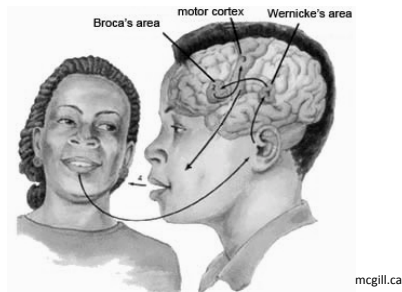


Math Difficulties: Reasons and Remedies



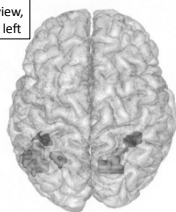
Nancy Knop, Ph.D., ET/P
www.summitcenter.us

Basic brain areas for word sense: Listening/speaking



Math is different

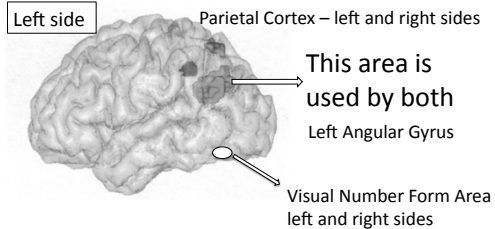
Top view,
front left



Dehaene, et al., 2003

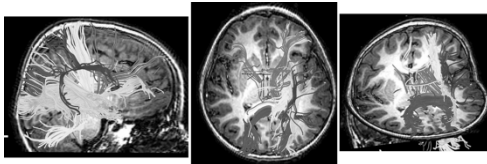
- ☐ = how many/how much
- ☐ = paying attention to the amount
- ☐ = talking/writing about math

Get your math brain together with your language brain!



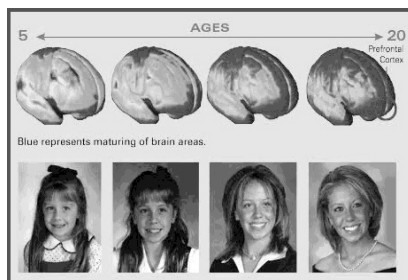
Brain connections for math

Rykhlevskala, Uddin , Kondos and Menon 2009

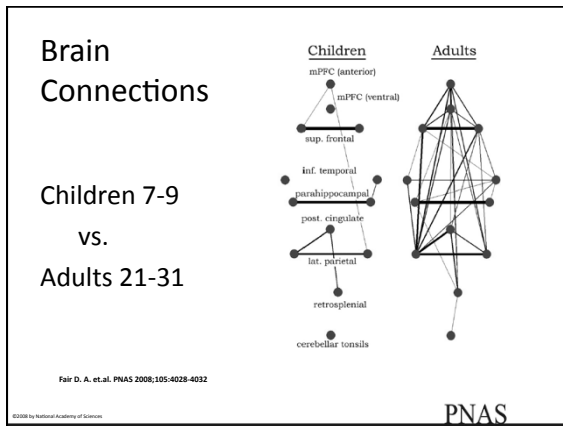


Gray matter locations and white matter connections are reduced in developmental dyscalculia.

Brain Development – age 5 to 20



Brain imaging P. M. Thompson, UCLA



Summary – brain development

- Brain areas from birth dedicated to quantity
- Brain structures that develop with experience
 - Visual number form area (VNFA)
 - Links to language
 - Connections for understanding concepts
- Both specialized areas and connections are reduced in Dyscalculia

Cognitive development in math:

Preschool

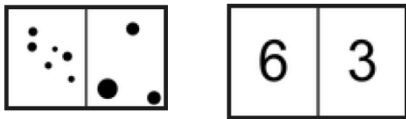
- From birth: subitizing, estimating – the approximate number system
- Discriminate more/less
- Understand cardinality
- Learn counting words
- Associate word with specific quantity – the exact number system
- add and subtract one
- Use fingers/objects to aid adding

Cognitive Development in Math *Age 5-7*

- Learn number symbols – the exact number system
- Add small numbers without counting out
 - $2 + 2 = 4$
- Shift in adding strategy $3 + 5 = ?$
 - Counting all 1,2,3,4,5,6,7,8
 - Counting on (min) 3...4,5,6,7,8
 - Counting on (max) 5....6,7,8
- Gradual shift from using fingers/objects to retrieval
- Understand ordinality - number sequence

Numeracy Screener predicts elementary math achievement

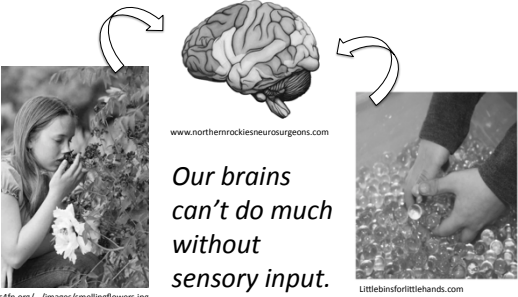
Daniel Ansari lab: www.numeracyscreener.org



Cognitive development in math *after 2nd grade*

- FOUNDATION BUILDING: success depends on it
- Increased use of retrieval
- Inverse relationship of addition and subtraction
- Base-10 arithmetic, place value
- Multiplication, division
- Fractions
- Decoding word problems

Learning is embodied




Our brains can't do much without sensory input.

cs4fn.org/_/images/smellingflowers.jpg
www.northernrockiesneurosurgeons.com
Littlebinsforlittlehands.com

HANDS AND GESTURE are important for developing math processing

- Transition from approximate to exact counting?
- Visual-spatial understanding.
- Reducing cognitive load.
- Learning from each others' gestures.




www.jonline.com
Photo/Kristyna Wentz-Graff

Susan Goldin-Meadow Lab, University of Chicago

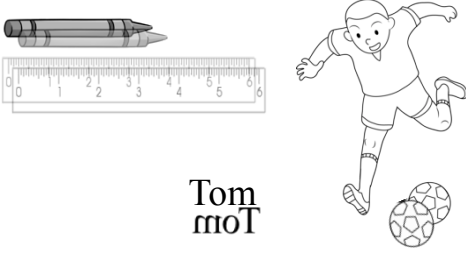
VISION: Our brains must learn to see.

We must tune our brains for letters and numbers.




b d p q
9 6 2 5

Typical readers tune for printed symbols between K and 2nd grade.




Tom
moT

Bad vision can result in
faulty brain pathways - “amblyopia”





- “20/20” vision is not enough.
It only means that each eye can read
lines on an eye chart 20 feet away.
- **COMPREHENSIVE EXAM NEEDED**
to test vision for reading and math
 - far and near visual acuity
 - binocular focusing
 - tracking coordination
 - eye health

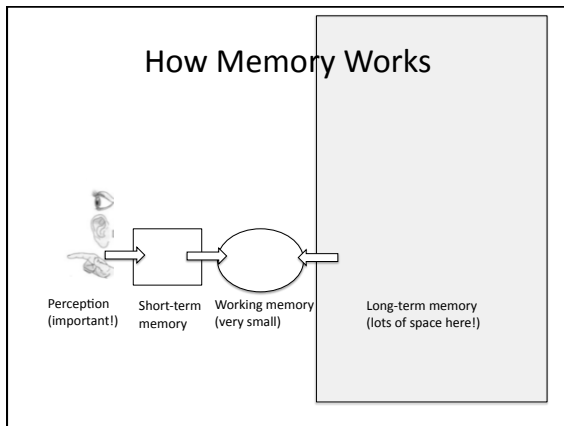


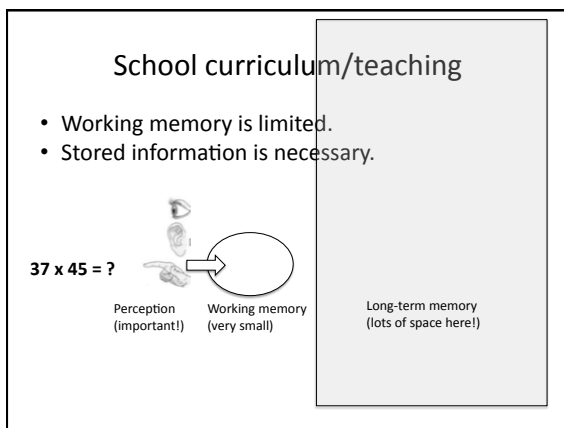
6 months, 3 years, before first grade,
every two years from age 6-18.

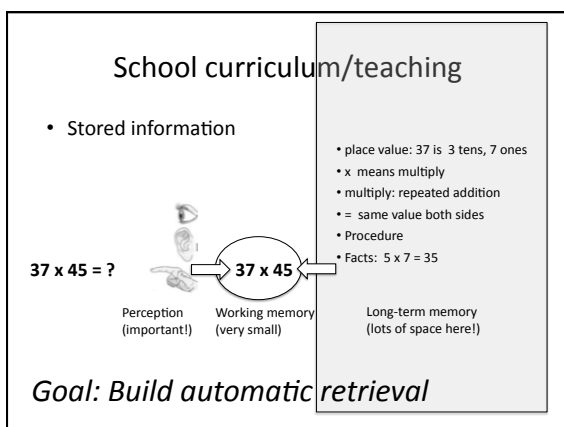
Solutions

- **VISUAL ACUITY –**
Glasses.
- **VISUAL FUNCTION –**
Vision therapy for
binocular focusing,
tracking, brain
processing.







School curriculum/teaching

217 x 43

Partial Products

217
x 43

21 (3 x 7)
840 (3 x 30)

9231

3 x 1 Digit Multiplication: Box Model

243
x 3

729

Working memory

goal: avoid cognitive overload

What children need

- A solid foundation in long-term memory.
- Automatic access to stored information.
- Teaching that recognizes brain development and avoids cognitive overload:
 - multisensory, in context – concrete to abstract
 - sequential, incremental
 - prescriptive - to build foundation, fill gaps

MEMORIZATION?

YES !

www.wikihow.com/Learn-Multiplication-Facts

- Number symbols
- Math facts
- Enough procedural knowledge to grow on
- Enough to play with/think about

DIRECT INSTRUCTION or CONSTRUCTIVISM?

- **Direct instruction is necessary.**

- Children don't have time to reconstruct the evolution of math knowledge.
- Working memory must be conserved.
- Accessible long-term memory must be developed.



AND – Games, projects, labs, and explorations with skilled guidance and corrective interaction make sense and build deeper understanding.



PROCEDURES or CONCEPTS?

This is not a chicken or egg question



an iterative process

Johnson, Siegler and Wagner, 2001



Especially important for students with Learning Disabilities:

A specific prescription that is
sequential, incremental, and multisensory

Indications of Math disability/dyscalculia

- Lack of one-to-one correspondence
- Continued use of counting-all instead of counting on.
 - after age six
- Continued reliance on actual finger counting
- Less ability to use retrieval-based processes, more errors in retrieval.
 - after age seven for basic addition/subtraction
- Less ability to hold and manipulate information in working memory.

Reasons for Math Difficulty not just dyscalculia....

- Developmental dyscalculia (~5%) – core deficits?
 - Reduced magnitude awareness
 - Reduced visual-spatial awareness
 - Links to dyslexia, reduced verbal connections
 - Resulting in lack of VNFA and brain connections
- Asynchronous brain development
 - Working memory
 - Executive function
 - Attention and processing issues
- Foundation gaps
- Math anxiety



I can't help it!
My brain's not ready yet.

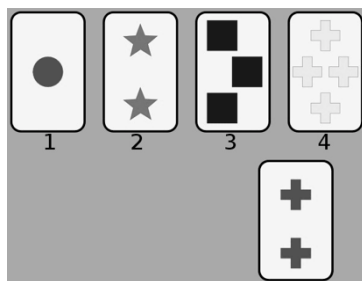
Math and Reading Disability, ages 8-15 Neuropsych test differences –

	Math Disability	Reading Disability
Working Memory	✓	✓
Processing Speed	✓	✓
Set Shifting	✓	
Phoneme Awareness		✓
Rapid Naming		✓

✓ = most important

Willcutt et al. 2013

Set Shifting – Wisconsin Card Sorting Test

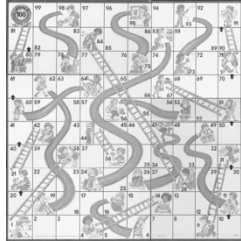


What isn't working? Assessments Ed Therapists can use

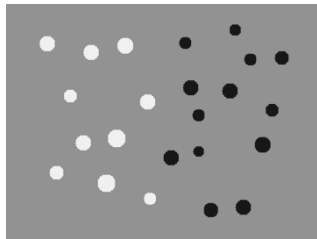
- Early Math Readiness – observe counting, finger knowledge, strategies
- Screen processing issues, refer to specialists
- Ansari Lab: www.numeracyscreener.org (free)
- Level Screening – Connecting Math Concepts, <http://www.nifdi.org/programs/mathematics/cmc> (free)

Strategies for early math development

- Build approximate number system/number sense
- Counting games
- Board games
- Bedtime math
- Begin to build the exact number system.

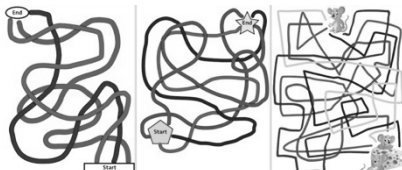
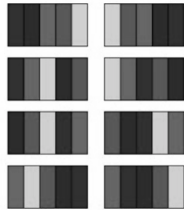


The Approximate Number System (ANS) Panamath testing/training



<http://www.panamath.org/download.php>

BUILD FINGER KNOWLEDGE www.youcubed.org



Strategies for school math difficulty

- Working memory – cognitive load down, automaticity up
- Processing speed – fewer tasks, more time, vision support
- Set shifting – identify problems in mixed sets; interleaving
- Phonemic awareness – help with reading, multi-step word problems
- Rapid naming – avoid timed tests (question vision)

VISION: VISUAL CROWDING



Multiply/Divide Simplify

- 1) $\left(\frac{2}{3}\right) \times \left(\frac{3}{5}\right)$
- 2) $\frac{6}{25} \times \left(-\frac{10}{30}\right)$
- 3) $\frac{2}{9} \times \frac{6}{14} \times \frac{7}{8}$
- 4) $\frac{3}{4} \div \frac{3}{4}$
- 5) $-\frac{1}{2} \div \frac{5}{6}$
- 6) $\frac{7}{12} \div \left(-\frac{5}{6}\right)$
- 7) $\left(\frac{1}{4}\right) \div \left(\frac{2}{3}\right)$
- 8) $\frac{3}{4} \times \frac{16}{3} \times \frac{5}{4}$

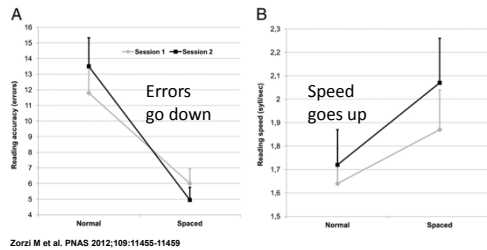
Multiply/Divide, Simplify

1. $\frac{2}{3} \times \frac{3}{5}$
2. $\frac{6}{25} \times \left(-\frac{10}{30}\right)$
3. $\frac{2}{9} \times \frac{6}{14} \times \frac{7}{8}$
4. $\frac{3}{4} \div \frac{3}{4}$

If it's hard to read, it's hard to do: processing fluency affects effort prediction and motivation.
Song and Schwarz, 2008

Fewer errors and faster reading when letters and lines have wider spacing

Children ages 8-14, diagnosed dyslexic



Set shifting

47 - 21	99 - 10	73 - 33	89 - 30
47 + 12	32 - 12	59 - 42	32 + 54

Math difficulty and word problems

Cameron bought twelve pounds of candy corn for 79 cents a pound, and eighteen pounds of M&Ms for \$1.09 a pound, planning to make packages of candy for the Northgate-Eastside game. The two types of candy will be mixed and sold in one-pound bags. What is the least price that Cameron can charge for each of the thirty bags, in order to make at least a 25% profit?

- Type-face, size, and spacing

➡ Challenge for visual processing and decoding

Math difficulty and word problems

Cameron bought twelve pounds of candy corn for 79 cents a pound, and eighteen pounds of M&Ms for \$1.09 a pound, planning to make packages of candy for the Northgate-Eastside game. The two types of candy will be mixed and sold in one-pound bags. What is the least price that Cameron can charge for each of the thirty bags, in order to make at least a 25% profit?

- Type-face, size, and spacing
- Alpha-numeric and place value language shifts
- Irrelevant details
- Multi-step, multiple processes

→ Challenges for visual processing, decoding, rule-shifting, inhibition, planning, working memory, and processing speed

Word problems – analyze and solve

- In track last week, the boys ran sixteen laps. The girls ran four more laps. Each lap is $\frac{1}{4}$ mile. How many miles did the girls run?
- In track last week, the boys ran sixteen laps. The girls ran four more laps. Each lap is $\frac{1}{4}$ mile. How many miles did the girls run?

+ ×



- $16 + 4 = 20 \times \frac{1}{4} = 5$. The girls ran 5 miles.

Math anxiety

- Impact on Working Memory
- “Stereotype threat”
- Parent and teacher math anxiety.



Bedtime Math – a free app
www.bedtimemath.org

Berkowitz et al., Science, 9 October 2015

**Students with good working memory
 → potential to succeed in math**

Higher stress hormone in saliva

- High math anxiety: **CHOK**
- Low math anxiety: **THRIVE**

Reframe anxiety as excitement

Mattarella-Micke A et al., 2011
 Beilock lab

Strategies to relieve anxiety

- Parents – Model positive interaction with math.
 - Encourage support strategies. - Allow development.
- Students - Journal, get it off your chest.
 - Reappraise anxiety as excitement. – Get help.
- Teachers – Eliminate stereotype threat.
 - Use accommodations that reduce stress.
- Schools – Choose/train teacher role models.
 - Monitor achievement. - Work with parents.



Educational Therapists: Remedies for math difficulties

- Diagnose the issues – true dyscalculia, foundation gaps, development/curricula issues, anxiety.
- Be mindful of and refer out for processing issues – vision, hearing, attention.
- Design an individualized prescription for remediation and accommodation.
- Be professional in your work with the team – support teachers!

Selected references (see other links above)

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