Understanding Cognitive Skills and Brain Training

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Reading Center, Rochester, MN
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Who am I (not)?

- Ph.D. in Child Psychology from Arizona State University; Board Certified through ABPP 2006
- Fellowship at Mayo Clinic 1996-1998; Consultant 1998-2007; Supplemental Consultant 2008-present
- Specialty in Pediatric Psychology, treating children with physical illnesses (no neuropsychology specialty).
- Most important credential: Mother of two children, Mimi and Myles, one of whom has special learning issues


SPEED.
I AM SPEED.

Overview of Presentation

- Intelligence versus Achievement
- Cognitive skills – building blocks of achievement
- What is a learning disability?
- Using cognitive training to address LD: From Orton-Gillingham to online brain training
- Overview of current brain training efforts
- Buyer beware!

Intelligence vs. Achievement

- Intelligence –
  - Your capacity to learn, solve problems, think abstractly, adapt, manage complexity, structure your own behavior, etc.
  - Measured by "IQ Tests" - Intelligence Quotient (e.g., WAIS-IV, WISC-IV, Cattell Culture Fair III, Woodcock-Johnson Tests of Cognitive Abilities-III, Stanford-Binet Intelligence Scales V)
  - IQ once thought to be unitary construct; now best represented by multiple domains. For example, on the WISC IV
    - Verbal Comprehension (VC) Index
    - Perceptual Reasoning (PO) Index
    - Processing Speed (PS) Index
    - Working Memory (WM) Index
  - IQ once thought to be stable; now we are coming to see that skills within IQ may be trained (e.g., Working Memory)

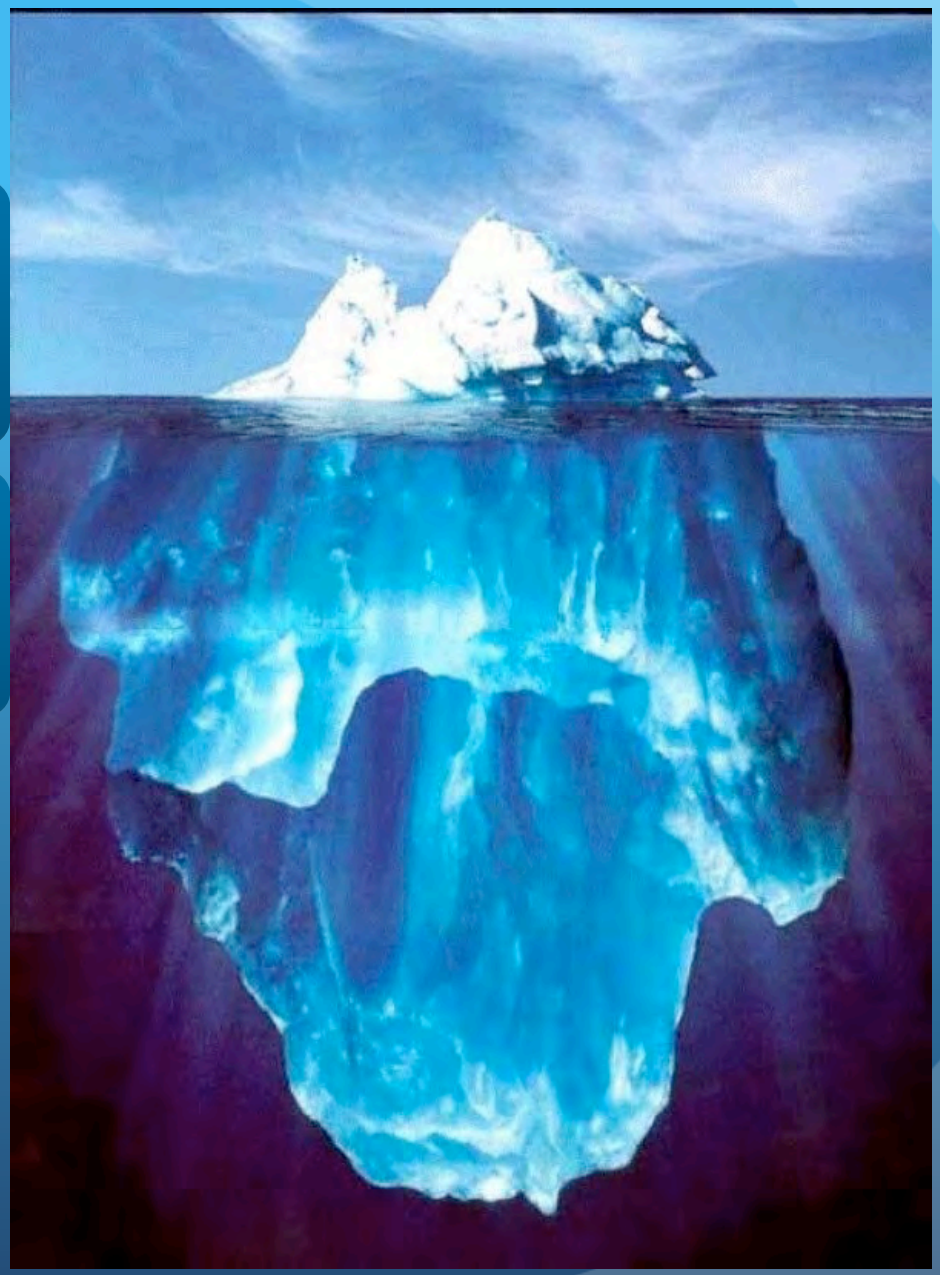
Intelligence vs. Achievement

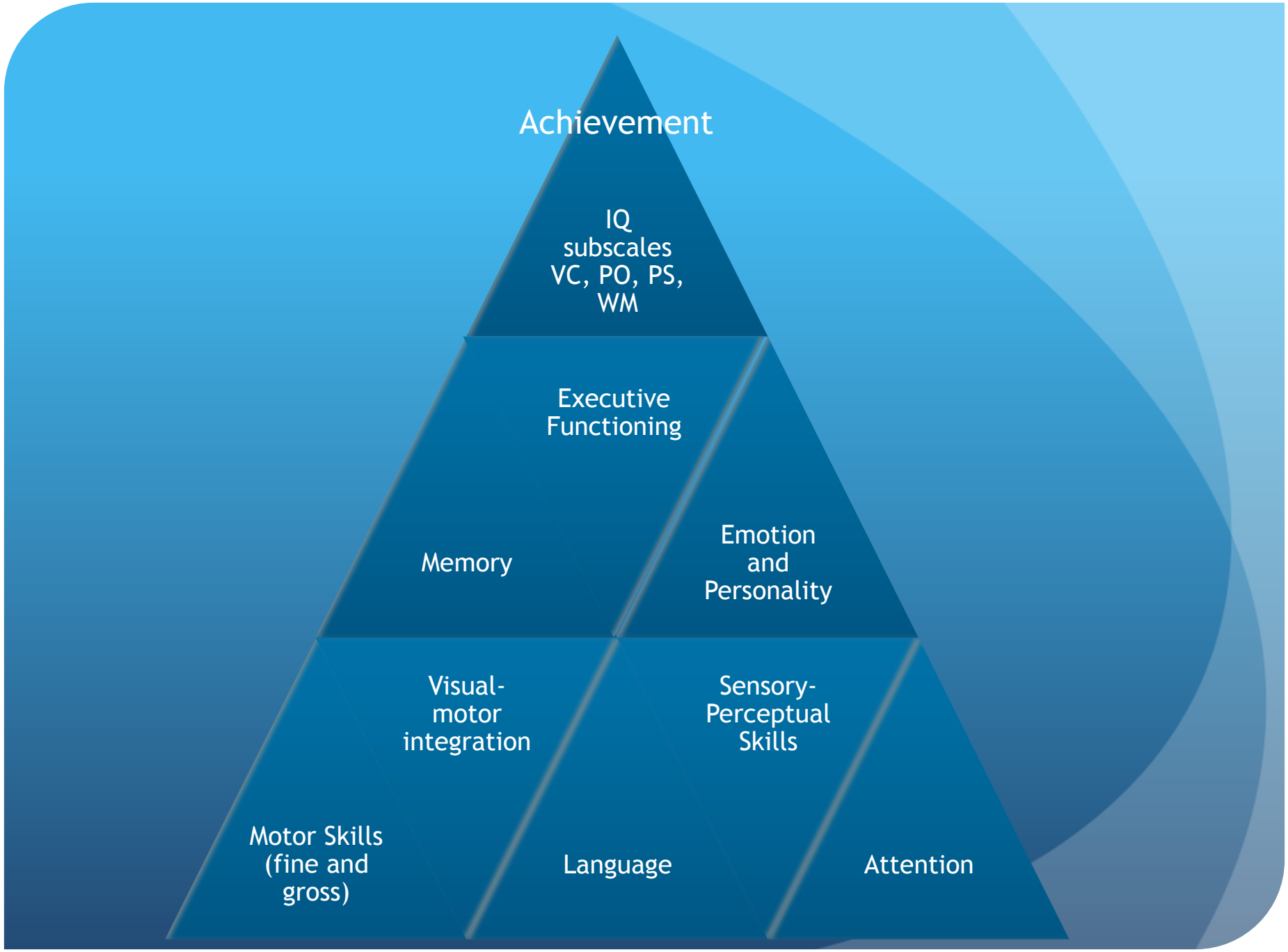
- Achievement
  - "What a child has learned so far…" in various subjects
    - Reading
    - Math
    - Written Language
  - Assessment measures- Woodcock Johnson Tests of Achievement WJ-III, Wechsler Individual Achievement Test – WIAT, Wide Range Achievement Test (WRAT)
  - IQ and Achievement generally correlated
    - High IQ expect High Achievement
    - Avg. IQ expect Avg. Achievement
    - Low IQ expect Low Achievement

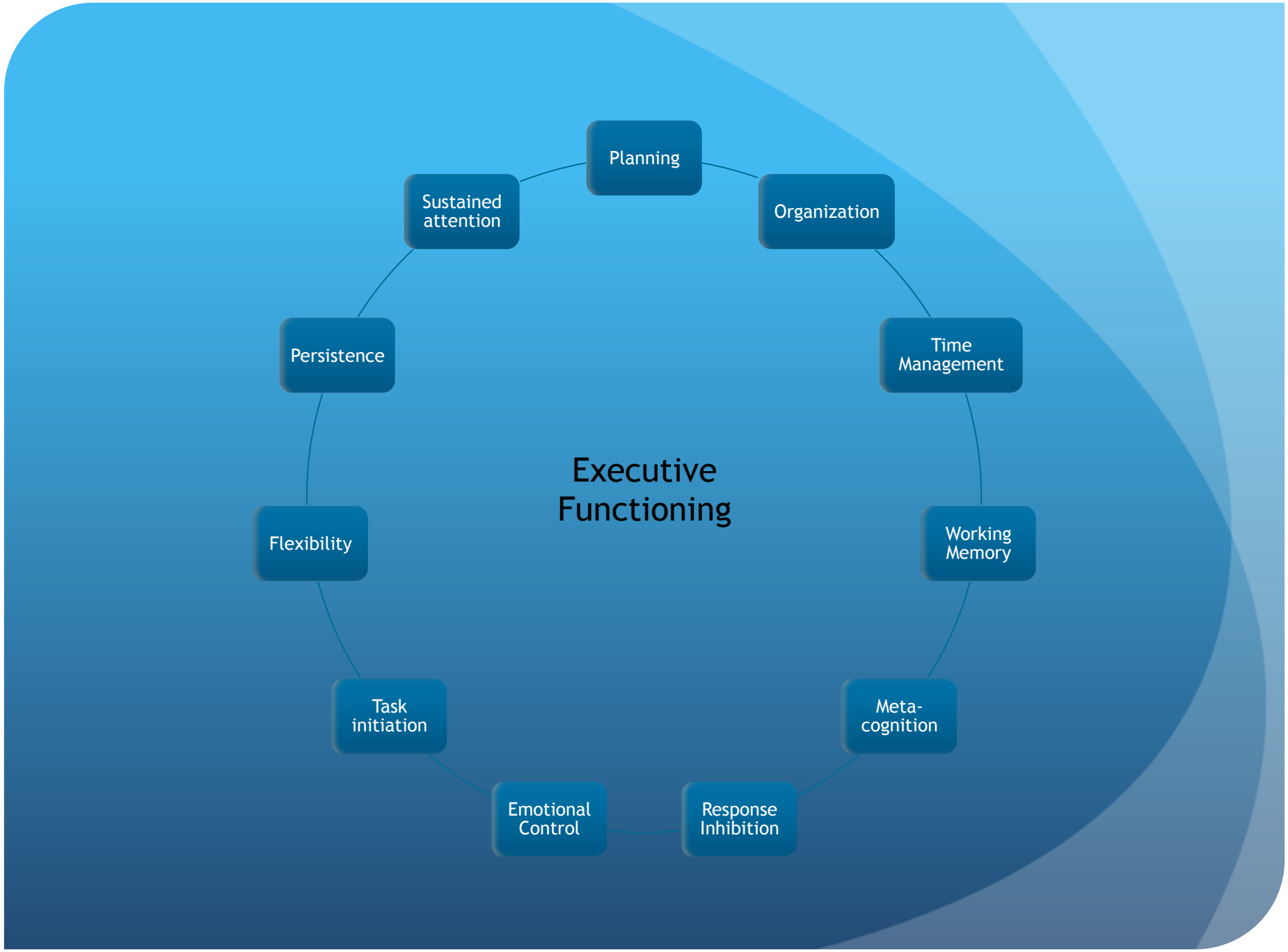
Achievement

Intelligence

Neuropsychological Skills




Achievement
IQ subscales VC, PO, PS, WM
Executive Functioning
Memory
Emotion and Personality
Visual-motor integration
Sensory-Perceptual Skills
Motor Skills (fine and gross)
Language
Attention


Planning
Organization
Time Management
Working Memory
Meta-cognition
Response Inhibition
Emotional Control
Task initiation
Flexibility
Persistence
Sustained attention
Executive Functioning

Neuropsychological skills required in the classroom…MANY!

- Think about the skills required for these activities:
  - Reading a book and answering questions about the subject and events
  - Applied math problem – Jane has 15 apples, 7 green and 8 red. She eats 3 and gives Jack 4 red ones. Does she have enough apples for a pie recipe that calls for 10 apples?
  - A science fair project – developing a hypothesis to conducting the experiment, building the presentation board, describing results to a judge
  - Writing a Powerpoint presentation to teach your classmates about the Revolutionary War
  - Negotiating a social conflict in small group setting

Learning disability…

- Traditional ***psychology*** definition:
  - Discrepancy between intelligence and achievement
  - Significant difference between what the child has learned so far and what you would expect given their capacity to learn
- Traditional ***educational*** definition:
  - Child functioning below grade level (under-achieving) despite adequate educational instruction (RTI)
- Addressed with proper educational intervention
  - Dyslexia → Direct instruction in sound-symbol relationships; O-G
  - Dyscalculia → Rote repetition of math facts, skip counting, etc.
  - Dysgraphia → OT for fine motor coordination/strength exercises

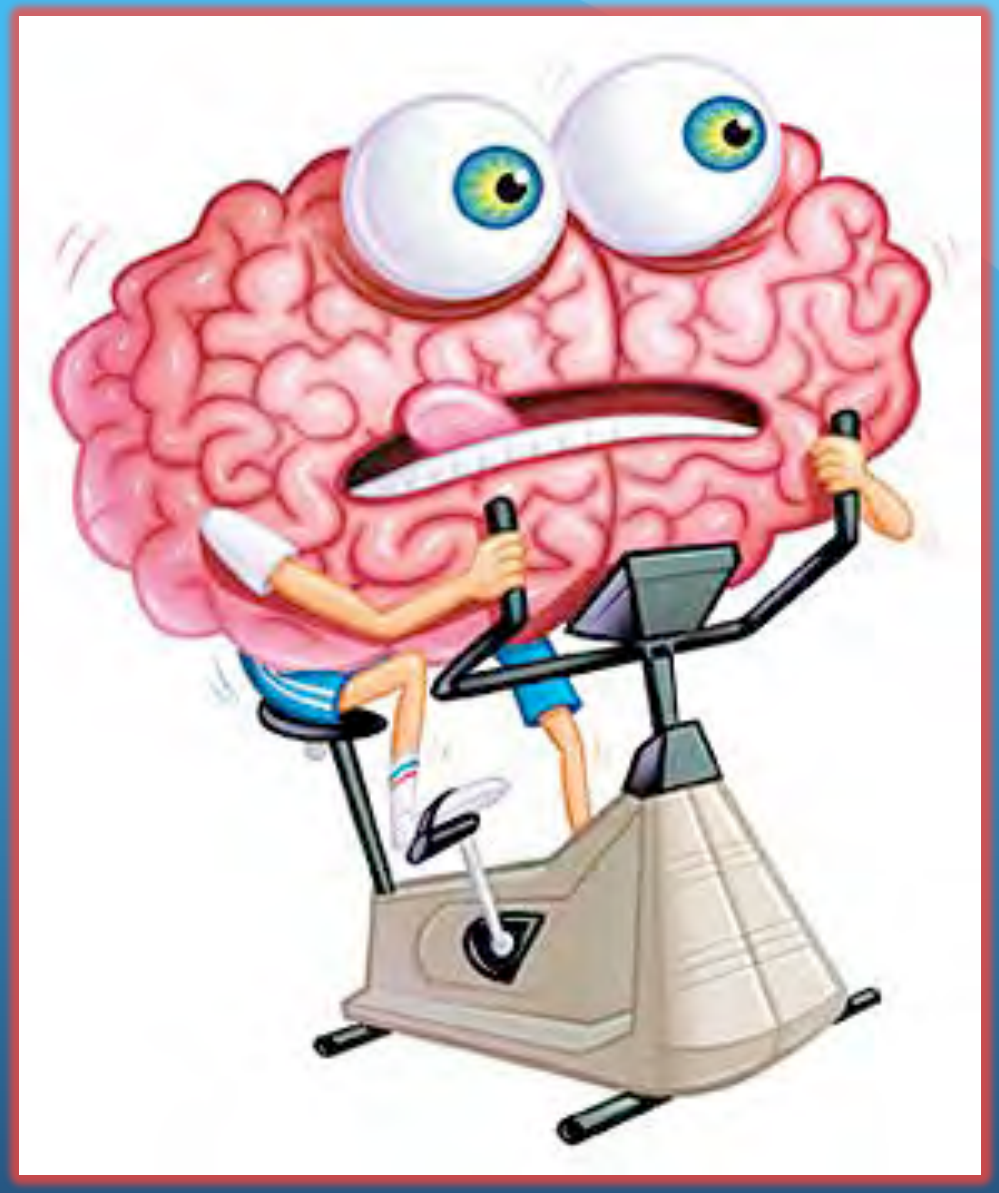
Environment can impact the brain, behavior, and functioning…

- Negatively
  - Malnutrition
  - Abuse and neglect
  - Television/Video games
- Positively
  - Early intervention education/head start
  - Cognitive-Behavioral Therapy
  - “Use it or lose it” notions of aging
  - Orton-Gillingham instruction for reading
- Neuroplasticity - The brain’s capacity to change or rewire itself in response to learning and experience

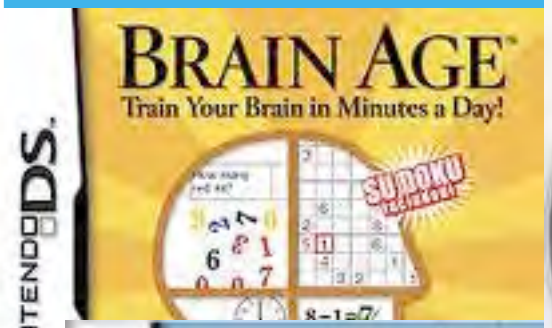
Brain Training

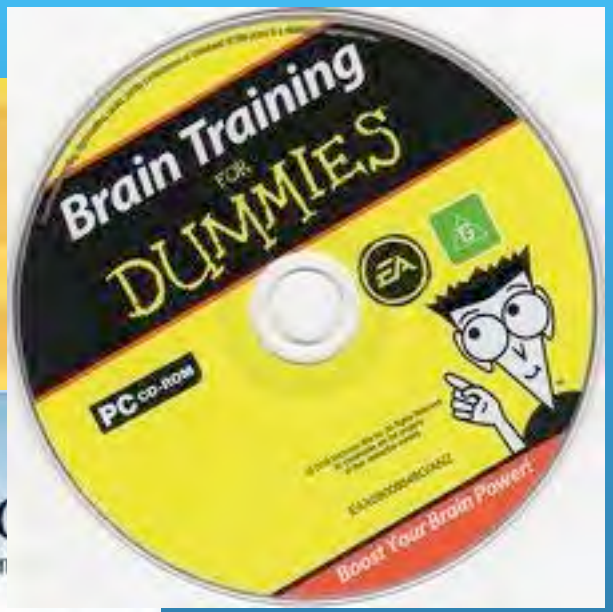
- Can we develop interventions that target neuropsychological skills and thereby improve functioning?

- Definition - The structured use of cognitive or mental exercises or techniques with the aim of improving specific brain functions.



Brain training explodes…



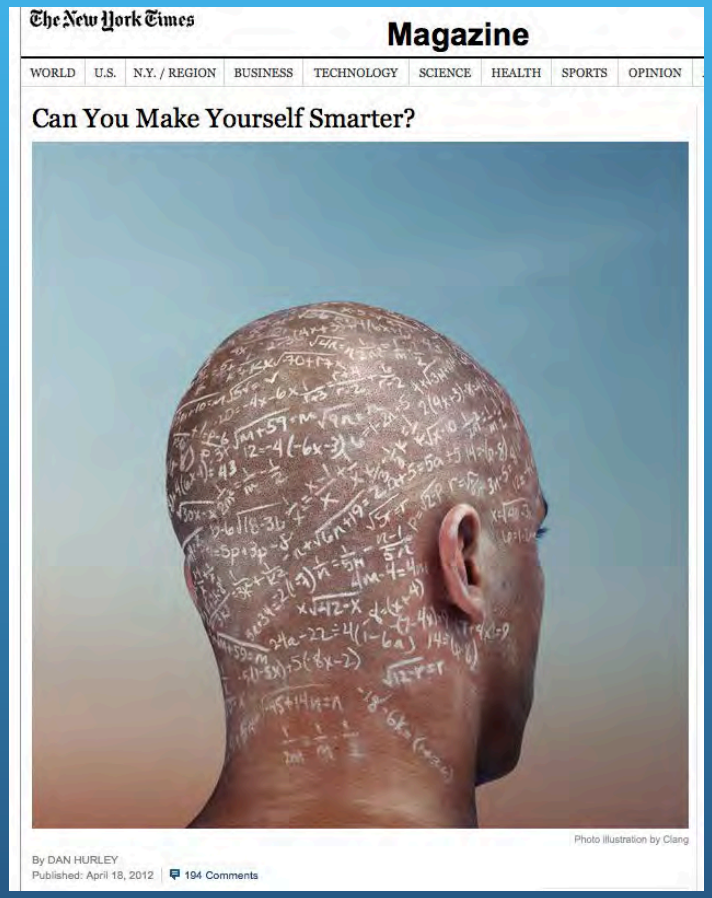


LearningRx™

PositScience®

Brain Training in the Media

April 2012



The New York Times

Magazine

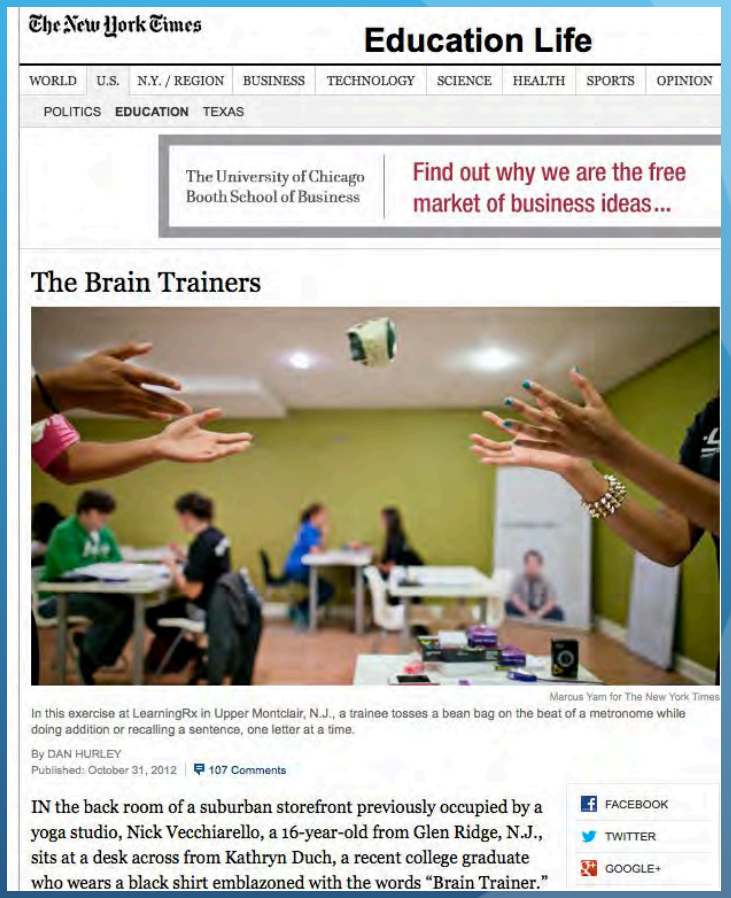
WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION

Can You Make Yourself Smarter?

Photo illustration by Clang

By DAN HURLEY
Published: April 18, 2012 | 194 Comments

October 2012



The New York Times

Education Life

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The Brain Trainers

Marcus Yam for The New York Times

In this exercise at LearningRx in Upper Montclair, N.J., a trainee tosses a bean bag on the beat of a metronome while doing addition or recalling a sentence, one letter at a time.

By DAN HURLEY
Published: October 31, 2012 | 107 Comments

IN the back room of a suburban storefront previously occupied by a yoga studio, Nick Vecchiarello, a 16-year-old from Glen Ridge, N.J., sits at a desk across from Kathryn Duch, a recent college graduate who wears a black shirt emblazoned with the words “Brain Trainer.”

With easy access to internet and apps via iphones, ipads, and computers, should we all start brain training?

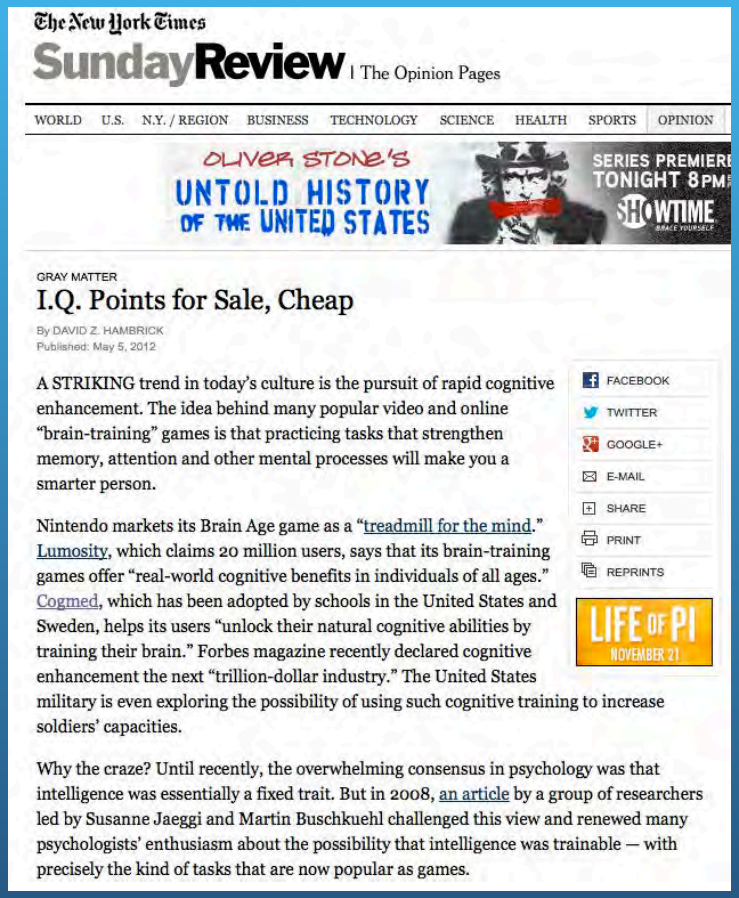
Not so fast…

Nature 2010

- Owen et. al, studied brain training in 11K subjects
  - 6-week online study, recruited via BBC show
  - 10-minutes/day, three days/week minimum
  - 2 experimental groups
    - I: Tasks involved reasoning, planning, problem-solving
    - II: Tasks involved attention, memory, visual processing, similar to "commercially available brain training devices"
- "'Brain Training', or the goal of improved cognitive function through the regular use of computerized tests, is a multimillion-pound industry, yet in our view scientific evidence to support its efficacy is lacking."

Controversy…

May 2012



The New York Times
SundayReview | The Opinion Pages

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION

GRAY MATTER

I.Q. Points for Sale, Cheap

By DAVID Z. HAMBRICK
Published: May 5, 2012

A STRIKING trend in today's culture is the pursuit of rapid cognitive enhancement. The idea behind many popular video and online "brain-training" games is that practicing tasks that strengthen memory, attention and other mental processes will make you a smarter person.

Nintendo markets its Brain Age game as a "treadmill for the mind." Lumosity, which claims 20 million users, says that its brain-training games offer "real-world cognitive benefits in individuals of all ages." Cogmed, which has been adopted by schools in the United States and Sweden, helps its users "unlock their natural cognitive abilities by training their brain." Forbes magazine recently declared cognitive enhancement the next "trillion-dollar industry." The United States military is even exploring the possibility of using such cognitive training to increase soldiers' capacities.

Why the craze? Until recently, the overwhelming consensus in psychology was that intelligence was essentially a fixed trait. But in 2008, an article by a group of researchers led by Susanne Jaeggi and Martin Buschkuehl challenged this view and renewed many psychologists' enthusiasm about the possibility that intelligence was trainable — with precisely the kind of tasks that are now popular as games.

Marketing for Brain Training… Can you tell what works?

- Learning Rx
  - http://www.youtube.com/watch?feature=player_detailpage&v=d5HOi1_15PA
  - No published studies in edited, peer-reviewed journals (as of 10/2012)
- Fast ForWord Language (FFWL)
  - http://www.youtube.com/watch?v=QsSUamFekwI&feature=player_embedded
  - "*Fast ForWord*® was found to have no discernible effects on the alphabetics and general literacy achievement domains, and potentially positive effects on the reading fluency and comprehension domains for adolescent learners." (WWC 2010)
  - Qualified support by International Dyslexia Association 2011
- Cogmed
  - http://www.youtube.com/watch?v=ThEOoe1i-oE
  - Many published studies in peer-reviewed journals, including positive RCT's; 80% of subjects improve
  - http://www.cogmed.com/research

Grading the claims of Brain Training Programs -

Sharp Brains 2009 and Rabipour & Raz, Brain and Cognition 2012

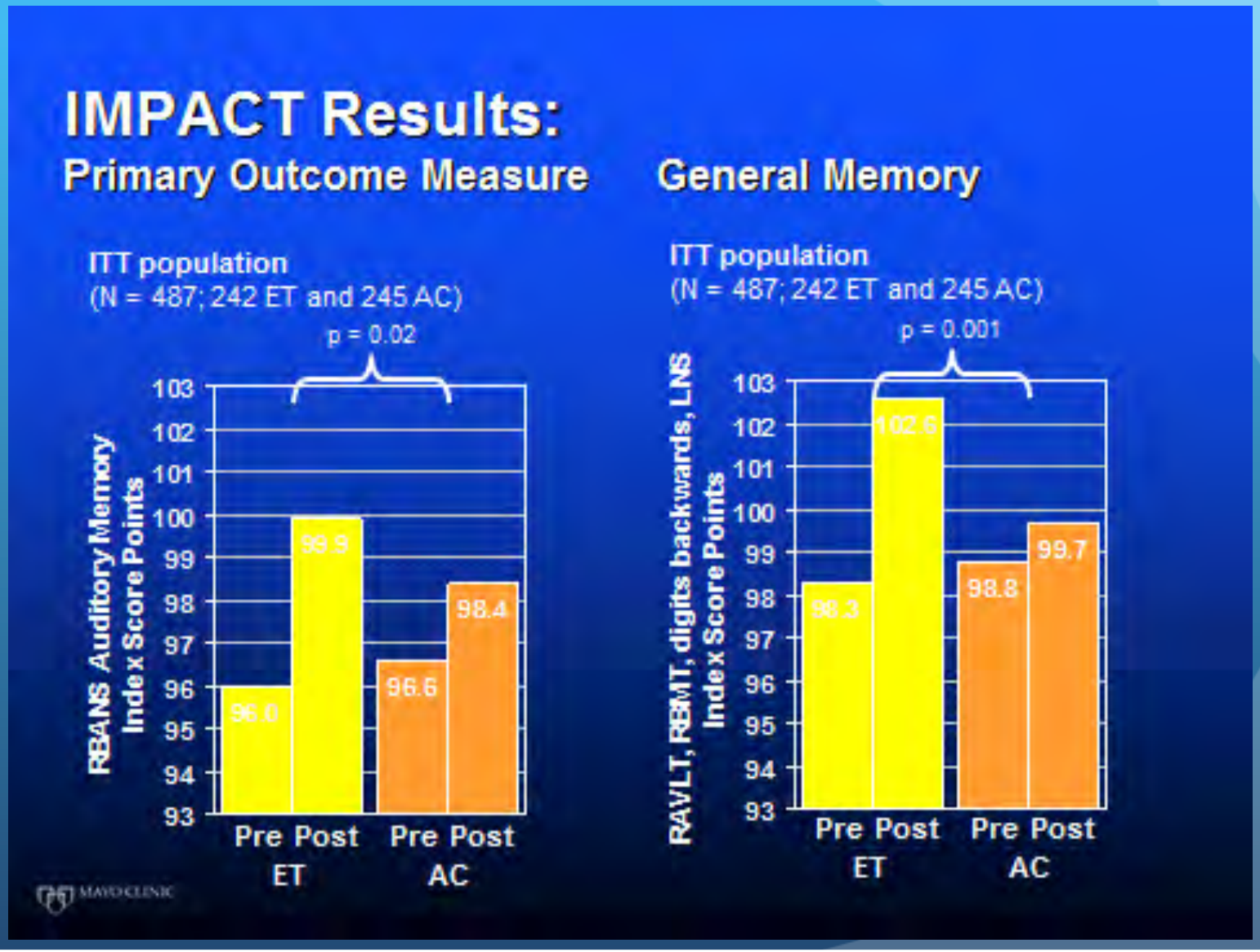
Program	Comments	Evidence
BrainAge	Nintendo doesn't claim to have proof	None
Fitbrains	Gaming	None
Cognifit	Multiple collaborators	Some
Happy Neuron	Gaming but has scientific advisors	?None
Learning Rx	Not included in reviews	None yet
Lumosity	Reputable Scientific Advisory Board and research partners	Kesler 2011
FastForWord	Possibly helpful for dyslexia	Some mixed
Posit Science	PS/WM-RCT's, IMPACT study w/ seniors	Positive Results
Cogmed	WM-RCT's and lots of ongoing research	Positive Results

PS=Processing Speed; WM=Working Memory;
RCT=Randomized Controlled Trials
Evidence=Studies supporting intervention published in peer-reviewed, edited journals

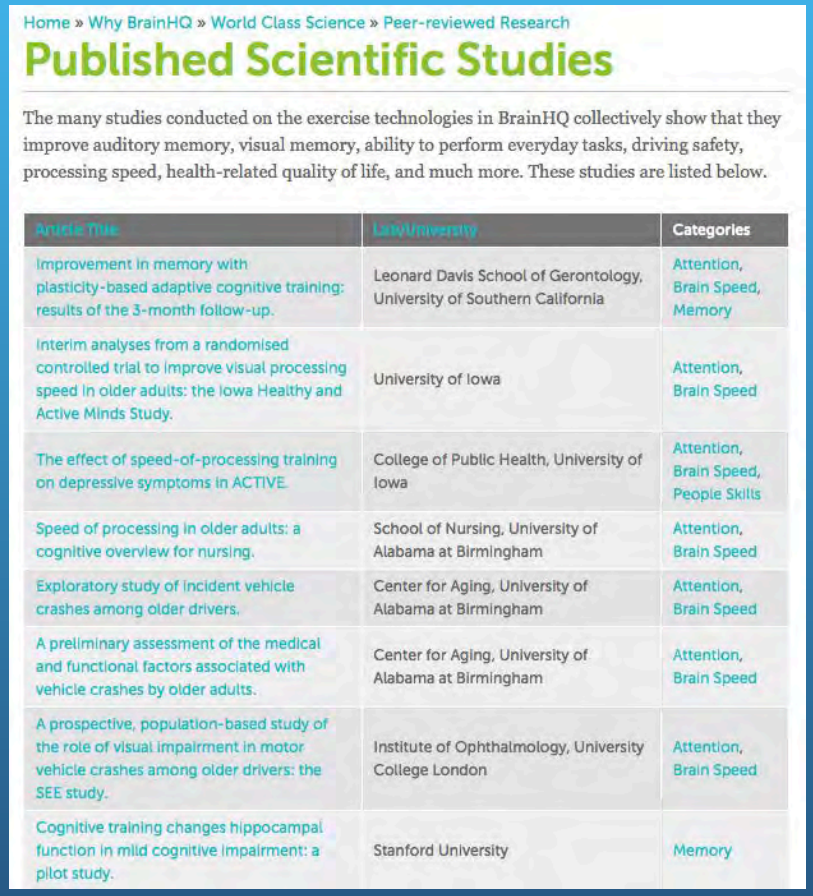
What is a RCT?

- Random Controlled Trial - "…the most rigorous way of determining whether a cause-effect relation exists between treatment and outcome…" BMJ 1998
  - Random assignment of subjects to intervention vs. control
  - Direct comparison of outcomes
  - Prevent biases if double blinded so that the researcher and the subjects do not know if they are in experimental or control group
- "…a specific type of scientific experiment, and the gold standard for a clinical trial." Wikipedia, 10/12

What is a RCT? Posit Science, Smith et. al 2009



Published Research- www.positscience.com



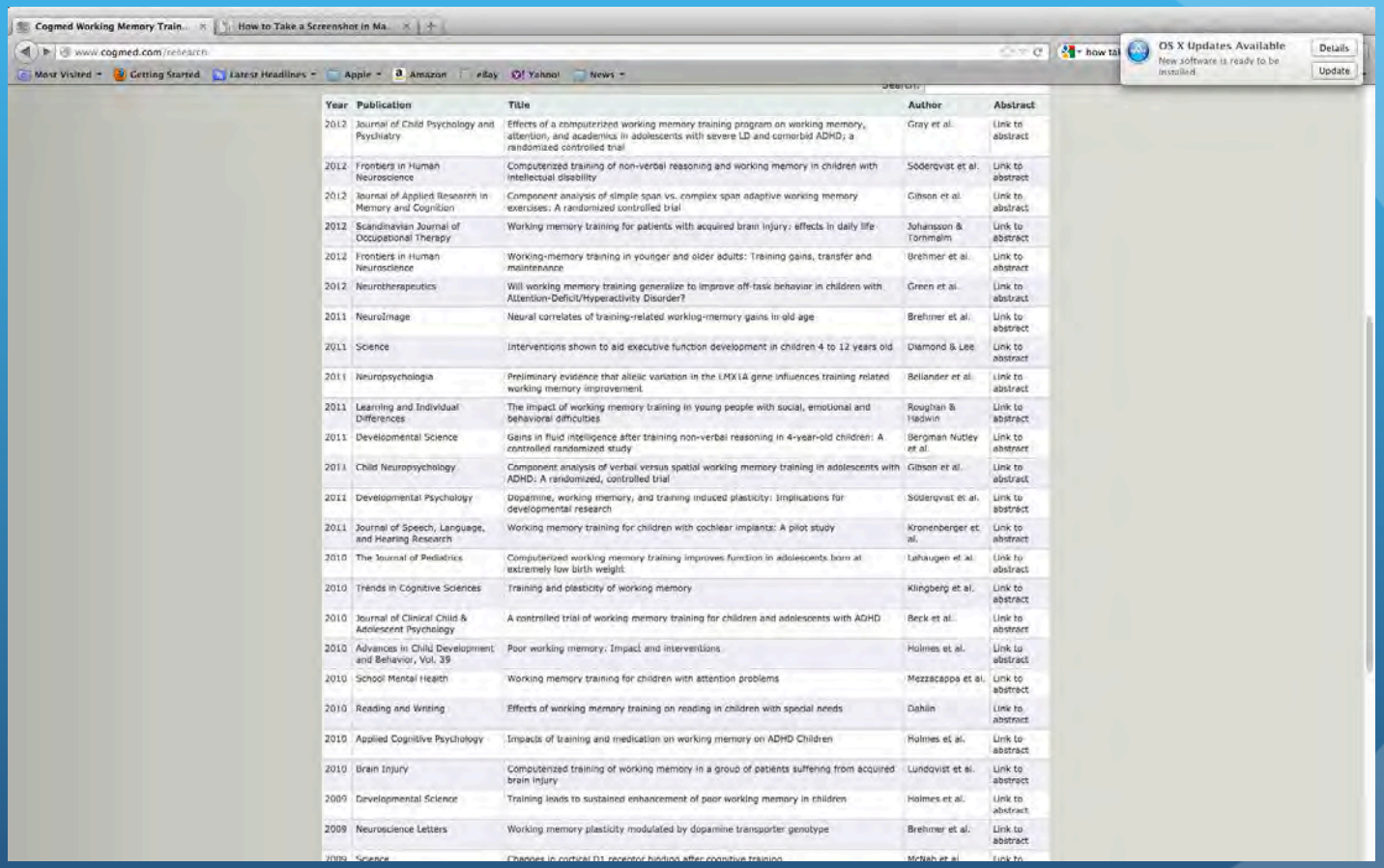
Home » Why BrainHQ » World Class Science » Peer-reviewed Research

Published Scientific Studies

The many studies conducted on the exercise technologies in BrainHQ collectively show that they improve auditory memory, visual memory, ability to perform everyday tasks, driving safety, processing speed, health-related quality of life, and much more. These studies are listed below.

Article Title	Lab/University	Categories
Improvement in memory with plasticity-based adaptive cognitive training: results of the 3-month follow-up.	Leonard Davis School of Gerontology, University of Southern California	Attention, Brain Speed, Memory
Interim analyses from a randomised controlled trial to improve visual processing speed in older adults: the Iowa Healthy and Active Minds Study.	University of Iowa	Attention, Brain Speed
The effect of speed-of-processing training on depressive symptoms in ACTIVE.	College of Public Health, University of Iowa	Attention, Brain Speed, People Skills
Speed of processing in older adults: a cognitive overview for nursing.	School of Nursing, University of Alabama at Birmingham	Attention, Brain Speed
Exploratory study of incident vehicle crashes among older drivers.	Center for Aging, University of Alabama at Birmingham	Attention, Brain Speed
A preliminary assessment of the medical and functional factors associated with vehicle crashes by older adults.	Center for Aging, University of Alabama at Birmingham	Attention, Brain Speed
A prospective, population-based study of the role of visual impairment in motor vehicle crashes among older drivers: the SEE study.	Institute of Ophthalmology, University College London	Attention, Brain Speed
Cognitive training changes hippocampal function in mild cognitive impairment: a pilot study.	Stanford University	Memory

Published Research- www.cogmed.com



Year	Publication	Title	Author	Abstract
2012	Journal of Child Psychology and Psychiatry	Effects of a computerized working memory training program on working memory, attention, and academics in adolescents with severe LD and comorbid ADHD; a randomized controlled trial	Gray et al.	Link to abstract
2012	Frontiers in Human Neuroscience	Computerized training of non-verbal reasoning and working memory in children with intellectual disability	Söderqvist et al.	Link to abstract
2012	Journal of Applied Research in Memory and Cognition	Component analysis of simple span vs. complex span adaptive working memory exercises: A randomized controlled trial	Gibson et al.	Link to abstract
2012	Scandinavian Journal of Occupational Therapy	Working memory training for patients with acquired brain injury: effects in daily life	Johansson & Tornmalm	Link to abstract
2012	Frontiers in Human Neuroscience	Working-memory training in younger and older adults: Training gains, transfer and maintenance	Brehmer et al.	Link to abstract
2012	Neurotherapeutics	Will working memory training generalize to improve off-task behavior in children with Attention-Deficit/Hyperactivity Disorder?	Green et al.	Link to abstract
2011	NeuroImage	Neural correlates of training-related working-memory gains in old age	Brehmer et al.	Link to abstract
2011	Science	Interventions shown to aid executive function development in children 4 to 12 years old	Diamond & Lee	Link to abstract
2011	Neuropsychologia	Preliminary evidence that allelic variation in the LMX1A gene influences training related working memory improvement	Bellander et al.	Link to abstract
2011	Learning and Individual Differences	The impact of working memory training in young people with social, emotional and behavioral difficulties	Roughan & Hadwin	Link to abstract
2011	Developmental Science	Gains in fluid intelligence after training non-verbal reasoning in 4-year-old children: A controlled randomized study	Bergman Nutley et al.	Link to abstract
2011	Child Neuropsychology	Component analysis of verbal versus spatial working memory training in adolescents with ADHD: A randomized, controlled trial	Gibson et al.	Link to abstract
2011	Developmental Psychology	Dopamine, working memory, and training induced plasticity: Implications for developmental research	Söderqvist et al.	Link to abstract
2011	Journal of Speech, Language, and Hearing Research	Working memory training for children with cochlear implants: A pilot study	Kronenberger et al.	Link to abstract
2010	The Journal of Pediatrics	Computerized working memory training improves function in adolescents born at extremely low birth weight	Lohaugen et al.	Link to abstract
2010	Trends in Cognitive Sciences	Training and plasticity of working memory	Klingberg et al.	Link to abstract
2010	Journal of Clinical Child & Adolescent Psychology	A controlled trial of working memory training for children and adolescents with ADHD	Beck et al.	Link to abstract
2010	Advances in Child Development and Behavior, Vol. 39	Poor working memory: Impact and interventions	Holmes et al.	Link to abstract
2010	School Mental Health	Working memory training for children with attention problems	Mezzacappa et al.	Link to abstract
2010	Reading and Writing	Effects of working memory training on reading in children with special needs	Dahlin	Link to abstract
2010	Applied Cognitive Psychology	Impacts of training and medication on working memory on ADHD Children	Holmes et al.	Link to abstract
2010	Brain Injury	Computerized training of working memory in a group of patients suffering from acquired brain injury	Lundqvist et al.	Link to abstract
2009	Developmental Science	Training leads to sustained enhancement of poor working memory in children	Holmes et al.	Link to abstract
2009	Neuroscience Letters	Working memory plasticity modulated by dopamine transporter genotype	Brehmer et al.	Link to abstract
2009	Science	Changes in cortical D1 receptor binding after cognitive training	McNab et al.	Link to

Possible key components to successful brain training…

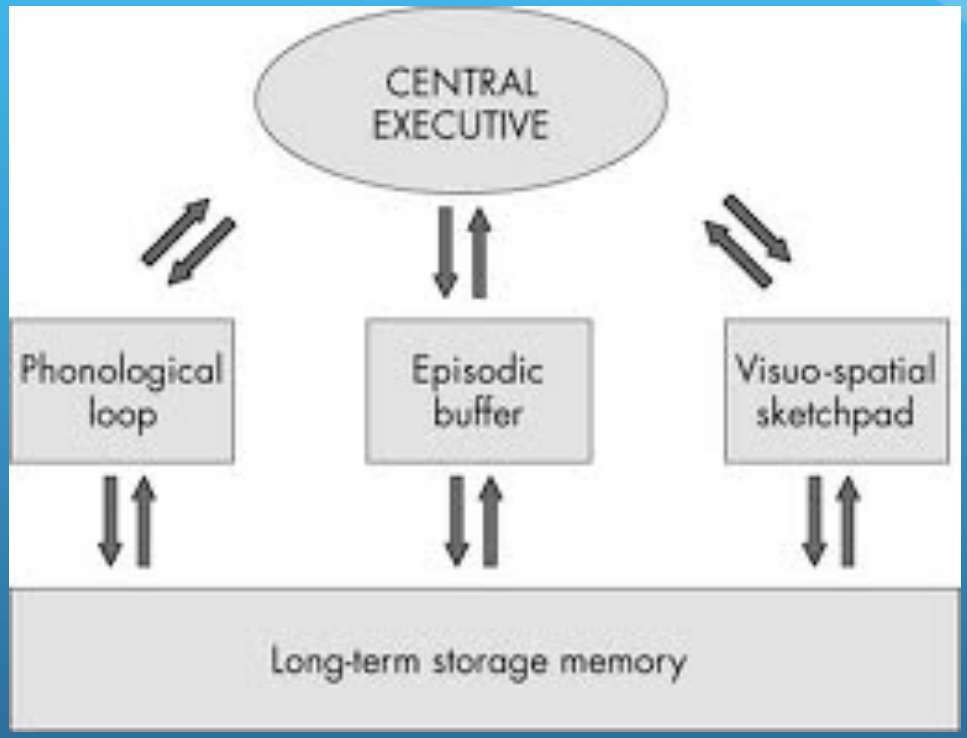
- Individualized
- Sustained mental effort
- Multiple trials with gradual increase in difficulty
- Keeping you at your edge – not bored, not overwhelmed
- Rewards positive performance
- Targets specific cognitive skill(s) and drills that skill

Get objective evaluation of educational therapies that work…

- What Works Clearinghouse (http://ies.ed.gov/ncee/wwc/)
- The Cochrane Collaboration (www.cochrane.org)
- TRIP Database for evidence based medicine (www.tripdatabase.com)
- Quackwatch (www.quackwatch.com)
- Other resources (may or may not be unbiased)
  - SharpBrains.com
  - MindFit.com

So what does brain training look like when it targets a specific cognitive construct, e.g., Working Memory?

What is Working Memory…



Baddley 1974

Demonstration of Working Memory in the Classroom

http://research.aboutkidshealth.ca/teachadhd/abc/chapter3/view?searchterm=model

What is Working Memory (WM)?

- Examples:
  - Digits backwards
  - Holding instructions for a task before beginning
  - “SRA” - Moving information from paragraph to worksheet
- New(er) research shows that WM may be more highly correlated with Achievement than IQ
- Children with ADHD and many other conditions have poor working memory
- Question: Can we improve WM and thereby improve achievement and school performance?

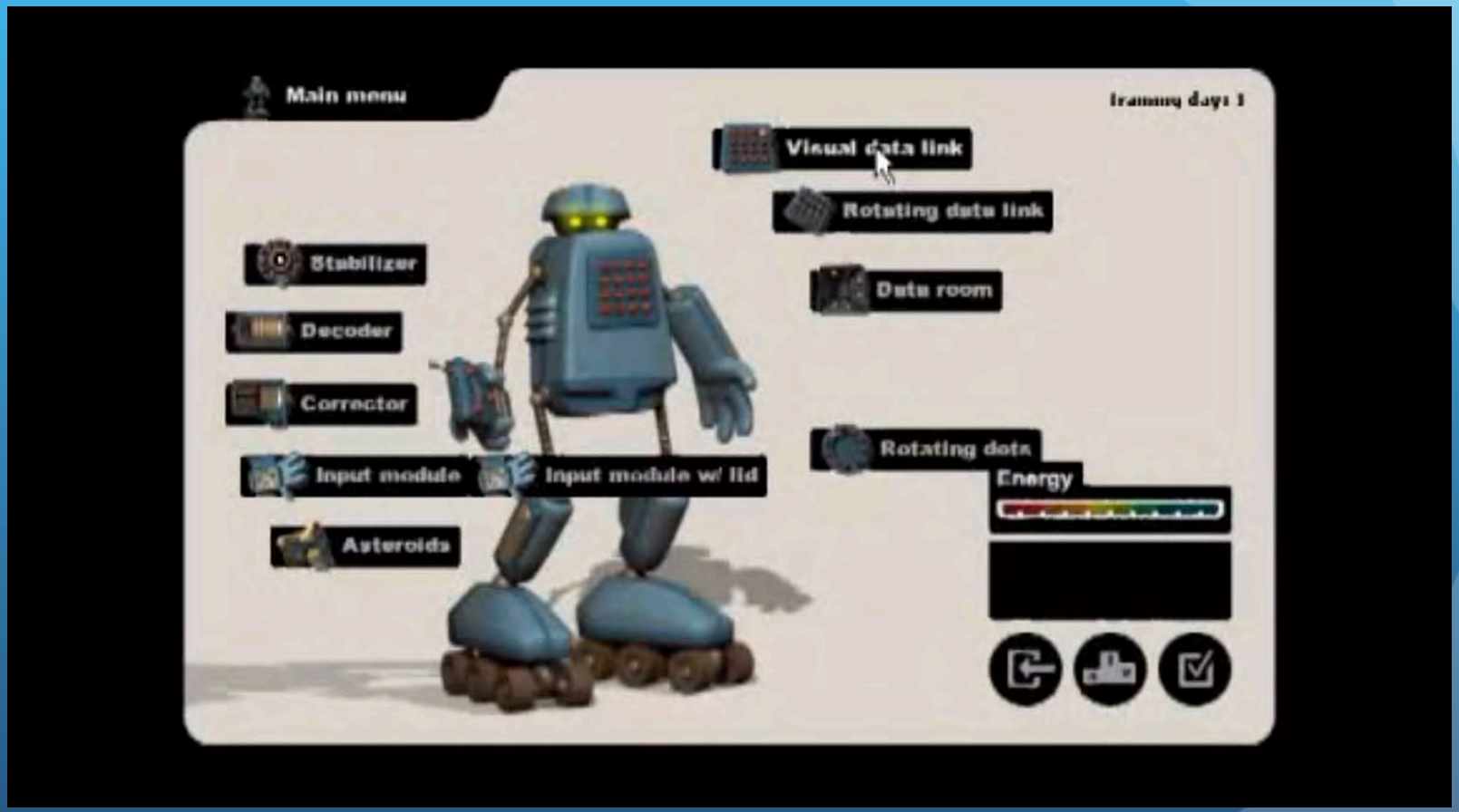
Cogmed

- Focused on increasing WM capacity
- Difficulty adjusted in real time based on user's performance; individualized and designed "to keep you on your edge"
- 5-weeks of about 30-45 minutes/day, 5 days/week
- Requires weekly meetings with a professional, trained Cogmed Qualified Coach(usually a psychologist) who reviews progress and alters training as needed
- Requires volunteer/parent/tutor who works alongside the user daily, providing encouragement
- Positive reinforcement is a key component of training, both within the program and from both Cogmed expert and parent

Cogmed – Brain training for Working Memory

- Klingberg, T., Fernell, E., Olesen, P.J., Johnson, M., Gustafsson, P., Dahlstrom, K., et al. (2005). Computerized training of working memory in children with ADHD--A randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, 44(2), 177–186.
- www.cogmed.com
- Demonstration

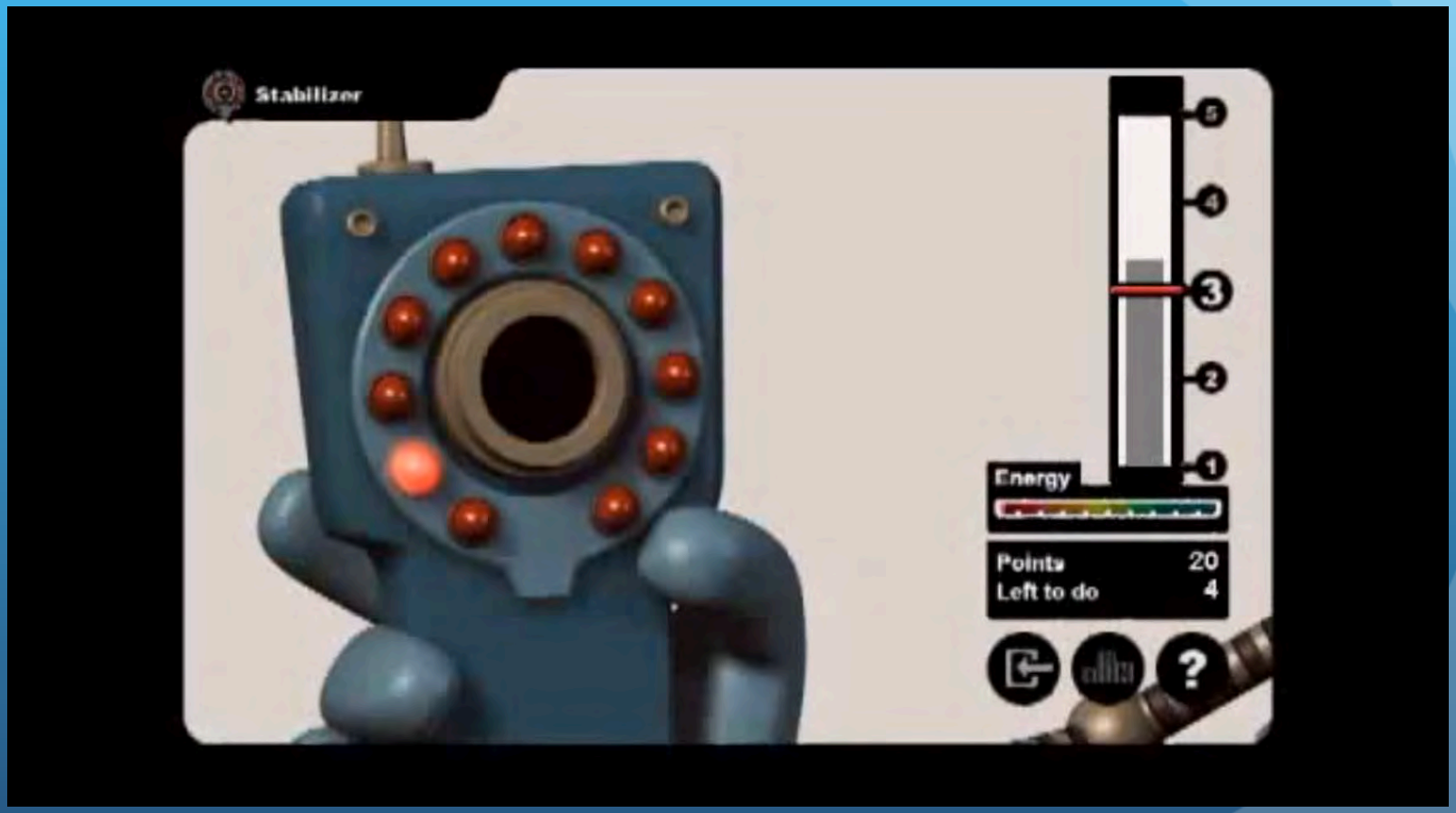
Cogmed – Training Exercises



Cogmed – Visual Data Link

Cogmed - Asteroids

Cogmed - Stabilizer



Cogmed Verdict

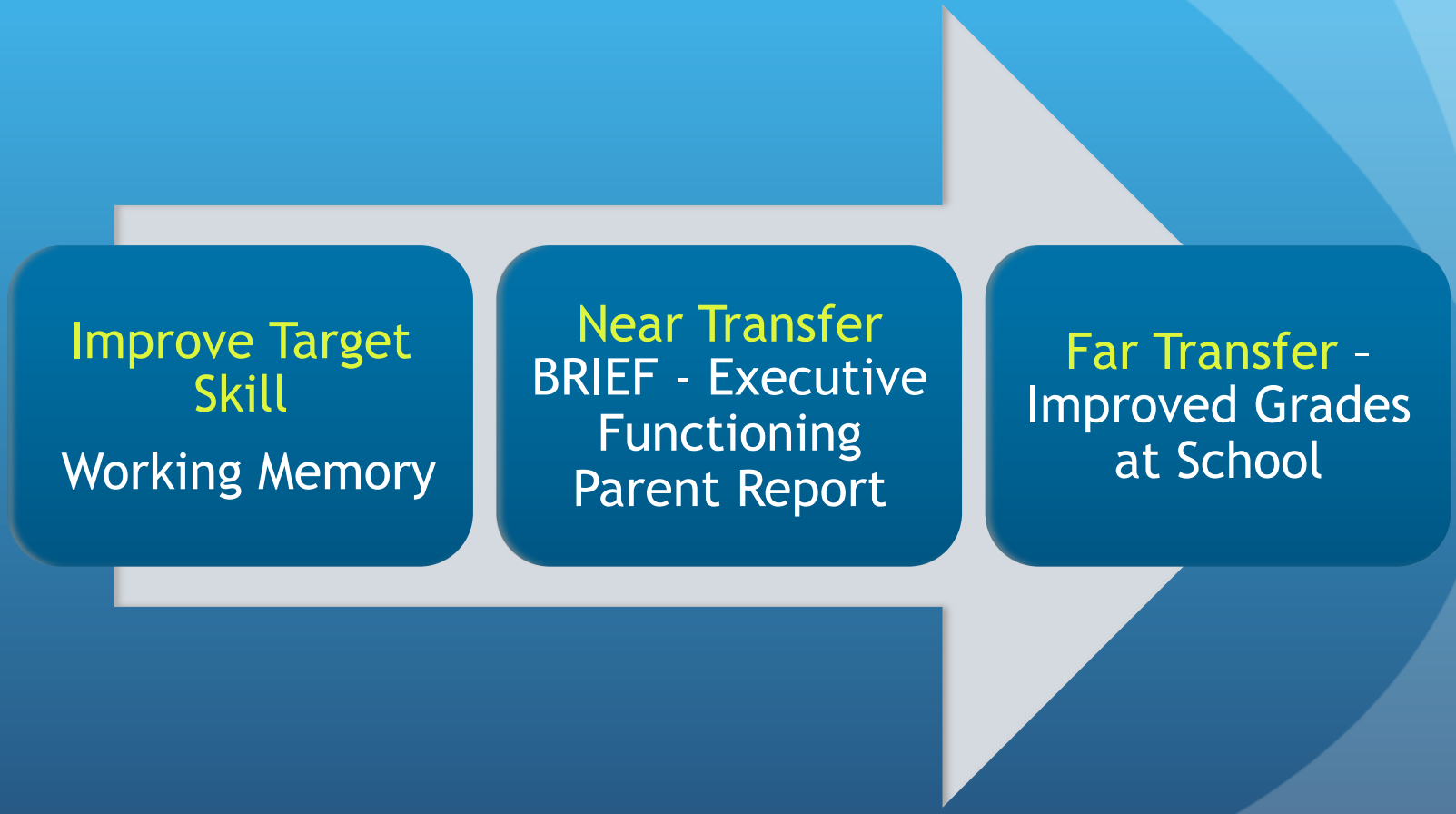
- Looks promising, but caution still needed…

Review of WM Research

"…contrary to the reports provided at the beginning of this article (and contrary to the claims of commercial providers), the present literature provides insufficient evidence of its efficacy. Our primary concerns regard the need for researchers to a) include multiple measures of abilities of interest, b) consistently measure near transfer with valid WM capacity tasks that differ from the method of training, c) eliminate the use of no-contact control groups, and d) ensure that when subjective measures of change are used, raters are blind to the condition assignment. Until these controls are consistently applied, the meaningfulness of training effects cannot be evaluated."

Shipstead, Redick,& Engle, Psych. Bull. 2012

High Burden of Proof for Interventions…



Buyer Beware!!!

- Demand to see published research from peer-reviewed, edited journals
- Look for randomized controlled trials (RCT's) and meta-analyses
- Don't be dazzled by marketing hype/advertising
- Glitzy tech-based delivery does not necessarily make it an effective intervention
- Be skeptical
  - if training claims "to help everyone"
  - about for-profit companies – they want your money
  - if evidence originates from a single research lab and has not been replicated elsewhere

In Summary…

- Many different cognitive skills form the basis of learning and achievement
- Brain training involves strengthening cognitive skills; OG can be considered one form of brain training
- The internet and other media has spawned an explosion of “brain training” interventions
- There are a few interventions which have received research support; most have not
- Computer/Internet-based interventions likely to be the future of brain training