scope and Sequence



Reading RULES!
Scope and Sequence
First Grade Word Study and Text Reading

Unit	Target letter-sounds	Target word parts	Decodable Text	New High Frequency Words
1	/s/ = Ss	consonants, short vowels	Snake Talk*	
2	/m/ = Mm		Yummy!*	
3	/a/ = Aa		I Am Sam	I, yes
4	/n/ = Nn		Cans and Sans	and, like
5	/k/ = Kk		Ann Can	am, you
6	/k/ = k, /k/ = ck		Ty and K	all, can, see
7	/t/ = Tt		Can You See It?	a, on, we
8	/p/ = Pp		Pam Likes to Nap	in, to
9	/h/ = Hh		Can I See Tom?	is, it
10	/g/ = Gg	blends	We Can't Stop!	at, go, the
11	/d/ = Dd		Dot and Dan	my, she
12	/i/ = Ii		Dot Likes to Dig	got, her, oh
13	/r/ = Rr		To the Top	did, little, no, up
14	/l/ = Ll		On a Log	an, for, he
15	/h/ = Hh		Hal Likes Hats	has, of, that
16	/f/ = Ff		Fran Can Flip	look
17	/z/ = Zz	compound words	Ted Can Do Tricks	by, do, if
18	/v/ = Vv		My Wagon is Red	as, for, get
19	/b/ = Bb		The Sunset Pond	down, into, then, what
20	/j/ = Jj		Jen's Best Gift Ever	from, him, up
21	/kw/ = qu		NF: We Can Get It!	are, this, will
22	/th/ = th		This and That	not, their, they
23	/y/ = Yy		Scamp Gets a Bath	n/a
24	multisyllable word strategy: schwa	multisyllable words, schwa, contractions, -er ending	It is Halloween	off, with, too
25	/ks/ = Xx		Fred and Max in the Sandbox	them
26	/er/ = Wrr, /s/ = -es ending		Will it Up at Bat	hurt, his
27	/z/ = Zz		I Like Soccer	n/a
28	/w/ = Ww		Vield	when
29	Introduce contractions; review multi-syllable words		POEM: Gull Talk	have

Reading RULES!
Scope and Sequence
First Grade Word Study and Text Reading

Unit	Target letter-sounds	Target Word Parts	Decodable Text	New High Frequency Words
30	/ē/ = ee	word endings and useful word parts	Meg and Jim's Sled Trip	day
31	-ing		A Cricket Sings	n/a
32	review/ink		NF: Stink Bug	n/a
33	-er		Grandma Dot	after
34	ang/ong/ung		I Sang a Song to Spring	said, was
35	ank/unk/onk + review ink		POEM: -ank?	your
36	al, all		Fun in Winter, Spring, Summer, Fall	n/a
37	ed endings /d/ /t/		Just a Box	had
38	review		NF: Balls	or, over
39	-y		Am I Lucky?	so
40	consonant -le, review contractions		Hints of Fall	n/a
41	review		NF: Insects	n/a
42	th/wh	digraphs, long vowels with silent e	The Twins THIS and THAT	been, out, were
43	/ch/ = ch/tch		"Mista" Sanchez and the Kickball Champ	because, earth, one
44	sh		Frank the Fish	could, were
45	ph		Poem 3: Phil Can Read!	word
46	review digraphs		NF: Interesting Elephants	other, there, one
47	/ū/ = u_e		Mister Mule's Stove	how, put
48	/ī/ = i_e		My Summertime Camping Trip	our, come
49	/ō/ = o_e		The Case of Jake's Escape	five/fif
50	u_e, e_e		Summer Fun at Dube Park (part 1)	every
51	silent e review and consolidation		Summer Fun at Dube Park (part 2)	here, want
52	silent e review and consolidation		NF: Amazing Snakes	about, two

*not a flyleaf book

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Provide Clear, Explicit Instruction and Feedback

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Please…

- Tell me how it works.
- Show me how to do it.
- Watch me do it and tell me if I'm doing it right.
- Help me practice until it gets easier.

…Sometimes you might have to show me again.

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Why provide feedback?

Practice strengthens connections in the brain.

What we practice becomes a *habit*.

Don't let students practice their mistakes!

Image Credit: 671228706, romrodinka, iStock /Getty Images Plus

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Meaningful Reading and Writing Practice INTEGRATED with Phonics instruction

- Students ***apply the word reading skills and strategies they are learning*** in reading and writing.
- Teacher provides real-time feedback and support.
- At-risk students do not "automatically" apply the skills they have learned.

DON'T teach a "separate" phonics program and then tell students to look at pictures and guess when they come to a hard word while they are reading.

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Popular Strategies of Struggling Readers When they Encounter Difficult Words

- Guessing words
- Looking at pictures instead of print
- Skipping words
- Waiting to be told words
- Mumbling
- Acting out to escape the reading situation

Teach students to use phonics to decode unknown words as they are reading and how to access unfamiliar words when they encounter them!
Change bad habits of guessing!

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Monitor Learning

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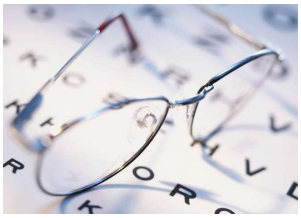
You're Teaching…But Are They Learning?



Don't just "cover" critical content; teach it to mastery.
When confusion is built on confusion, the result is a *mess*!

*"If it's not working, **change it**!"*

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Take-Away Messages from This Session:

- Dyslexia is a language-based condition
- It is a word-level reading problem; its primary characteristic is difficulty reading and spelling single words.
- Dyslexia may be mild, moderate, or severe.
- Identify dyslexia using reading-related measures and monitoring students' response to scientific reading instruction and intervention.
- Non-instructional treatments and interventions have *little or no support* from scientific research

Teach them to read!

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Take-Away Messages from This Session:

- Provide consistent, evidence-based small-group supplemental instruction for students who need it.
- Provide explicit, systematic instruction in phonemic awareness, phonics, and word study.
- Teach students to APPLY phonics and word study skills when they read and write new or difficult words.
- Monitor progress; if it's not working after a reasonable period of time, change it!

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Voices of Students

"I would not mind starting over…But can you do that without my friends knowing about it? If so, I would love to learn my letter sounds again and learn how to pronounce words right. It would be good if I could figure out what words mean and could figure out what those stories mean."

…A middle school student

McCray, Vaughn, & Neal, 2001

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