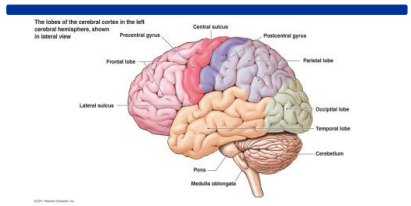
The Neuropsychology of Learning Disabilities: Developing Evidenced-Based Reading, Writing, and Math Interventions



jack hirose & ASSOCIATES, INC

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Dr. Feifer's Journey 1992-present

www.schoolneuropsychpress.com

- School psychologist 20+ years
- Diplomate in school neuropsychology
- 2008 **Maryland School Psychologist of the Year**
- 2009 **National School Psychologist of the Year**
- Author: **8 books** on learning and emotional disorders
- Test Author: **FAR-FAM-FAW-FACT**
- Currently in private practice at Monocacy Neurodevelopmental Center in Maryland.
- ABSNP Diplomate and Faculty Instructor

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The Challenge of Post-Pandemic Assessments

- COVID-19 has caused the closure of nearly all schools in the United States in 2020, affecting more than 55 million students.
- According to NASP (2021): *"Schools should assume children have lost **about 25%** of the prior grade level's instruction. It is an estimate because districts varied in the use of in person, virtual, and hybrid models of schooling, as well as the nature and quality of instruction"*
- NASP **does not** advocate retention, but rather screening through an MTSS model.
- **Traditional** vs **Diagnostic** Achievement Tests!

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Prevalence of LD in Canada

- More Canadian children have a learning disability than all other types of educational disabilities combined.
- According to Statistics Canada, 3.2% of Canadian children have a learning disability – whereas up to 20% may have dyslexia.
- More than **half a million** adults in Canada live with a learning disability, making it more challenging for them to learn in universities, and on the job.
- Research from the Literacy and Policing Project indicates that **65% of the incarcerated population** in Canada reads at less than a **grade 8** level of literacy.

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Literacy in Canada

Program for International Student Assessment (2018)

Canadian results in reading over time, 2009–2018

	2009		2012		2015		2018	
	Average score	Standard error	Average score	Standard error	Average score	Standard error	Average score	Standard error
Canada	524	(1.5)	523	(3.2)	527	(4.1)	520	(4.0)
Newfoundland and Labrador	506	(3.7)	503	(4.5)	505	(4.9)	512	(5.6)
Prince Edward Island	486	(2.4)	490	(3.7)	515*	(7.0)	503	(9.0)
Nova Scotia	516	(2.7)	508	(4.0)	517	(6.0)	516	(5.2)
New Brunswick	499	(2.5)	497	(3.7)	505	(6.3)	489	(5.0)
Quebec	522	(3.1)	520	(4.4)	532	(5.8)	519	(5.0)
Ontario	531	(3.0)	528	(5.1)	527	(5.6)	524	(5.0)
Manitoba	495	(3.6)	495	(4.2)	498	(6.0)	494	(4.9)
Saskatchewan	504	(3.3)	505	(3.8)	496	(4.9)	499	(4.6)
Alberta	533	(4.6)	525	(4.8)	533	(6.2)	532	(5.5)
British Columbia	525	(4.2)	535	(5.2)	536	(6.5)	519	(5.7)

* Significant difference compared with baseline (2009)
Note: The linkage error is incorporated into the standard error for 2012, 2015, and 2018.

- *487 International Reading Average-79 countries
- * 22,500 students -800 schools participated
- *Includes anglophone and francophone school systems
- * Canada mean =520 (Tied 8th) U.S. mean=505

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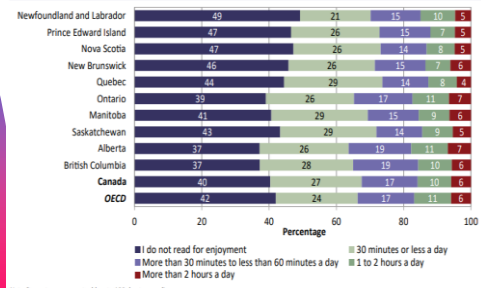
Literacy in Canada

Program for International Student Assessment (2018)

Percentage of students by time spent reading for enjoyment



Note: Percentages may not add up to 100 due to rounding.

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The State of Learning Disabilities in U.S.

National Center for Learning Disabilities (2017)

- **39 percent** of children in special education have a specific learning disability, making this the largest of the 13 disability categories covered under special education law.
- **One third** of all students with a learning disability have repeated a grade, which greatly increases the risk of dropping out.
- The dropout rate for students with a learning disability is **18.1%** and nearly **three times** the rate of students without a disability **(6.5%).**
- Only **1 in 4** students with a learning disability tell their respective colleges.
- Incarcerated individuals are **2 to 3 times** more likely to be dyslexic.
- Dyslexia symptoms occur in up to 5-17% of the population (Munzer et al., 2020

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Defining Dyslexia

- *"Dyslexia 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."*

  - International Dyslexia Association

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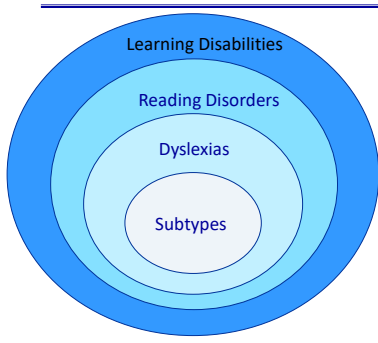
DEVELOPMENTAL DYSLEXIA



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Canadian LD Definition

LEARNING DISABILITY (Grades 1–12: Code 54)

This is the official definition adopted by the Learning Disabilities Association of Canada (LDAC) on January 30, 2002.

"Learning Disabilities" refer to a number of disorders which may affect the acquisition, organization, retention, understanding or use of verbal or nonverbal information. These disorders affect learning in individuals who otherwise demonstrate at least average abilities essential for thinking and/or reasoning. As such, learning disabilities are distinct from global intellectual deficiency.

Learning disabilities result from impairments in one or more processes related to perceiving, thinking, remembering or learning. These include, but are not limited to: language processing; phonological processing; visual spatial processing; processing speed; memory and attention; and executive functions (e.g., planning and decision-making).

Learning disabilities range in severity and may interfere with the acquisition and use of one or more of the following:

- oral language (e.g., listening, speaking, understanding)
- reading (e.g. decoding, phonetic knowledge, word recognition, comprehension)
- written language (e.g., spelling and written expression)
- mathematics (e.g., computation, problem solving).

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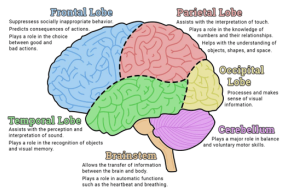
School Neuropsychology

➢ ***Neuropsychology:*** **An analysis of learning and behavior which examines *brain-behavior* relationships. The underlying assumption is that the brain is the seat of ALL behavior; therefore, knowledge of cerebral organization should be the key to unlocking the mystery behind most academic tasks.**

The Human Brain



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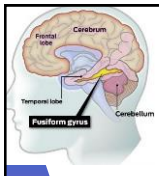
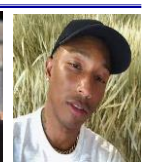
Is Reading a Form of Synesthesia?







Duke Ellington Billy Joel Pharrell Williams

- **Synesthesia** – cross wiring of senses. These musicians hear colors.
- **Exaptation** – the brain is evolving to learn modern tasks including reading (Stephen Jay Gould, 1982; DeHaene, 2013).

**Reading involves hearing symbols echo in the brain.
Is dyslexia is a failure to become a synesthete?

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Four Universal Truths of Reading

1. **In all word languages studied to date, children with developmental reading disorders (dyslexia) primarily have difficulties in identifying, recognizing, categorizing, and/or manipulating phonological units at all linguistic levels** (Goswami, 2007).

Screening for Success (Hulme & Snowling, 2016)

1. **Phonological awareness skills.**
2. **Ability to link sounds with letters.**
3. **Rapid letter-naming skills.**
   a) **Rapid naming of letters better than objects** (Kilpatrick, 2015).
   b) **Rapid naming of letters is moderately correlated with reading performance (.28-.57%) and explains some of the reading variance independent of phonological awareness** (Truong et al., 2019)

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Dyslexia Screening Instruments

1. **Shaywitz Dyslexia Screen** - A brief rating form of observed reading-related behaviors by teachers of children K-3

2. **CTOPP**- A measure of phonological awareness, phonological memory, and rapid naming. 12 subtests in total.

3. KTEA-3

4. WIAT 4

5. **FAR** - 3 subtests consisting of phonemic awareness, rapid automatic naming, and semantic concepts. Score of **78** or below classified **90%** of norm group correctly.

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Four Universal Truths of Reading

2. **The English language *is not* a purely phonological!**

- **1 letter grapheme: c a t. The sounds /k/ is represented by the letter 'c'.**
- **2 letter grapheme: l ea f. The sound /ee/ is represented by by the letters 'e a'.**
- **3 letter grapheme: n igh t. The sound /ie/ is represented by the letters 'i g h'.**
- **4 letter grapheme: th r ough. The sound /oo/ is represented by the letters 'o u g h**

- **The English language includes over 1,100 ways of representing 44 sounds using a series of different letter combinations** (Uhry & Clark, 2005). **In Italian there is no such ambiguity as just 33 graphemes are sufficient to represent the 25 phonemes.**
- **Therefore, 25% of words are phonologically irregular (i.e. "debt", "yacht", "onion", etc..) or have one spelling but multiple meanings –*homonyms*- (i.e. "tear", "bass", "wind", etc.)**
- ***Summary*: We need to develop orthography!!**

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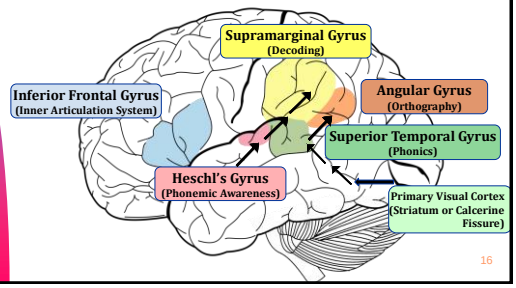
The Reading Brain: How Words are Assembled

3. Specific neuroimaging techniques have demonstrated that phonological processing and orthographic processing are a by-product of the functional integrity of the *temporal-parietal* junctures in the left hemisphere of the brain (Paz-Alonso et al., 2018; Glezer et al., 2016;Sandak et al., 2004; McCandliss & Noble, 2003).



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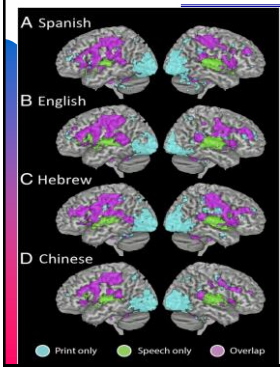
A Universal Reading Brain

Rueckl et al., (2015). Universal brain signature of proficient reading: Evidence from four contrasting languages. **Proceedings of the National Academy of Sciences**; 112(50): 15510–15515



- Proficient reading entails the convergence of phonological and orthographic processing systems onto a common network of neural structures dominated by the left perisylvian regions of the brain.
- Dyslexics in transparent orthographic systems, such as Spanish, German, Italian, Greek have difficulty in acquiring reading speed as a hallmark deficit of dyslexia (Ziegler et al., 2003; Davies et al., 2007; Constantinidou & Stainthorp, 2009; Wimmer et al., 2010).

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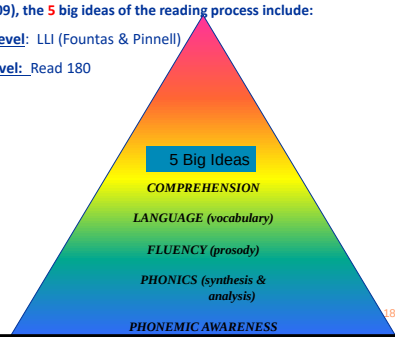
Four Universal Truths of Reading

4. According to the National Reading Panel (2000), and modified by Grizzle et al. (2009), the 5 big ideas of the reading process include:

Elementary Level: LLI (Fountas & Pinnell)

Secondary Level: Read 180



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Do Interventions Change the Brain?

- Barquero, L.A., Davis, N., & Cutting, L. E.(2014). Neuroimaging of reading intervention and activation likelihood estimate meta-analysis. Plos One, 9(1), 1-16.

- Research is beginning to show two specific brain changes with LD kids as a result of reading interventions:

1. Hemispheric "normalization" – the left hemisphere begins to assert dominance after just four weeks of intervention.

2. Hemispheric "compensation" – children with reading difficulty also activate brain structures in the frontal lobe following intervention, suggesting greater text attention and working memory engagement (IFG), and enhanced error detection and EF skills (ACC).

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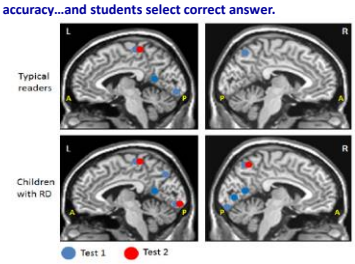
Do Interventions Change the Brain?

- Horowitz-Kraus, T., Vannest, J.J., Kadis, D., Cicchino, N., Wang, Y.Y. & Holland, S. K.(2014). Reading acceleration training changes brain children with reading disorders. *Brain and Behavior*, 886-902.
  - 33 children with reading disorders 8-12 years-old.
  - RAP training…4 weeks…20 min daily….fluency and comprehension
  - Computer presentation of sentences…which dissipate based on response accuracy…and students select correct answer.



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Four Subtypes of Reading Disorders

(1) Dysphonetic Dyslexia – difficulty sounding out words in a phonological manner.

(2) Surface Dyslexia – difficulty with the rapid and automatic recognition of words in print.

(3) Mixed Dyslexia – multiple reading deficits characterized by impaired phonological and orthographic processing skills. Most severe form of dyslexia.

(4) Comprehension Deficits – mechanical side of reading is fine but difficulty persists deriving meaning from print.

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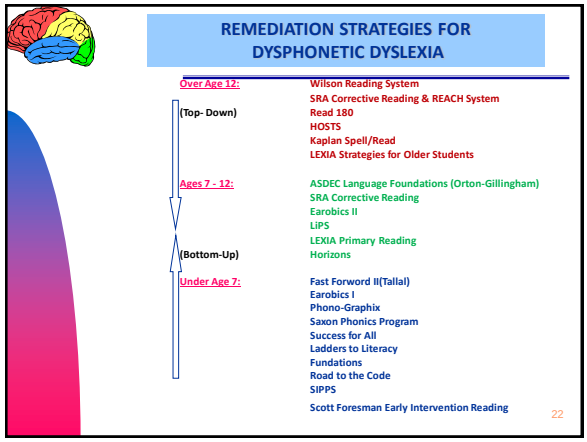
REMEDIATION STRATEGIES FOR DYSPHONETIC DYSLEXIA
Over Age 12:
(Top- Down)
Ages 7 - 12:
(Bottom-Up)
Under Age 7:
Wilson Reading System
SRA Corrective Reading & REACH System
Read 180
HOSTS
Kaplan Spell/Read
LEXIA Strategies for Older Students
ASDEC Language Foundations (Orton-Gillingham)
SRA Corrective Reading
Earobics II
LiPS
LEXIA Primary Reading
Horizons
Fast Forword II(Tallal)
Earobics I
Phono-Graphix
Saxon Phonics Program
Success for All
Ladders to Literacy
Fundations
Road to the Code
SIPPS
Scott Foresman Early Intervention Reading
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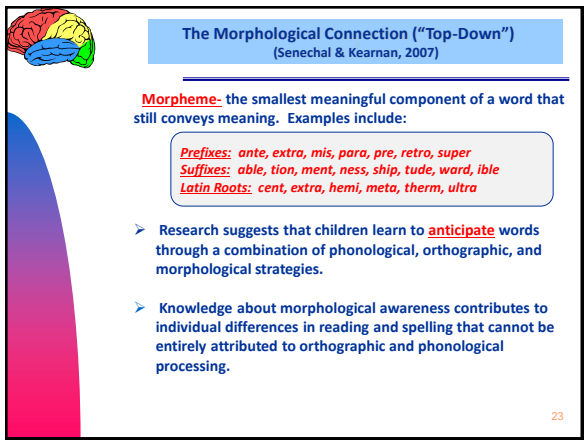
The Morphological Connection ("Top-Down")
(Senechal & Kearnan, 2007)
Morpheme- the smallest meaningful component of a word that still conveys meaning. Examples include:
Prefixes: ante, extra, mis, para, pre, retro, super
Suffixes: able, tion, ment, ness, ship, tude, ward, ible
Latin Roots: cent, extra, hemi, meta, therm, ultra
Research suggests that children learn to anticipate words through a combination of phonological, orthographic, and morphological strategies.
Knowledge about morphological awareness contributes to individual differences in reading and spelling that cannot be entirely attributed to orthographic and phonological processing.
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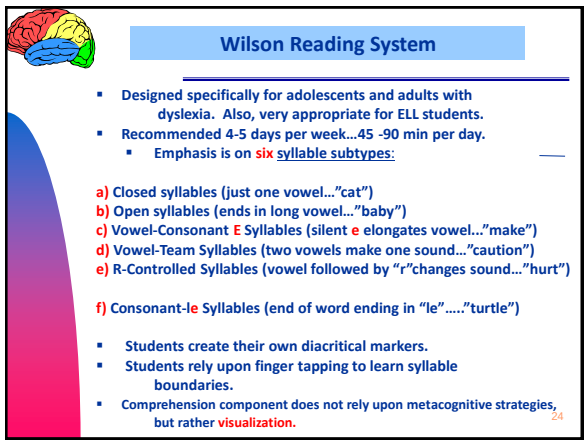
Wilson Reading System
Designed specifically for adolescents and adults with dyslexia. Also, very appropriate for ELL students.
Recommended 4-5 days per week…45 -90 min per day.
Emphasis is on six syllable subtypes:
a) Closed syllables (just one vowel…"cat")
b) Open syllables (ends in long vowel…"baby")
c) Vowel-Consonant E Syllables (silent e elongates vowel…"make")
d) Vowel-Team Syllables (two vowels make one sound…"caution")
e) R-Controlled Syllables (vowel followed by "r"changes sound…"hurt")
f) Consonant-le Syllables (end of word ending in "le"….."turtle")
Students create their own diacritical markers.
Students rely upon finger tapping to learn syllable boundaries.
Comprehension component does not rely upon metacognitive strategies, but rather visualization.
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REMEDIATION OF SURFACE DYSLEXIA

Over Age 12:	Academy of Reading Wilson Reading System Laubauch Reading Series Read 180
Ages 7 - 12:	Read Naturally Great Leaps Reading Quick Read RAVE-O Fast Track Reading
Under Age 7:	Destination Reading Reading Recovery Early Success Fluency Formula

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Read Naturally

- A fluency based program designed to develop speed, accuracy, and proper expression.
- Designed to be used 3 times per week…30 minutes, mainly for students between 2nd (51wpm) though 8th (133 wpm) grades.
- Each level of the program has 24 non-fiction stories.
  a) Student placed in level and goal is set.
  b) Cold read for one minute graphing wpm and identifying difficult words.
  c) Read with tape three times consecutively.
  d) Hot read is attempted.
  e) Comprehension questions involve main idea, details, vocabulary, inferences, and short answers.

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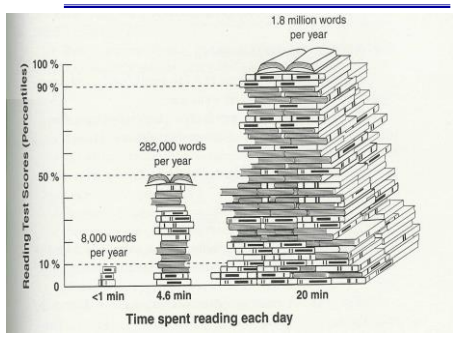
TIME SPENT READING AFTER SCHOOL

(Shaywitz, 2003)



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Does Vision Therapy Work?

Joint Statement—Learning Disabilities, Dyslexia, and Vision

abstract

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4 REMEDIATION STRATEGIES FOR MIXED DYSLEXIA

(1) Balanced Literacy - An eclectic and approach capitalizing on the particular strengths of the child. Consider using a multi-sensory type of Orton-Gillingham program, coupled with a fluency model such as Read Naturally, and the computerized models of Read 180.

(2) Top Down Strategies – Often atypical development mapping individual sounds to the visual word form association areas.

(3) Socioeconomic Status - is a very strong predictor of reading skills due primarily to the home literacy environment. Therefore, schools need to provide more reading opportunities.

(4) Motivation and Confidence –Great Leaps, Read Naturally, etc. tend to give immediate feedback.

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Developing a Balanced Literacy Model

- **Leveled Literacy Intervention** (LLI) is a short-term supplementary, small-group literacy intervention literacy intervention designed to help struggling readers achieve grade-level competency.
- The intervention provides explicit instruction in phonological awareness, phonics, fluency, vocabulary, reading comprehension, oral language skills, and writing.
- Approximately 25 studies supporting its effectiveness.

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Read 180 (Dr. Ted Hasselburg)

- A 90 minute per day balanced literacy program.
- Designed for grades 4th – 12th.

1) 20 minute whole group instruction where teachers model fluent reading skills.
2) Students then move to three-20 min stations.
   a) Teacher Station – small group differentiated instruction to reinforce previous concepts.
   b) Computer Station:
      - *Reading Zone (phonics, fluency, vocab)*
      - *Word Zone (automaticity of decoding)*
      - *Spelling Zone*
      - *Success Zone (comprehension strategies)*
   c) *Library Station – read silently and written language activities.*

- Software adapts level of instruction to learner.
- Expensive, but research based…recommended for most struggling readers.

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4 Components of Reading Comprehension

1. Content Affinity - attitude and interest toward specific material.

2. Working Memory - the ability to temporarily suspend information while simultaneously learning new information. The amount of memory needed to execute a cognitive task.

3. Executive Functioning - the ability to self-organize verbal information to facilitate recall.

4. Language Foundation – vocabulary knowledge is vital for passage comprehension.

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Reading Comprehension Interventions

1. Stop & Start Technique – student reads a passage out loud and every 30 seconds "stop" to ask questions.
2. Directional Questions – ask questions at the beginning of the text instead of the end.
3. Read Aloud – reading out loud allows student to hear their own voices and facilitates working memory.
4. Story Maps – pre-reading activity where graphic organizers are used to outline and organize the information.
5. Active Engagement – encourage active, not passive reading, by having children take notes or putting an asterisk next to important information. Also, multiple colors for highlighting.

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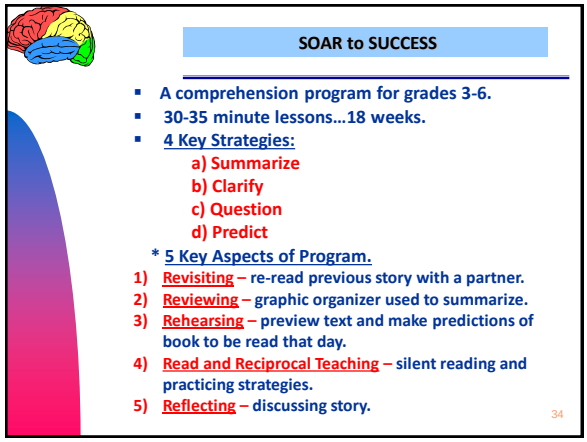
SOAR to SUCCESS
A comprehension program for grades 3-6.
30-35 minute lessons…18 weeks.
4 Key Strategies:
a) Summarize
b) Clarify
c) Question
d) Predict
* 5 Key Aspects of Program.
1) Revisiting – re-read previous story with a partner.
2) Reviewing – graphic organizer used to summarize.
3) Rehearsing – preview text and make predictions of book to be read that day.
4) Read and Reciprocal Teaching – silent reading and practicing strategies.
5) Reflecting – discussing story.
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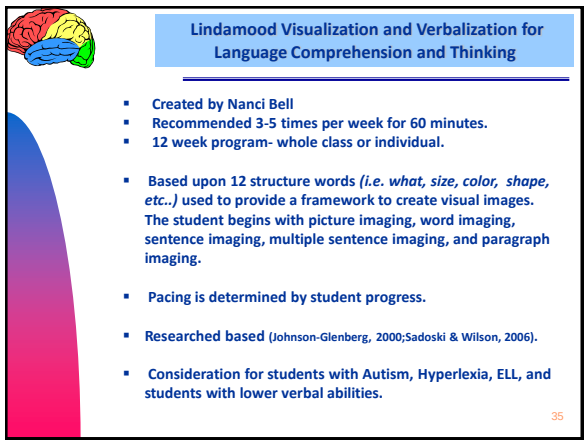
Lindamood Visualization and Verbalization for Language Comprehension and Thinking
Created by Nanci Bell
Recommended 3-5 times per week for 60 minutes.
12 week program- whole class or individual.
Based upon 12 structure words (i.e. what, size, color, shape, etc..) used to provide a framework to create visual images. The student begins with picture imaging, word imaging, sentence imaging, multiple sentence imaging, and paragraph imaging.
Pacing is determined by student progress.
Researched based (Johnson-Glenberg, 2000;Sadoski & Wilson, 2006).
Consideration for students with Autism, Hyperlexia, ELL, and students with lower verbal abilities.
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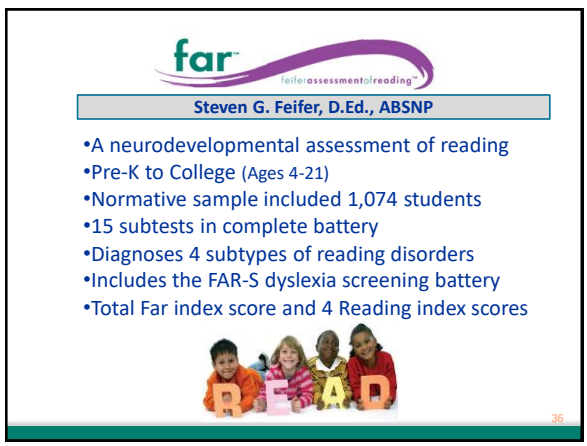
far
feiferassessmentofreading
Steven G. Feifer, D.Ed., ABSNP
•A neurodevelopmental assessment of reading
•Pre-K to College (Ages 4-21)
•Normative sample included 1,074 students
•15 subtests in complete battery
•Diagnoses 4 subtypes of reading disorders
•Includes the FAR-S dyslexia screening battery
•Total Far index score and 4 Reading index scores
READ
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far™ feiler assessment of reading™

Index	Subtest	Grade range	Approximate administration time in minutes
Phonological Index (PI)	Phonemic Awareness (PA)	PK to college	5 to 10
	Nonsense Word Decoding (NWD)	Grade 2 to college	2
	Isolated Word Reading Fluency (ISO)	K to college	1
	Oral Reading Fluency (ORF)	K to college	2 to 3
	Positioning Sounds (PS)	PK to college	3 to 4
Fluency Index (FI)	Rapid Automatic Naming (RAN)	PK to college	2
	Verbal Fluency (VF)	PK to college	2
	Visual Perception (VP)	PK to college	1
	Orthographical Processing (OP)	K to college	8
	Irregular Word Reading Fluency (IRR)	Grade 2 to college	1
Comprehension Index (CI)	Semantic Concepts (SC)	PK to college	5 to 8
	Word Recall (WR)	PK to college	4
	Print Knowledge (PK)	PK to Grade 1	4
	Morphological Processing (MP)	Grade 2 to college	7
	Silent Reading Fluency (SRF)	Grade 2 to college	8

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What is Dysgraphia?

Dysgraphia is a broad-based term that refers to a specific learning disability in written expression. The term can include problems with letter formation, legibility, letter spacing, spelling, fine motor coordination, rate of writing, grammar and overall sentence production (Chung et al., 2020).

Developmental Dysgraphia refers to difficulty acquiring writing skills despite adequate learning opportunities and cognitive skills.

- Younger children tend to have deficits with the motoric aspects of the written stroke, whereas older children struggle with more cognitive-linguistic elements of writing (Biotteau et al., 2019).

Acquired Dysgraphia refers to a learned skill (writing) being disrupted by a specific injury or degenerative condition.

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Types of Writing Genres

- **Persuasive** - change the reader's point of view in order to affect the reader's action.
- **Expository**- explaining objective information to enhance the reader's overall understanding.
- **Experiential** - to describe a personal experience or narrative to others.
- **Prosaic** – to convey a particular sentiment or emotion from a personal experience. Often written in a metaphoric style inclusive of poem, lyric, or sonnet.
- **Analytical** – heavily structured style of writing where scientific scrutiny involved.

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Warning Signs of Developmental Dysgraphia

Age Group	Signs of Dysgraphia
Preschool aged children	• Awkward pencil grasp • Lack of hand dominance • Fatigues quickly when writing • Letters poorly formed or inversed • Difficulty writing within margins • Overflow motor movements • Does not anchor paper with opposite hand.
Elementary aged students	• Illegible or messy handwriting • Letter transpositions • Mirror writing • Switching between cursive and print • Slower paced writing • Poor spelling impacts legibility. • Frequent erasures
Secondary school students	• Poor planning and organizational skills. • Discrepancy between verbal output and written output. • Difficulty keeping pace when note-taking. • Does not separate ideas by paragraph. • Paragraphs do not flow from general to specific. • Grammar impacts legibility.

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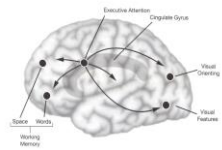
Cognitive Constructs and Written Language

Attention: (Selective & Sustained)

- Poor planning
- Uneven tempo
- Erratic legibility
- Inconsistent spelling
- Poor self monitoring
- Impersistence



BRAIN REGION - Anterior Cingulate Gyrus
***Effort control and top-down attention**

41

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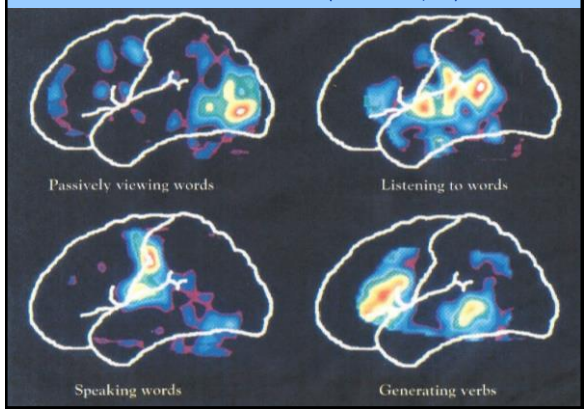
THE WRITING BRAIN (Posner & Raichle, 1994)

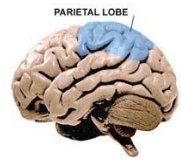


42

Cognitive Constructs and Written Language

Spatial Production

- Poor spatial production
- Poor visualization
- Poor margination
- Organization problems
- Uneven spacing
- Poor use of lines



BRAIN REGION –Right Parietal Lobe

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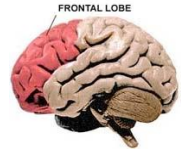
Cognitive Constructs and Written Language

Sequential Production

- Poor connected writing
- Letter reversals
- Organizational deficits
- Lack of cohesive ties
- Deficits in working memory, especially with ADHD kids, leads to sequential dysfunction.



BRAIN REGION – Left Prefrontal Cortex

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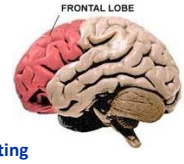
Cognitive Constructs and Written Language

Working Memory Skills

- Poor *word retrieval* skills
- Poor spelling
- Poor grammar rules
- Loss of train of thought
- Deterioration of continuous writing
- Poor elaboration of ideas
- Cortical mapping of language is ***distributed*** throughout brain ***(i.e. nouns vs. verbs)***



BRAIN REGION – Semantic memories stored in temporal lobes. Retrieved by frontal lobes

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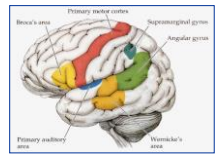
Cognitive Constructs and Written Language

Language



- Poor vocabulary
- Lack of cohesive ties
- Poor grammar
- Simplistic sentence structure
- Left hemisphere stores language by converging words into semantic baskets; right hemisphere excels in more divergent linguistic skills (simile and metaphor).
- Writing genre impacts retrieval!

BRAIN REGION – Temporal Lobes

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Divergent Retrieval and Writing

- *"Subdivisions"* (1982) written by Neil Peart and was used to express the loneliness of growing up in a bland suburb and being forced to conform to an unwanted norm:

"Growing up it all seems so one-sided
Opinions all provided
The future pre-decided
Detached and subdivided
In the mass production zone
Nowhere is the dreamer or the misfit so alone"

- Ries and colleagues (2016) noted right frontal activity has been shown to increase when word selection difficulty is increased or more abstract, and greater cognitive flexibility is required.

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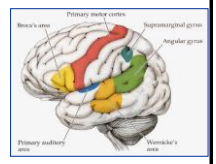
Cognitive Constructs and Written Language

Intelligence



- Concrete ideation
- Poor development of ideas
- Poor audience awareness
- Weak opinion development
- Simplistic sentence structure

BRAIN REGION – Inferior Parietal Lobes

48

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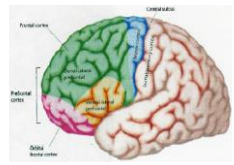
Cognitive Constructs and Written Language

Executive Functioning

- Organize and plan ideas
- Self monitor
- Task initiation
- Sustain attention to task
- Difficulty making cognitive shifts from one topical area to another.



BRAIN REGION – Dorsolateral Prefrontal Cortex

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Motor Output Speed (Pollock et al, 2009)

Grade Levels	Handwriting Speed
Grade 1	15 - 32 letters per minute
Grade 2	20 - 35 letters per minute
Grade 3	25 - 47 letters per minute
Grade 4	34 - 70 letters per minute
Grade 5	38 - 83 letters per minute
Grade 6	46 - 91 letters per minute

BRAIN REGION – Basal Ganglia

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3 Subtypes of Written Language Disorders

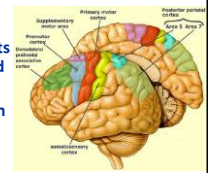
(1) Graphomotor Dysgraphia - apraxia refers to a wide variety of motor skill deficits in which the voluntary execution of a skilled motor movement is impaired.

a) **Premotor cortex - plans the execution of a motor response.**

b) **Supplementary motor area – guides motor movement.**

c) **Cerebellum - provides proprioceptive feedback.**

d) **Basal Ganglia – procedural memory and automaticity of handwriting.**



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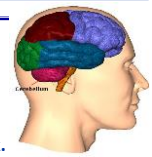
Cognitive Constructs and Written Language



- The cerebellum contains 50% of the neurons in the brain.
- Guides and corrects motor movements based upon proprioceptive feedback.
- Made up of purkinje cells and granule cells which are primarily excitatory, and help fine tune the writing process.
- Over time, the physical act of sequencing subtle motor movements becomes less effortful and more reflexive.
- Deficits mainly lead to motor coordination issues….ataxia….*("3971" ATM Code spatial/sequential)*

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3 Subtypes of Written Language Disorders

(2) Dyslexic Dysgraphias: (Spelling Miscues)

a) Dysphonetic dysgraphia - the hallmark feature of this disorder is an inability to spell by *sound* due to poor *phonological* skills. There is often an over-reliance on the visual features of words when spelling *(i.e " sommr" for "summer")* .

b) Surface dysgraphia - a breakdown in the *orthographic* representation of words. Miscues made primarily on phonologically irregular words *(i.e. "laf" for "laugh"; "juse" for "juice"; "mite" for "mighty").*

c) Mixed Dysgraphia - characterized by a combination of both *phonological* errors and *orthographical* errors depicting faulty arrangement of letters and words *(i.e "ceshinte" for "kitchen").*

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Key Spelling Strategies

1. Incorporate nonsense words into weekly spelling instruction to make sure students can represent each sound with a letter.
2. Use tile spelling markers to color-code vowel digraphs in words by families*(i.e. Sauce, Pause, cause, etc…)*
3. Place a heavy focus on prefixes and suffixes during instruction.
4. Have students write each word with white space in between each syllable in the word using the box approach. *(i.e. fascinate)*

f a s c i n a t e

5. Show multiple spellings of a word and have the student select the correct choice *(i.e wuz, was, whas).*

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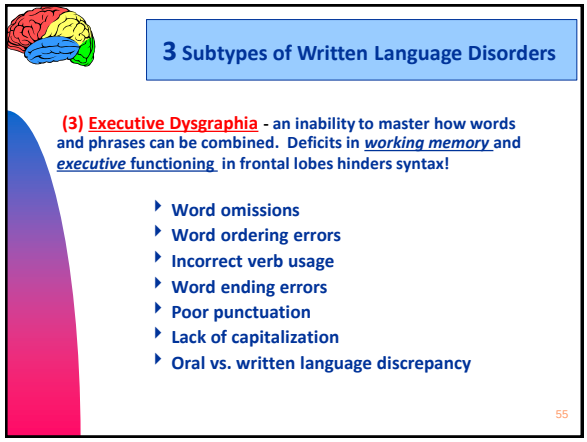
3 Subtypes of Written Language Disorders
(3) Executive Dysgraphia - an inability to master how words and phrases can be combined. Deficits in working memory and executive functioning in frontal lobes hinders syntax!
Word omissions
Word ordering errors
Incorrect verb usage
Word ending errors
Poor punctuation
Lack of capitalization
Oral vs. written language discrepancy
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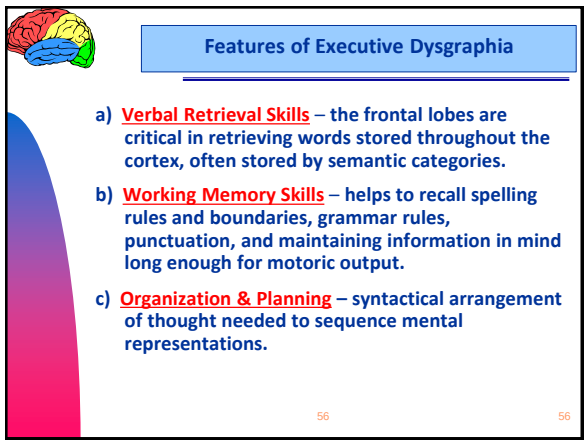
Features of Executive Dysgraphia
a) Verbal Retrieval Skills – the frontal lobes are critical in retrieving words stored throughout the cortex, often stored by semantic categories.
b) Working Memory Skills – helps to recall spelling rules and boundaries, grammar rules, punctuation, and maintaining information in mind long enough for motoric output.
c) Organization & Planning – syntactical arrangement of thought needed to sequence mental representations.
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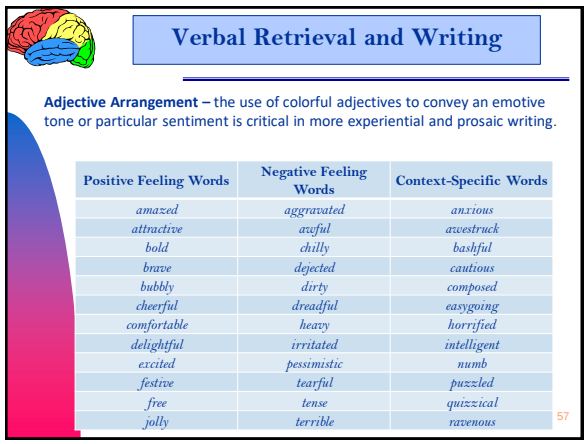
Verbal Retrieval and Writing
Adjective Arrangement – the use of colorful adjectives to convey an emotive tone or particular sentiment is critical in more experiential and prosaic writing.
Positive Feeling Words
amazed
attractive
bold
brave
bubbly
cheerful
comfortable
delightful
excited
festive
free
jolly
Negative Feeling Words
aggravated
awful
chilly
dejected
dirty
dreadful
heavy
irritated
pessimistic
tearful
tense
terrible
Context-Specific Words
anxious
awestruck
bashful
cautious
composed
easygoing
horrified
intelligent
numb
puzzled
quizzical
ravenous
57

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Executive Functioning and Written Language

Classification	Writing Dysfunction
(1) Initiating	* Poor idea generation * Poor independence
(2) Sustaining	* Lose track of thoughts * Difficulty finishing * Sentences disjointed
(3) Inhibiting	* Impulsive/Distractible
(4) Shifting	* Perseverations * "Stuck" on topic

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Executive Functioning and Written Language

Classification	Writing Dysfunction
(5) Poor Organization	* Frequent erasers * Forget main idea * Disjointed content
(6) Poor Planning	* Poor flow of ideas * Lack of cohesive ties
(7) Poor Word Retrieval	*Limited word choice * Simplistic sentences
(8) Poor Self Monitor	* Careless miscues * Sloppy work

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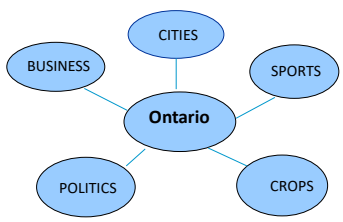
Executive Functioning Interventions

Graphic Organizers – this involves a pre-writing activity whereby the student simply lists a word or phrase pertaining to the topic. An example may include a brainstorming a web:



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Self Monitoring Strategies

COPS *strategy* – a directional proof-reading strategy where the student re-reads the passage passage four times prior to completion.

1) Capitalize the first word of each sentence.

2) Organize the information by reviewing topic sentences and double check paragraph breaks.

3) Punctuation miscues must be reviewed.

4) Spelling miscues must be reviewed.

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Self Monitoring Writing Rubric

IDEAS

4 The topic and details are well developed.
3 The topic is clear but more details are needed.
2 Details that don't fit the topic confuse the reader.
1 The topic is not clear.

ORGANIZATION

4 The beginning, middle, and ending work well.
3 Some parts of the essay are unclear.
2 All parts of the essay run together.
1 The order of information is confusing.

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Self Monitoring Writing Rubric

WORD CHOICE

4 Words make the meaning clear.
3 Clearer words are needed.
2 Some words are overused.
1 Words are used incorrectly.

CONVENTIONS

4 Conventions are used well.
3 There are few errors.
2 Errors make the essay hard to understand.
1 Help is needed to make corrections

AUDIENCE AWARENESS

4 The passage is clear and understandable for the intended audience.
3 The reader may need background knowledge to fully comprehend.
2 There are some parts of the passage that are difficult to understand.
1 The passage is extremely confusing for the intended audience.

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Strategies for Secondary Students

- Inspirations – teaches how to craft concept maps, idea maps, and other visual webbing techniques to assist in planning, organizing, and outlining. Very effective word predictive software.
- Kurzweil Technology - adaptive technology to further practice grammar, spelling, and punctuation. Voice activated software also an option.
- Journal or Diary – can be a fun and effortless way to practice writing on a daily basis.
- Keyboarding - speed up output to reduce pressure from working memory skills to retain information over longer periods of time.
- Livescribe - a *"smart"* pen which would both record lecture information in the class, as well as transcribe notes to a computer screen. Smart pens allow students to better organize their notes.

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Handwriting Supplemental Programs

Name	Supplemental Program
1. Handwriting Without Tears	Developmentally appropriate and multisensory approach using innovative letter order and style.
2. Zaner-Bloser	Apps, writing games, and other reading and writing resources.
3. Big Strokes for Little Folks	Geared for students who can recognize letters but struggle to write them.
4. Sensible Pencil	Applicable to both home and school in teaching letter writing skills.
5. Loops and Other Groups	A kinesthetic approach to teach writing in cursive.

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10 Research Based Strategies (Graham & Perin, 2007)

(1) Writing Strategies *(effect size .82)*
(2) Summarization (*effect size .82)*
(3) Collaborative Writing *(effect size .75)*
(4) Specific Product Goals *(effect size .70)*
(5) Word Processing *(effect size .55)*
(6) Sentence Combining *(effect size .50)*
(7) Prewriting *(effect size .32)*
(8) Inquiry activities *(effect size .32)*
(9) Process Writing Approach *(effect size .32)*
(10) Study of Models *(effect size .25)*

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5 Steps for Executive Dysgraphia (Ray, 2001)

(1) Prewriting - use graphic organizers.
(2) Drafting – use model to take notes and model how to organize in a text form using topic sentences.
(3) Revising – second draft emphasizing content, and elaboration of ideas and making connections.
(4) Editing – re-read for capitalization and punctuation errors.
(5) Publishing – peer assisted strategies and teaching students to give and receive feedback base upon a writing rubric.

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EmPOWER & SRSD

EmPOWER – developed by Dr. Bonnie Singer through Architects for Learning. Can use in any class in any grade. Six steps include:
Evaluate –break down the task to determine what I have to do.
Plan – identify my purpose for writing and select strategies.
Organize – show my thinking and organize my ideas.
Work – work my ideas into a well structured text.
Evaluate – assess my work.
Re-Work – make necessary changes.

SRSD – **S**elf-**R**egulated **S**trategy **D**evelopment. Research based to improve planning, editing and written product (De la Paz, 2007; De la Paz & Graham, 2002; Englert, 2009; Graham, 2006; Graham & Perin, 2007; Perin, 2007).

- 5 steps include: Discuss It, Model It, Make It Your Own, Support It, Independent Performance.

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faw
feiferassessmentofwriting

- A neurodevelopmental assessment of written language disorders.
- Pre-K to College (Ages 4-21)
- 12 subtests in complete battery/10 subtests core
  Diagnoses 3 subtypes of writing disorders:
  1) Graphomotor Dysgraphia
  2) Dyslexic-Dysgraphia
  3) Executive Dysgraphia
- Includes the FAW-S dysgraphia screening battery
- Yields a Compositional Writing Index (CWI)

P4R

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faw
feiferassessmentofwriting

Structure of the FAW

Index	Subtest	Grade range	Approximate administration time in minutes
Graphomotor Index (GI)	Alphabet Tracing Fluency (ATF)	PK to college	1 - 2
	Motor Sequencing (MS)	PK to college	3 - 4
	Copying Speed (CS)	K to college	3 - 4
	Motor Planning (MP)	PK to college	2 - 3
Dyslexic Index (DI)	Homophone Spelling (HS)	K to college	3 - 4
	Isolated Spelling (IS)	PK to college	4 - 6
Executive Index (EI)	Executive Working Memory (EWM)	Grade 2 to college	10 - 12
	Sentence Scaffolding (SS)	Grade 2 to college	13 - 16
	Retrieval Fluency (RF)	PK to college	7 - 8
	Expository Writing (EW)	Grade 2 to college	6
Compositional Writing Index (CWI) *(optional)*	Expository Writing (EW)	Grade 2 to college	6
	Copy Editing (CE) *(optional)*	Grade 2 to college	4
	Story Mapping (SM) *(optional)*	Grade 2 to college	6

P4R

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Measuring Mathematics: 2019 NAEP DATA

- Survey taken every 2 years by NAEP to capture trends in learning.
- Students with disabilities (accommodations allowed), ESL, and private school students included.

Content items: digitally based assessments for grades 4 & 8

a) **Number properties and operations** – includes computation and understanding of number concepts.

b) **Measurement** - assesses use of instruments, application of processes, and concepts of area and volume.

c) **Geometry** – measures students' knowledge and understanding of shapes in two and three dimensions, spatial reasoning, and geometric properties.

d) **Data analysis, statistics, and probability** - includes graphical displays and statistics.

e) **Algebra** – measures students' understanding of patterns, using variables, algebraic representation, functions, and relationships.

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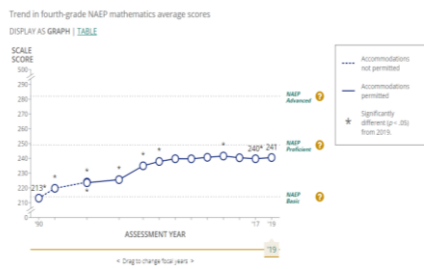
2019 NAEP DATA: 4th grade



- 40% of 4th graders at or above a Proficient level in mathematics (n=149,500 students from 8,280 schools)

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2019 NAEP DATA: 4th grade

State by State Comparison of Scores

Highest States	>Proficient	Lowest States	>Proficient
Minnesota	53%	Alabama	28%
Massachusetts	50%	New Mexico	29%
New Jersey	48%	Louisiana	29%
Virginia	48%	West Virginia	30%
Wyoming	48%	Alaska	33%
Florida	48%	Arkansas	33%
Pennsylvania	47%	California	34%
Indiana	47%	Washington DC	34%
Utah	46%	Nevada	34%

National 4th grade average: 241(40% Proficient or Above)

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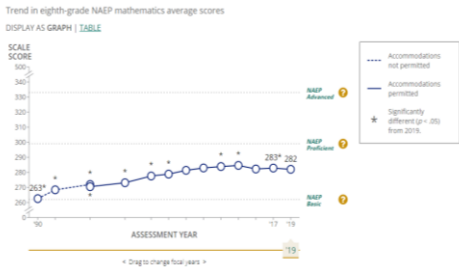
2019 NAEP DATA: 8th grade



- 33% of 8th graders at or above a Proficient level in mathematics (n=147,400 inclusive of 6,960 schools)

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2019 NAEP DATA: 8th grade

State by State Comparison of Scores

Highest States	>Proficient	Lowest States	>Proficient
Massachusetts	47%	New Mexico	21%
Minnesota	44%	Alabama	21%
New Jersey	44%	Washington DC	23%
Wisconsin	41%	Louisiana	23%
Washington	40%	West Virginia	24%
South Dakota	39%	Mississippi	24%
Connecticut	39%	Oklahoma	26%
Pennsylvania	39%	Nevada	26%
New Hampshire	38%	Arkansas	27%
Vermont	38%	Hawaii	28%

* **National 8th grade average: 282** (33% Proficient or Above)

* **Side Note:** Approximately **20 percent** of public-school teachers surveyed in both grades reported that a lack of adequate instructional resources was a *moderate* or *serious problem* in 2019.

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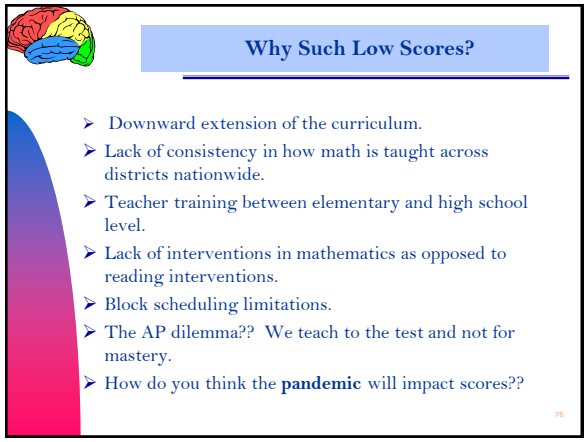
Why Such Low Scores?
Downward extension of the curriculum.
Lack of consistency in how math is taught across districts nationwide.
Teacher training between elementary and high school level.
Lack of interventions in mathematics as opposed to reading interventions.
Block scheduling limitations.
The AP dilemma?? We teach to the test and not for mastery.
How do you think the pandemic will impact scores??
76

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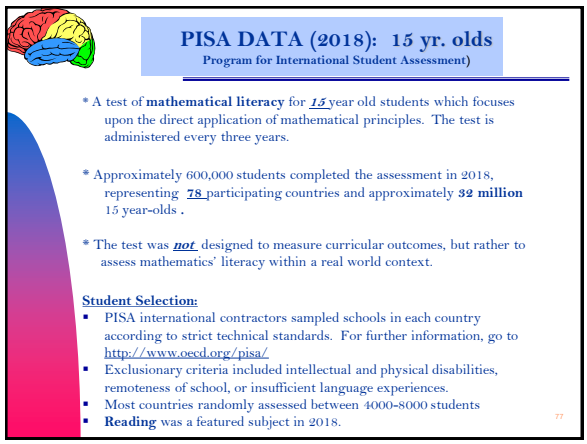
PISA DATA (2018): 15 yr. olds
Program for International Student Assessment)
* A test of mathematical literacy for 15 year old students which focuses upon the direct application of mathematical principles. The test is administered every three years.
* Approximately 600,000 students completed the assessment in 2018, representing 78 participating countries and approximately 32 million 15 year-olds .
* The test was not designed to measure curricular outcomes, but rather to assess mathematics' literacy within a real world context.
Student Selection:
PISA international contractors sampled schools in each country according to strict technical standards. For further information, go to http://www.oecd.org/pisa/
Exclusionary criteria included intellectual and physical disabilities, remoteness of school, or insufficient language experiences.
Most countries randomly assessed between 4000-8000 students
Reading was a featured subject in 2018.
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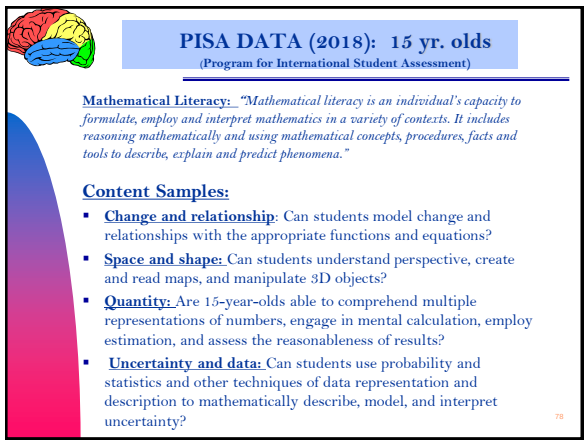
PISA DATA (2018): 15 yr. olds
(Program for International Student Assessment)
Mathematical Literacy: "Mathematical literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena."
Content Samples:
Change and relationship: Can students model change and relationships with the appropriate functions and equations?
Space and shape: Can students understand perspective, create and read maps, and manipulate 3D objects?
Quantity: Are 15-year-olds able to comprehend multiple representations of numbers, engage in mental calculation, employ estimation, and assess the reasonableness of results?
Uncertainty and data: Can students use probability and statistics and other techniques of data representation and description to mathematically describe, model, and interpret uncertainty?
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PISA DATA (2018): 15 yr. olds

Country	Average Score
International Average	**489**
1. B-S-J-Z China (Beijing, Shanghai, Jiangsu, and Zhejiang)	591
2. Singapore	569
3. Macao-China	558
4. Hong Kong (China)	551
5. Chinese Taipai	531
6. Japan	527
7. Korea	526
8. Estonia	523
9. Netherlands	519
10. Poland	516
11. Switzerland	515
12. Canada	512
13. Denmark	509
14. Slovenia	509
15. Belgium	508
16. Finland	507
17. Sweden	502
18. United Kingdom	502
19. Norway	501
20. Germany	500

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PISA DATA (2018): 15 yr. olds

Country	Average Score
International Average	**489**
21. Ireland	500
22. Czech Republic	499
23. Austria	499
24. Latvia	496
25. France	495
26. Iceland	495
27. New Zealand	494
28. Portugal	492
29. Australia	491
30. Russia	488
31. Italy	487
32. Slovak Republic	486
33. Luxembourg	483
34. Spain	481
35. Lithuania	481
36. Hungary	481

80

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PISA DATA (2018): 15 yr. olds

Country	Average Score
International Average	**489**
37. UNITED STATES	**478** (477 in 2015/40th)
38. Belarus	472
39. Malta	472
40. Croatia	464
41. Israel	463
42. Turkey	454
43. Ukraine	453
44. Greece	451
45. Cyprus	451
46. Serbia	448
47. Malaysia	440
48. Albania	437
49. Bulgaria	436
50. United Arab Emirates	435
78. Dominican Republic	325

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PISA Data 2018: Canadian Decline

Canadian results in mathematics over time, 2012–2018

	2012		2015		2018	
	Average score	Standard error	Average score	Standard error	Average score	Standard error
Canada	518	(1.8)	516	(4.2)	512	(4.1)
Newfoundland and Labrador	490	(3.7)	486	(4.8)	488	(7.3)
Prince Edward Island	479	(2.5)	499*	(7.3)	487	(11.6)
Nova Scotia	497	(4.1)	497	(5.8)	494	(7.2)
New Brunswick	502	(2.6)	493	(6.2)	491	(6.6)
Quebec	536	(3.4)	544	(5.9)	532	(4.9)
Ontario	514	(4.1)	509	(5.5)	513	(5.6)
Manitoba	492	(2.9)	489	(5.5)	482	(5.0)
Saskatchewan	506	(3.0)	484*	(4.6)	485*	(6.0)
Alberta	517	(4.6)	511	(5.9)	511	(6.1)
British Columbia	522	(4.4)	522	(6.1)	504*	(6.2)

* Significant difference compared with baseline (2012)
Note: The linkage error is incorporated into the standard error for 2015 and 2018.

- New Brunswick scores in mathematics are trending similar to much of Canada.

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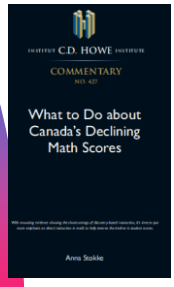
Anna Stoke (May, 2015)

Associate Professor of Mathematics and Statistics at University of Winnipeg



1. Employ the 80/20 rule for direct instruction to discovery based learning.
2. Reduce multiple strategy approaches that are inefficient and place too much burden on working memory.
3. Important concepts are introduced too late, especially Algebra.
4. Teacher training in mathematics needs to improve.

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What is a Math Disability?

Math Learning Disability (MLD) – a generic term referring to children whose math performance in the classroom is substantially below age- and grade-level expectations. Often used when there is unexpected underachievement.

*Dyscalculia – children with specific math-related deficits, including:

a) Learning and retrieving mathematical facts
(Language Retrieval)
b) Executing math calculation procedures
(Symbolic Working Memory)
c) Basic number sense and concept development
(Executive Functioning)
d) Visualizing magnitude representations.
(Visual-Spatial Memory)

* Up to **20%** of school age children have MLD or persistent difficulty with math (Iuculano et al., 2015)

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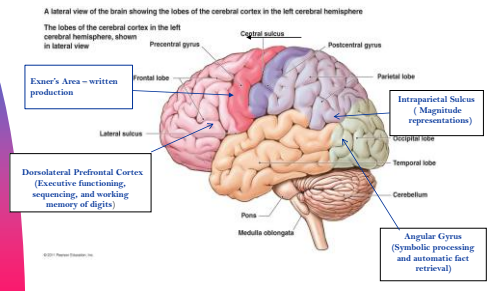
Mapping the Math Brain



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The Neural Machinery of Mathematics

Language Skills: (temporal lobes)

- Most Asian languages have linguistic counting systems past *ten* (*ten-one*, *ten-two*, *etc*) whereas English deviates from base-10 system (Campbell & Xue, 2001).
- Chinese numbers are brief *(i.e. 4=si, 7=qi)* allowing for more efficient memory. By age four, Chinese students can count to 40, U.S. students to 15.
- Calculator usage and "time on task" also relevant factors.
- U.S. kids spend 180 days in school
  South Korea children spend 220 days in school
  Japan kids spends 243 days in school

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The Neural Machinery of Mathematics

Working Memory System	Mathematical Skill
• Phonological Loop	• Retrieval of math facts • Writing dictated numbers
• Visual-Spatial Sketchpad (Symbolic or Spatial)	• Mental math with symbols • Magnitude comparisons • Geometric equations
• Central Executive System	• Inhibiting distracting thoughts • Modulating anxiety • Regulating emotional distress.

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Horizontal Vs. Vertical
(Trbovich & LeFevre, 2003)

- Solving problems in a vertical format required the use of more visual resources, particularly the visual-spatial sketchpad of working memory.
- Solving problems in a horizontal format required more phonological resources resulting in *slower* performance.

A	B
32 + 6	6 + 32
C	D
32 + 6	6 + 32

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The Neural Machinery of Mathematics

Executive Functioning Skills: (frontal lobes)

- Executive functions are a set of directive processes such as planning, self-monitoring, organizing, and allocating attention resources to effectively execute a goal directed task.
- Executive functioning is not synonymous with IQ.
- Executive functioning dictates "*what to do when*", a critical process in solving word problems.
- Executive functioning allows students to choose an appropriate algorithm when problem solving.

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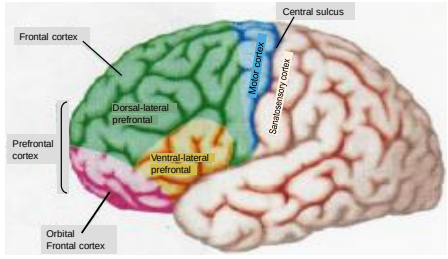
The Neural Machinery of Mathematics



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The Neural Machinery of Mathematics

EXECUTIVE DYSFUNCTION	BRAIN REGION	MATH SKILL
• *Selective Attention*	• *Anterior Cingulate/* • *Subcortical structures*	• Poor attention to math operational signs • Place value mis-aligned
• *Planning Skills*	• *Dorsal-lateral PFC*	• Selection of math process impaired • Difficulty determining salient information in word problems

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The Neural Machinery of Mathematics

EXECUTIVE DYSFUNCTION	BRAIN REGION	MATH SKILL
• *Organization Skills*	• *Dorsal-lateral PFC*	• Inconsistent lining up math equations • Frequent erasers • Difficulty setting up problems
• *Self-Monitoring*	• *Dorsal-lateral PFC*	• Limited double-checking of work • Unaware of plausibility to a response.
• *Cues Pattern Recognition*	• *Dorsal-lateral PFC*	• Symbolic reasoning

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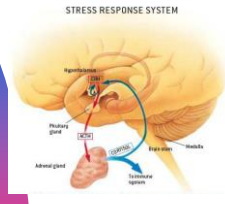
Math Anxiety



Cortisol – a glucocorticoid (glucose-cortex-steroid) that regulates the metabolism of glucose in the brain. A balance or homeostasis of cortisol is needed for optimal brain functioning. Too much *(Cushing's Syndrome)*…too little *(Addison's Disease)*.

- Anxiety impacts cognition and learning by way of working memory (Dowker et al., 2015)
- Anxiety and stress alters amygdala to PFC connections leading to poor executive functioning (Berens et al., 2017).

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The Truth About Math Anxiety: Do We Have a Math Phobia?

Implicit Messages:

"Oh not to worry Billy, I was never that good in math either."
"Wow, are you taking Algebra II….that is sooooo hard!"
"Hey Ritchie…it doesn't matter if you do not understand your math homework, you will never use this stuff in real life."

CAUSES OF MATH ANXIETY:

- Timed tests
- Pop quizzes
- Being called upon to write a math problem on the board
- Speeded skill drills and classroom competitions
- Teaching too quickly before concepts are consolidated
- Unit tests that cover too much information
- No visual cues
- Poor instruction
- Classroom climates that prevent students from asking questions
- Stressing teacher's own algorithm

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Anxiety Measures

- **Revised Children's Manifest Anxiety Scale-2nd Edition** – examines 5 areas of anxiety including physiological, defensiveness, worry, inconsistent responding, and social anxiety.
- **Multidimensional Anxiety Scale for Children – 2nd Edition** – includes both a self-report and parent report scale. There are 50 items in total.
- **Behavior Assessment Scale for Children-3rd Edition** – includes teacher, parent, and self-report scales to measure behavior and social emotional functioning.

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Building a Math Brain: 4 Neurocognitive Factors

1. **Approximate Number System** - non-symbolic representation of math represented by space and time.
2. **Connectivity** - linking non-symbolic representations with symbolic representations (numerals) to form our own internal number line.
3. **Automaticity** - facts and procedures.
4. **Quantitative knowledge** - mathematical reasoning emerges from the development of *number-sense* as students learn to apply mathematics to real world problems.

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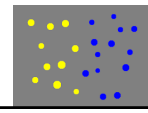
1. Approximate Number System

(Mazzocco, Feigenson & Halberda, 2011)

- A mental representational system of visual-spatial approximations that may underscore "number sense".
- Emerges independent of instruction (innate) and in non-humans as well. A preverbal skill.
- Distinguishes math LD from students from typical peers.
- Intuitively judging which line at the grocery store is shortest, or whether there is enough milk left in the carton to make breakfast are everyday examples.
- Activation in **inferior parietal sulcus**.



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2. Connectivity

- **Connectivity:** Neuroimaging studies of the brain have shown distinct, and connecting, neural circuits involved with non-symbolic data, and symbolic processing of information (Kucian et al., 2006; Rykhlevskaia et al., 2009; Holloway et al., 2011; Ashkenazi et al., 2014).
- The **intraparietal sulcus** tends to be involved in the nonsymbolic, or magnitude representation of numbers primarily in the **right hemisphere** (Rotzer et al, 2008).
- The symbolic processing of digits involves **the left angular gyrus** and **inferior frontal gyrus.** (Ansari, 2008; Butterworth & Varma, 2014).

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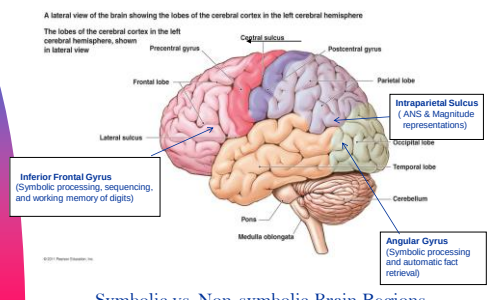
Making the Connection



Symbolic vs. Non-symbolic Brain Regions

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Measuring Connectivity: The Distance Effect

Distance Effect: when students are presented with two numerals and asked which one is larger, they tend to respond fastest when the numbers are quantitatively far apart, rather than close together (Butterworth & Varma, 2014).

Fast Response		Slow Response	
12	94	6	8
3	44	12	11
47	1	31	29
87	15	56	58
17	71	19	17
8	39	81	78

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Measuring Connectivity: The Distance Effect

Distance Effect: Whenever both numbers are relatively large, response times tend to be slower and less accurate as well **(Weber's Law).**

- Children with developmental dyscalculia tend to respond more slowly than typical peers when making comparisons between two numbers, even when controlling for IQ and general reading ability (Skagerlund & Traff, 2014).
- A child's reaction time, tends to be an excellent predictor of math fluency and math fact retrieval skills (Holloway & Ansari, 2009).

Fast Response		Slow Response	
12	94	1,211	1,221
3	44	38,004	38,409
47	1	987	978
87	15	10,242	10,202
17	71	261,789	261,689
8	39	8,111	8,101

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3. Math Facts and Brain Organization

- As number processing becomes more automatic, there is a shift of effortful control toward the back of the brain (Ashkenazi et al., 2014; Cho et al., 2012).
- Children with dyscalculia use more inefficient strategies, especially with subtraction (Rosenberg-Lee et al., 2015).
- Typically developing children often show a rapid shift from using slower, effortful counting strategies toward using more direct forms of automated fact retrieval by 3rd grade (Geary, 2004).

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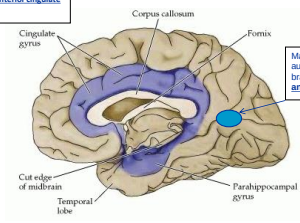
Mapping the Math Brain

Math fact retrieval is very effortful, slower, and requires more sustained attention when the **anterior cingulate gyrus** is involved.



Math fact retrieval is more automatic when posterior brain regions such as the **angular gyrus** are involved.

Math fact retrieval and the brain
(Cho et al, 2012)

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4. Quantitative Knowledge:
The Key for Higher Level Math Skills

- The development of quantitative knowledge is critical to comprehend more complex mathematics, as well as to establish cognitive flexibility when problem solving.
- Often dependent upon a variety of neuropsychological constructs including both visual spatial and symbolic reasoning and executive functioning skills.
- For example, the ability to develop a base-10 understanding of numerals and transcode challenging equations into more palatable forms of operations requires good executive functioning skills. Take the equation 9 X 16 = ____.

- The "24" Game: http://www.4nums.com/

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Evidenced Based Math Curriculums

Singapore Math – based upon math philosophy taught in Singapore…gained popularity after TIMSS study.

- Emphasis is on building upon math concepts so re-teaching is not needed, and little time devoted to reviewing previously taught skills before new concept taught.
- Flow of information is from Concrete to Pictorial to Abstract.
- The need for repetitive drill is minimized by logical sequencing of topics.
- The use of Bar-Models, which represent arithmetic quantities by line segments, facilitate understanding eliminate the need of rote memorization of facts.
- Word problems use to build semantic understanding of concepts.

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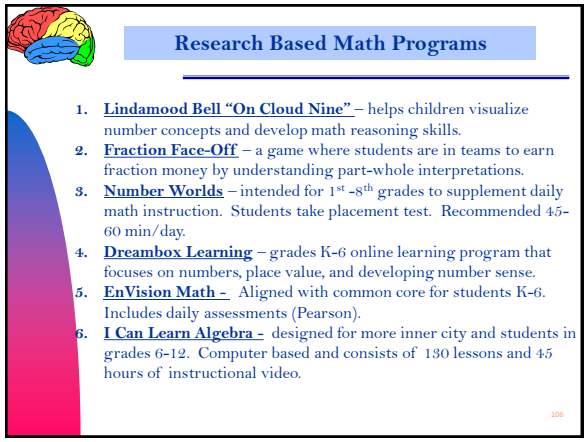
Research Based Math Programs
1. Lindamood Bell "On Cloud Nine" – helps children visualize number concepts and develop math reasoning skills.
2. Fraction Face-Off – a game where students are in teams to earn fraction money by understanding part-whole interpretations.
3. Number Worlds – intended for 1st -8th grades to supplement daily math instruction. Students take placement test. Recommended 45-60 min/day.
4. Dreambox Learning – grades K-6 online learning program that focuses on numbers, place value, and developing number sense.
5. EnVision Math - Aligned with common core for students K-6. Includes daily assessments (Pearson).
6. I Can Learn Algebra - designed for more inner city and students in grades 6-12. Computer based and consists of 130 lessons and 45 hours of instructional video.
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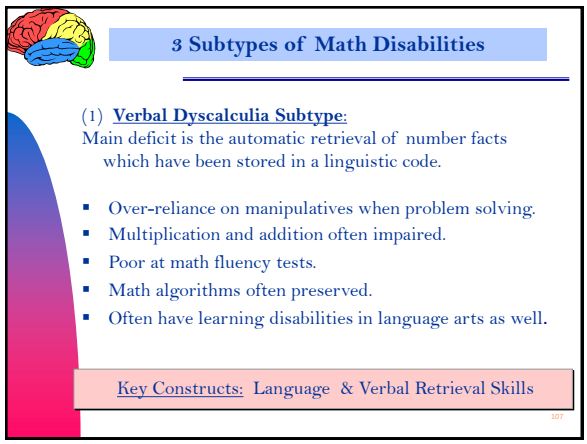
3 Subtypes of Math Disabilities
(1) Verbal Dyscalculia Subtype:
Main deficit is the automatic retrieval of number facts which have been stored in a linguistic code.
▪ Over-reliance on manipulatives when problem solving.
▪ Multiplication and addition often impaired.
▪ Poor at math fluency tests.
▪ Math algorithms often preserved.
▪ Often have learning disabilities in language arts as well.
Key Constructs: Language & Verbal Retrieval Skills
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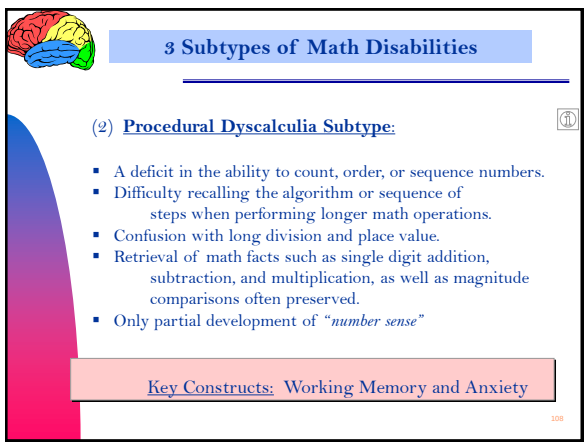
3 Subtypes of Math Disabilities
(2) Procedural Dyscalculia Subtype:
▪ A deficit in the ability to count, order, or sequence numbers.
▪ Difficulty recalling the algorithm or sequence of steps when performing longer math operations.
▪ Confusion with long division and place value.
▪ Retrieval of math facts such as single digit addition, subtraction, and multiplication, as well as magnitude comparisons often preserved.
▪ Only partial development of "number sense"
Key Constructs: Working Memory and Anxiety
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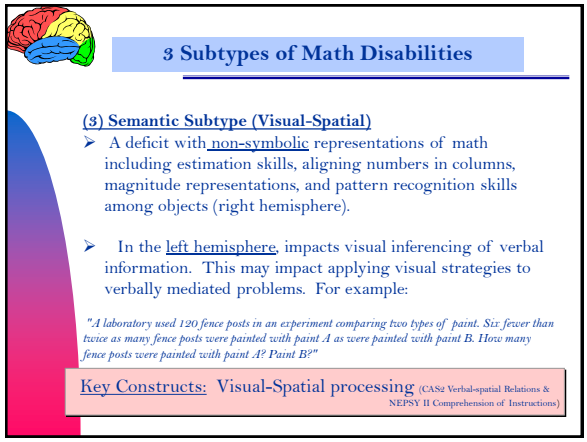
3 Subtypes of Math Disabilities
(3) Semantic Subtype (Visual-Spatial)
A deficit with non-symbolic representations of math including estimation skills, aligning numbers in columns, magnitude representations, and pattern recognition skills among objects (right hemisphere).
In the left hemisphere, impacts visual inferencing of verbal information. This may impact applying visual strategies to verbally mediated problems. For example:
"A laboratory used 120 fence posts in an experiment comparing two types of paint. Six fewer than twice as many fence posts were painted with paint A as were painted with paint B. How many fence posts were painted with paint A? Paint B?"
Key Constructs: Visual-Spatial processing (CAS2 Verbal-spatial Relations & NEPSY II Comprehension of Instructions)

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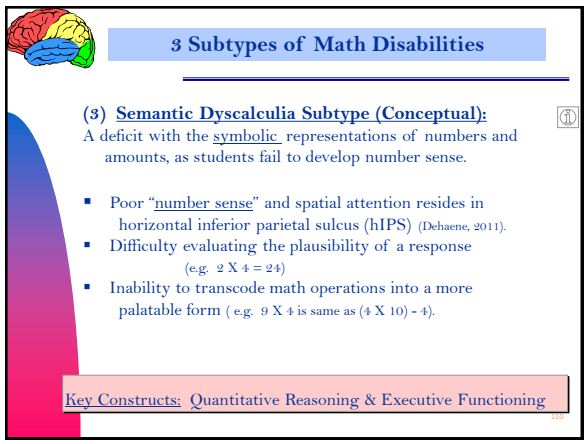
3 Subtypes of Math Disabilities
(3) Semantic Dyscalculia Subtype (Conceptual):
A deficit with the symbolic representations of numbers and amounts, as students fail to develop number sense.
Poor "number sense" and spatial attention resides in horizontal inferior parietal sulcus (hIPS) (Dehaene, 2011).
Difficulty evaluating the plausibility of a response (e.g. 2 X 4 = 24)
Inability to transcode math operations into a more palatable form (e.g. 9 X 4 is same as (4 X 10) - 4).
Key Constructs: Quantitative Reasoning & Executive Functioning
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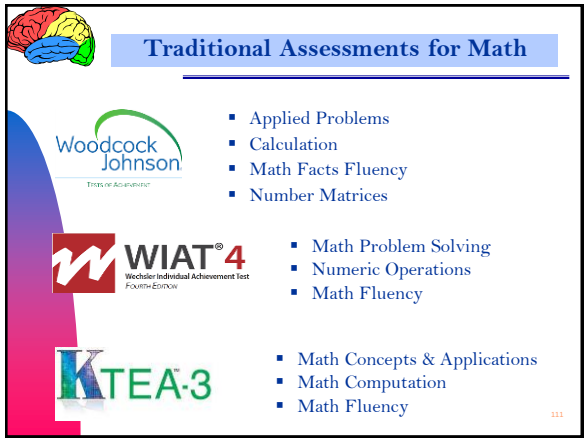
Traditional Assessments for Math
Woodcock Johnson
Tests of Achievement
Applied Problems
Calculation
Math Facts Fluency
Number Matrices
WIAT®4
Wechsler Individual Achievement Test
Fourth Edition
Math Problem Solving
Numeric Operations
Math Fluency
KTEA-3
Math Concepts & Applications
Math Computation
Math Fluency
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Steven G. Feifer, DEd

- A neurodevelopmental assessment of mathematics
- Pre-K to College (Ages 4-21)
- Normative sample included 1,061 students
- 19 subtests in complete battery
- Diagnoses 3 subtypes of math disorders
- Includes the FAM-S dyscalculia screening battery
- Total Fam index score and 3 math index scores:
  - a) Procedural subtype
  - b) Verbal subtype
  - c) Semantic subtype
- Qualification Level: **S or B**

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Structure of the FAM

Index	Subtest	Grade range	Approximate administration time
Procedural Index (PI)	Forward Number Count (FNC)	PK to college	5 minutes
	Backward Number Count (BNC)	K to college	5 minutes
	Numeric Capacity (NCA)	PK to college	3 minutes
	Sequences (SEQ)	PK to college	5 minutes
	Object Counting (OC)	PK to Grade 2	5 minutes
Verbal Index (VI)	Rapid Number Naming (RNN)	PK to college	1 minute
	Addition Fluency (AF)	K to college	1 minute
	Subtraction Fluency (SF)	K to college	1 minute
	Multiplication Fluency (MF)	Grade 3 to college	1 minute
	Division Fluency (DF)	Grade 3 to college	1 minute
	Linguistic Math Concepts (LMC)	PK to college	6 minutes
Semantic Index (SI)	Spatial Memory (SM)	PK to college	5 minutes
	Equation Building (EB)	Grade 3 to college	4 to 6 minutes
	Perceptual Estimation (PE)	PK to college	5 minutes
	Number Comparison (NCO)	PK to college	2 minutes
	Addition Knowledge (AK)	K to college	2 minutes
	Subtraction Knowledge (SK)	K to college	2 minutes
	Multiplication Knowledge (MK)	Grade 3 to college	2 minutes
	Division Knowledge (DK)	Grade 3 to college	2 minutes

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Let's Stay Connected!

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Tests: FAR- 2015 FAM- 2016 FAW - 2020
Psychological Assessment Resources

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