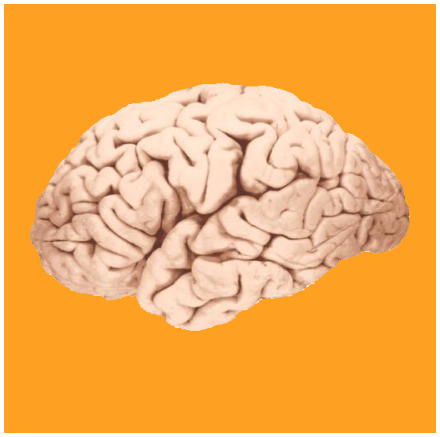
Neural Plasticity and Training in the Brain



H-126 Typical and Atypical Neurodevelopment
November 13th, 2017

Overview

- Brain plasticity
- Brain training: helpful, harmful, deceiving?
- Navigating the brain training maze
- Educating Educators: the role of basic and applied science

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Brain Plasticity (review)

THE TERM "PLASTICITY"....

...has generally been used 2 ways:

- ***RECOVERY OF FUNCTION***, whereby some function is returned following injury.
  - A related concept is **SPARING** (or lack of loss in performance following brain damage)
  - Both are often categorized as ***FUNCTIONAL PLASTICITY***.
- ***NEURONAL PLASTICITY*** is hypothesized to underlie functional plasticity

MECHANISMS OF NEURONAL PLASTICITY

- Anatomical: e.g., ability of existing synapses to modify their activity by spouting new axons or by an expansion of dendritic surfaces (e.g., new dendritic spines).
- Neurochemical: e.g., ability of existing synapses to modify their activity by, for example, increasing neurotransmitter synthesis and release
- Metabolic: e.g., fluctuations in cortical and subcortical metabolic activity (e.g., glucose utilization; increases blood supply via new capillary growth)

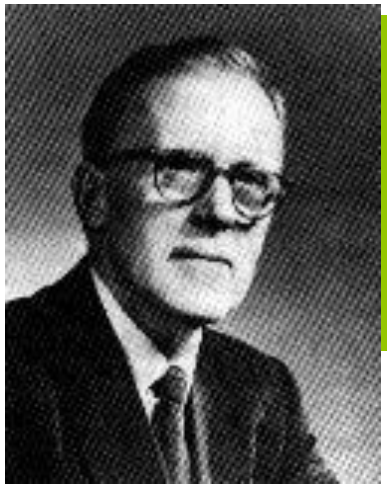
SUMMARY

- So, *functional* plasticity reflects the malleability of behavior (e.g., to be protected following damage or to recover from damage), whereas *neural* plasticity reflects the mechanism the underpins functional plasticity.
  - Example: efficacy of cognitive behavior therapy for treatment of depression or anxiety based on changing thought patterns (functional plasticity); such changes must be mediated by changes in brain (e.g., neural networks)

Brain Plasticity

- Developmental plasticity → specific to the change in neurons and synaptic connections as a consequence of developmental processes (can also be initiated by experience)
- Activity-or use-dependent plasticity → specific to the change in neurons and synaptic connections as a consequence of activity-dependent functions
- Experience-dependent activity → specific to the change in neurons and synaptic connections as a consequence of new information or training
- Injury-induced plasticity → specific to the change in neurons and synaptic connections as a consequence of and injury/insult

Donald Hebb



Hebb's postulate

"When an axon of cell A is near enough to excite cell B or repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased".

Donald O. Hebb (1949)

Hebb's Law can be represented in the form of two rules:

1. If two neurons on either side of a connection are activated synchronously, then the weight of that connection is increased.

   → persistent increase of the synaptic transmission efficacy, the effect is called **long-term potentiation** (LTP) of synapses.

2. If two neurons on either side of a connection are activated asynchronously, then the weight of that connection is decreased.

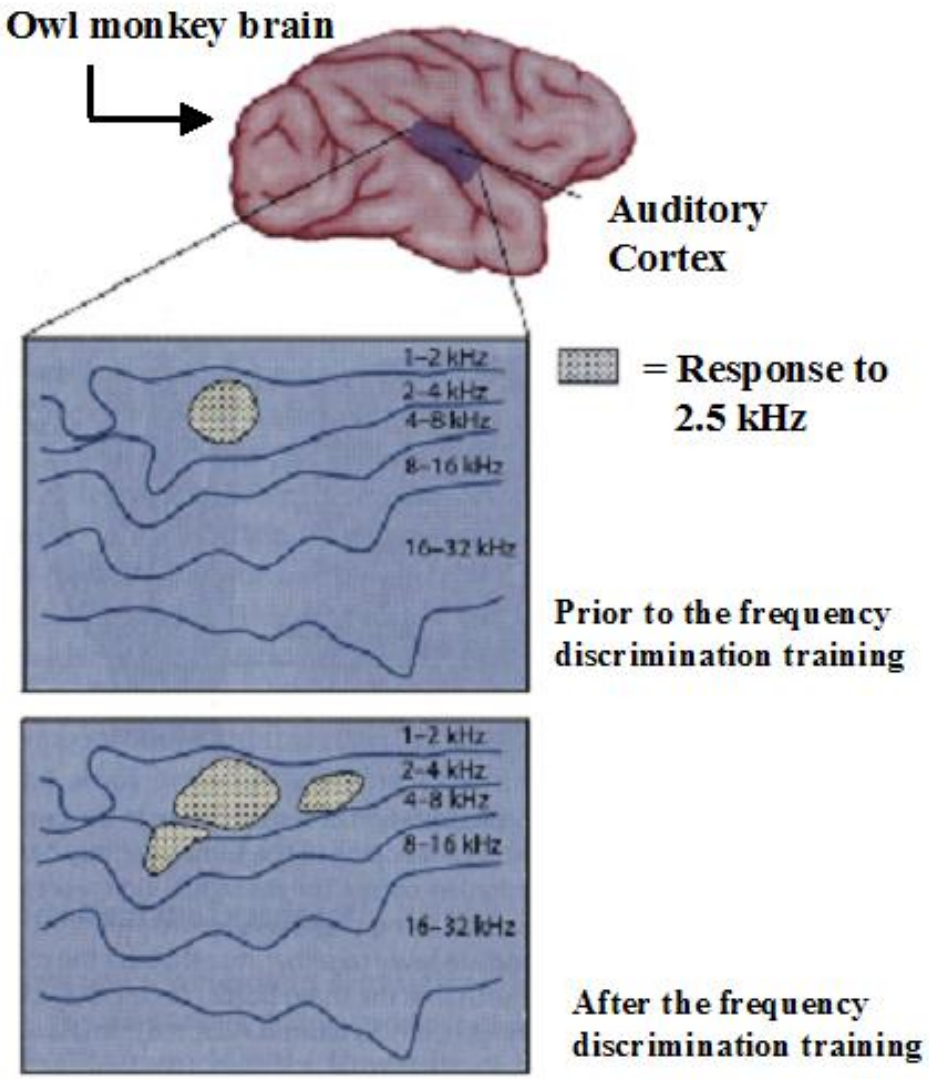
   → decrease of the synaptic efficacy (reduction in sensitivity), it is referred to as **long-term depression** (LTD) of synapses

The theory is often summarized as "*cells that fire together, wire together*" and "*cells that fire apart, wire apart*"

Developmental plasticity

- In the fetus (starting at around 23 weeks), spontaneous firing of the developing neuron can be observed.
- These early connections are weak and unspecific and during a critical/sensitive period these neurons and its synapses can change to achieve strengthened and refined synaptic connections.
- Damaged neuronal connections can often become functionally recovered during this time but not after.
- Large alterations in these neurons and its synapses can occur until synaptic circuitry is further defined.

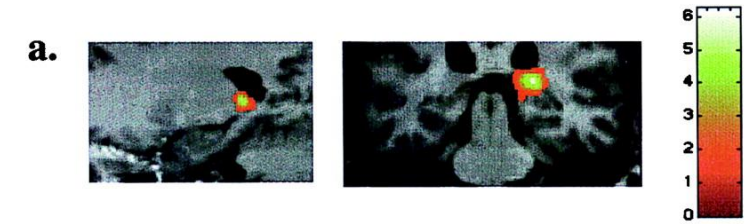
Experience-dependent plasticity

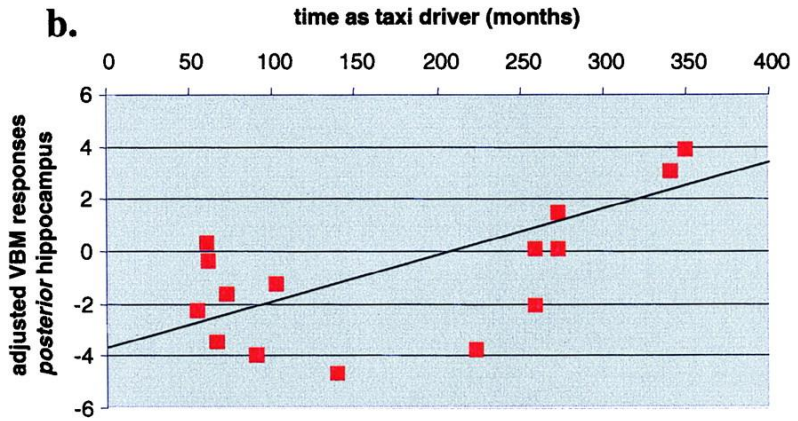


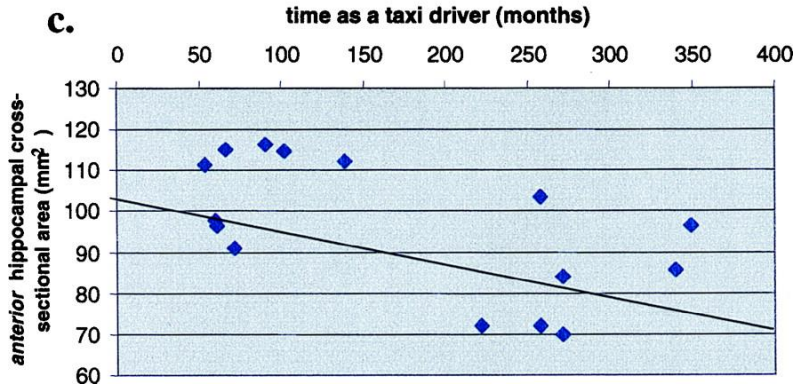
Increase in the cortical area of representation of a restricted frequency range in primary **auditory** cortex of adult owl monkeys that is correlated with the animal's performance at a frequency **discrimination** task

Recanzone et al., 1993)

Plasticity in taxi drivers

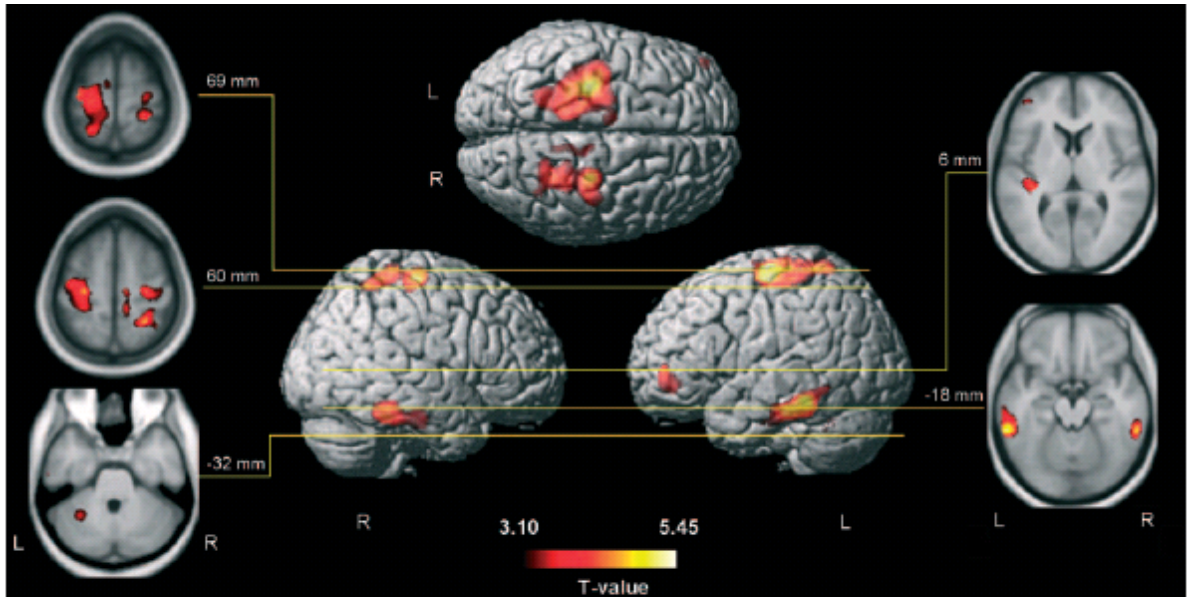






Maguire et al., (2000)

Anatomical differences between musicians and non-musicians



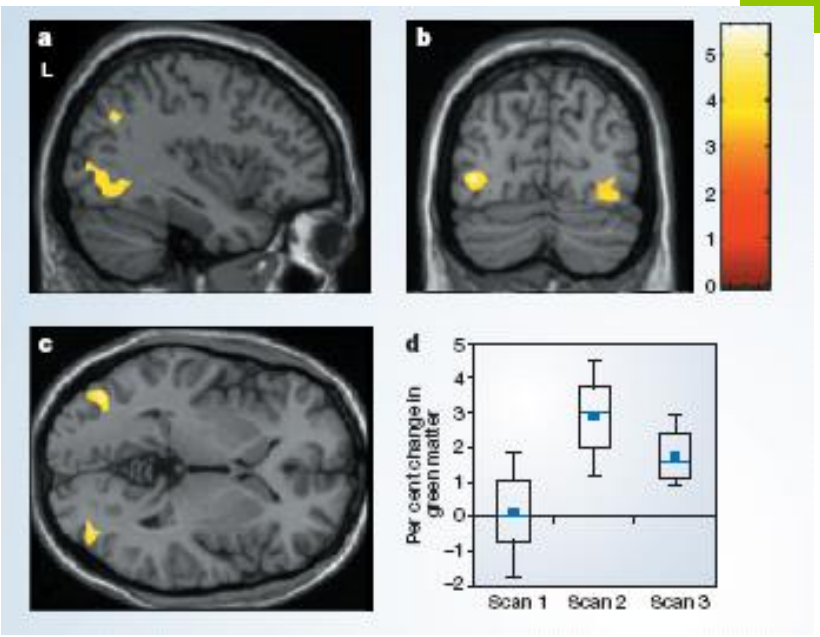
Brain regions with gray matter differences between professional musicians, amateur musicians and nonmusicians.

Gaser, Schlaug; 2003. The Journal of Neuroscience

Morphological changes induced by a short intervention

3 months training in juggling

Draganski et al., 2004. Nature.



Increased density of the grey matter in the jugglers compared to the non-juggler controls.

Zatorre et al., 2012
Nature Neuroscience Review

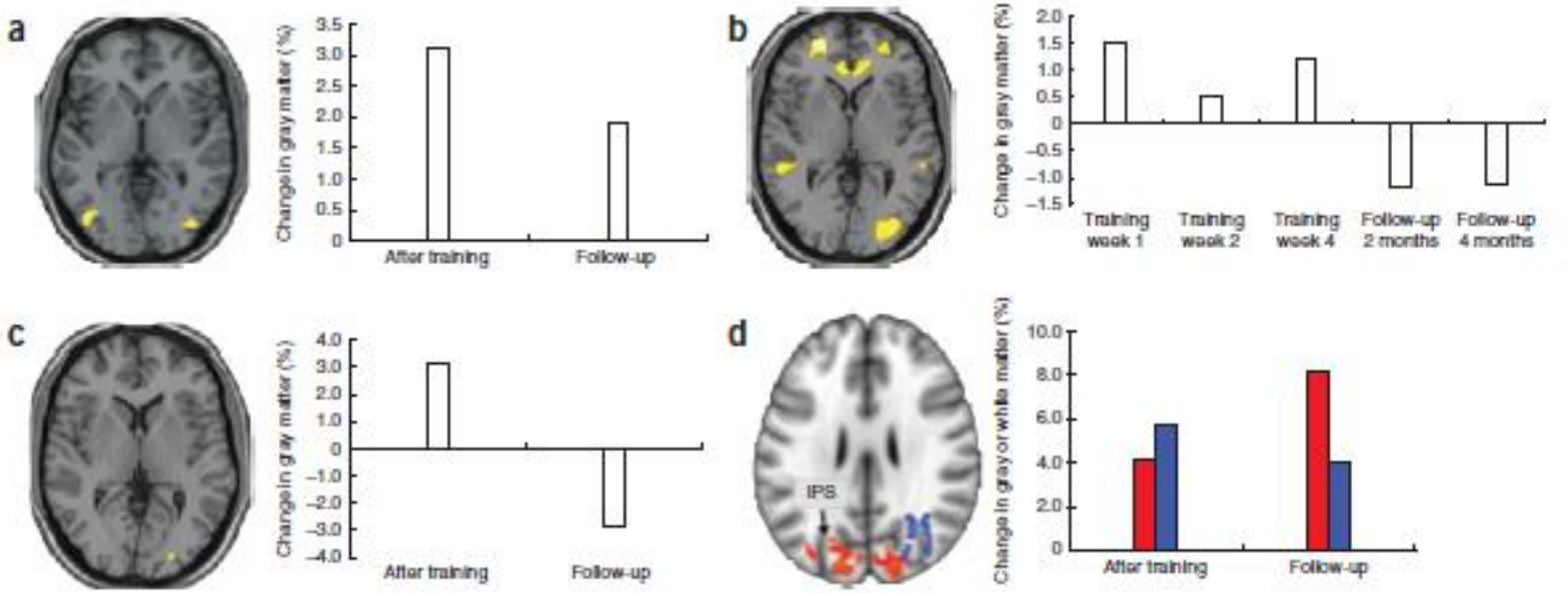
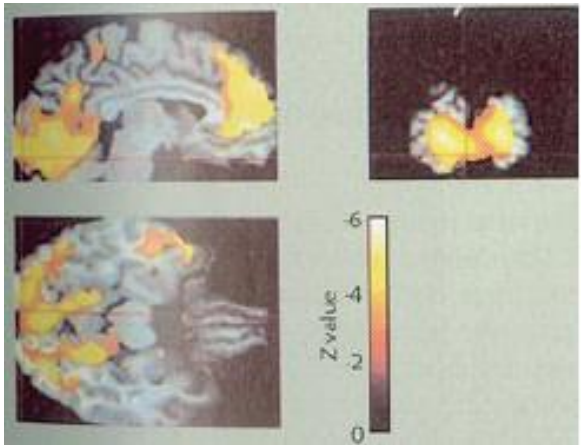


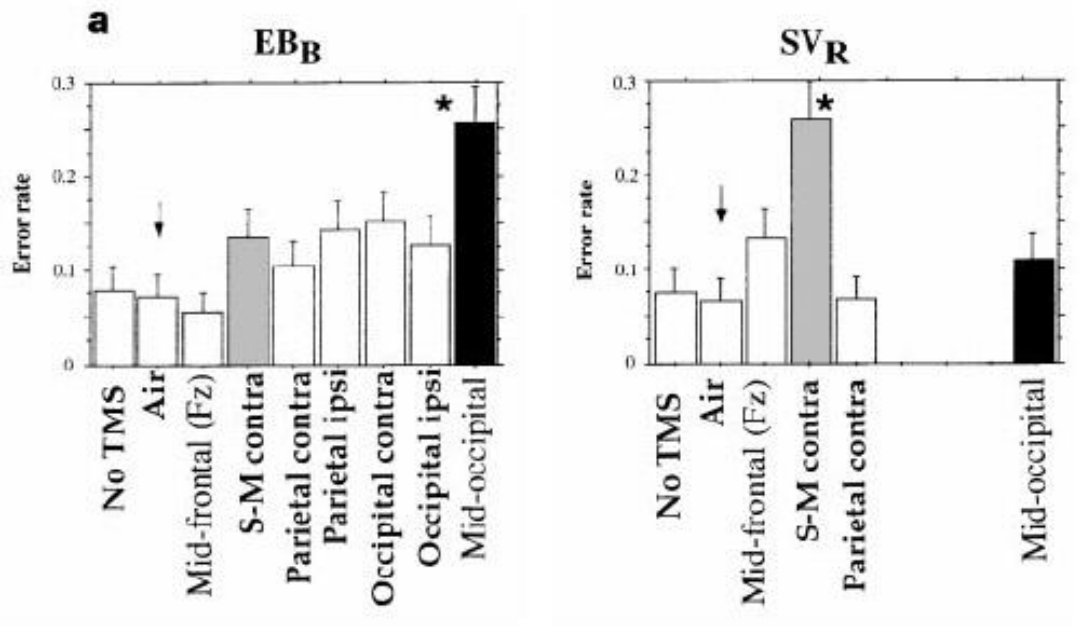
Figure 2 Longitudinal studies of structural changes in gray and white matter with learning. Several studies have used learning of juggling to test for brain structural plasticity in healthy adults. Figures adapted from the cited publications with permission. (**a**) Training for 3 months results in increases in gray matter density bilaterally in the visual motion area, V5 (ref. 7). (**b**) Serial scans throughout the training period show that such effects are apparent as early as 1 week after training begins[8]. (**c**) Given the same amount of training, older people learn less well on average than younger people, but those who are able to learn to juggle over the training period show similar brain structural changes[9,10]. (**d**) Not only gray matter (red clusters and bars), but also white matter (blue clusters and bars), shows training-related changes. Both gray matter density and white matter fractional anisotropy increase ~5% over a 6-week training period[9].

Cortical reorganization in blind people (injury/insult-dependent plasticity)



Activation of the 'visual cortex' in people who were born blind while they are reading Braille.

Sadato et al.; 2006



Error rates for stimulation (TMS) of different positions in early blind subjects and healthy controls. In blind subjects, stimulation of the mid/occipital position induced more errors in reading Braille than stimulation of any other position, whereas in sighted volunteers stimulation of the contralateral primary sensorimotor region induced more errors than stimulation of any other position.

Cohen et al.; 1997. Nature.

Candidate cellular mechanisms

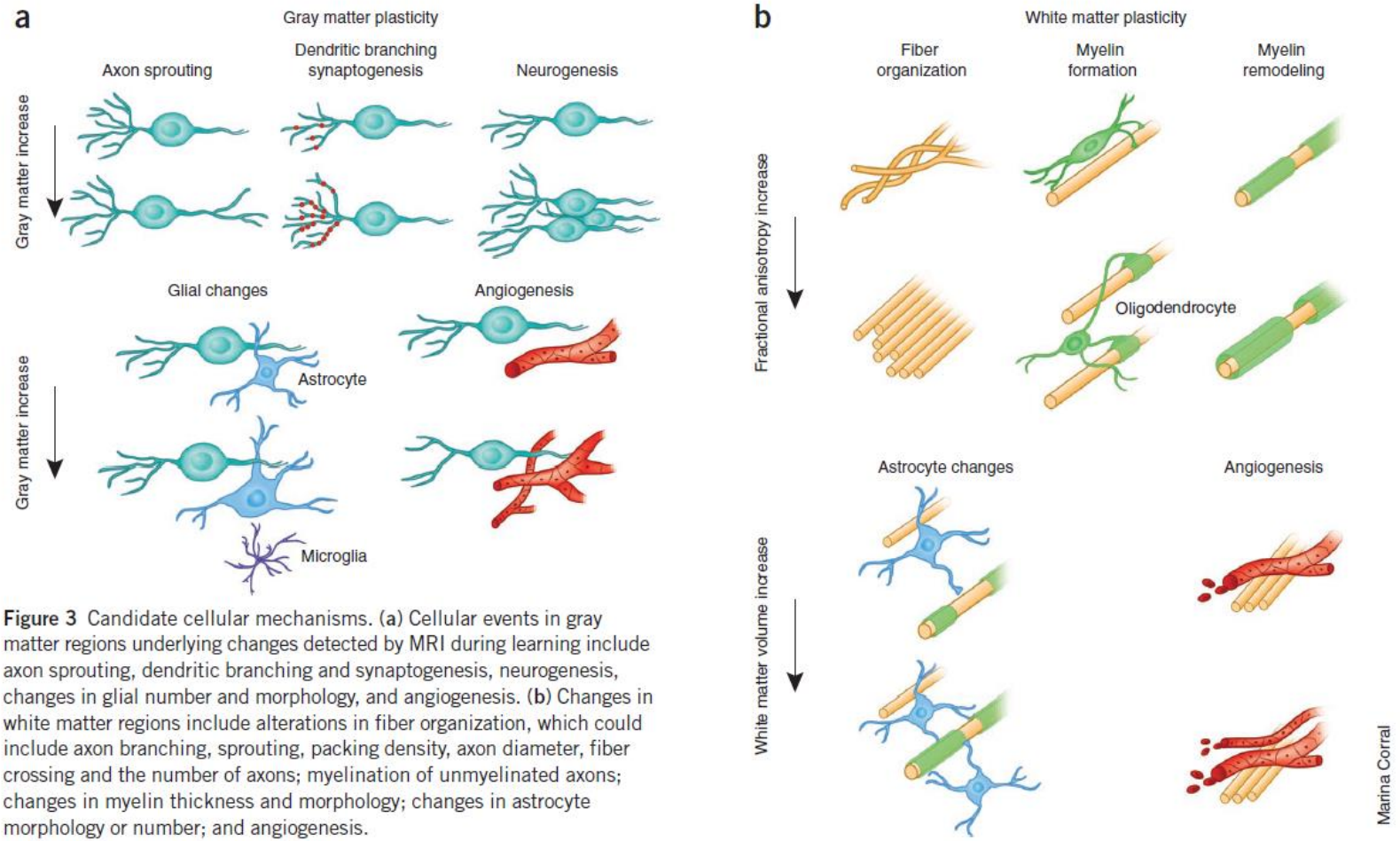


Figure 3 Candidate cellular mechanisms. (**a**) Cellular events in gray matter regions underlying changes detected by MRI during learning include axon sprouting, dendritic branching and synaptogenesis, neurogenesis, changes in glial number and morphology, and angiogenesis. (**b**) Changes in white matter regions include alterations in fiber organization, which could include axon branching, sprouting, packing density, axon diameter, fiber crossing and the number of axons; myelination of unmyelinated axons; changes in myelin thickness and morphology; changes in astrocyte morphology or number; and angiogenesis.

Zatorre et al., 2012)

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- Educating Educators: the role of basic and applied science

Brain Training

- Want to raise intelligence levels, think faster, boost your memory, and stretch your attention?
- Various brain training tools were developed to enhance many cognitive skills.
  - Lumosity: www.lumosity.com
  - Cogmed: www.cogmed.com
  - MindSparke: www.mindsparke.com
  - Tools of the mind: www.toolsofthemind.org
  - Elevate: www.elevateapp.com
  - brainHQ: www.brainhq.com
  - Fit brains: www.fitbrains.com
  - Brain Metrix: www.brainmetrix.com

Brain Training

Book: Moonwalking with Einstein by Joshua Foer
Boosting your memory capacity through training

http://www.gatesnotes.com/Books/Moonwalking-with-Einstein

Moonwalking with Einstein: The Art and Science of Remembering Everything
$11.55 prime | FREE One-Day
Delivered tomorrow for FREE with qualifying orders over $35. Details | In Stock. Ships from and sold by Amazon.com. Gift-wrap available.

Fantastic
By Alexis Ramirez on October 22, 2017
Format: Kindle Edition | Verified Purchase
Great insight to what it takes to improve one's memory, overall fantastic, I kept a couple of tricks for myself

Comment | Was this review helpful to you? Yes No Report abuse

I liked the book since it was quite a fun read ...
By Bogdan Tanase on October 9, 2017
Format: Kindle Edition | Verified Purchase
I liked the book since it was quite a fun read about the adventures of the author during his memory contest training. And some of the characters in the book were pretty entertaining.

However, it would have been nice to have some practical part about the actual memory training techniques.

Comment | Was this review helpful to you? Yes No Report abuse

Lots to think about
By nancy de Wied on January 4, 2012
Format: Hardcover | Verified Purchase
Not sure that I'd really want to go through all the practice and skills it takes to be a memory champion but this is an informative and entertaining read. I did try a few of the concepts including the memory palace ---It works! I liked the author's balance of different techniques of study intermingled with why we forget certain information. I am not reading this in one big gulp and I encourage people to read it by chapter and try a few of the techniques to experience a smidgen of what the man went through during his year of study. I work in elementary education and encounter many students with memory issues, perhaps some of these ideas would come in handy for kids studying mulitplication facts-----it also makes one question how immediate access to data in our technological world affects our motivation and ability to retain information and is it a positive way to evolve or not. Whatever your opinion is, it might be worth your time to read Foer's book.

Comment | Was this review helpful to you? Yes No Report abuse

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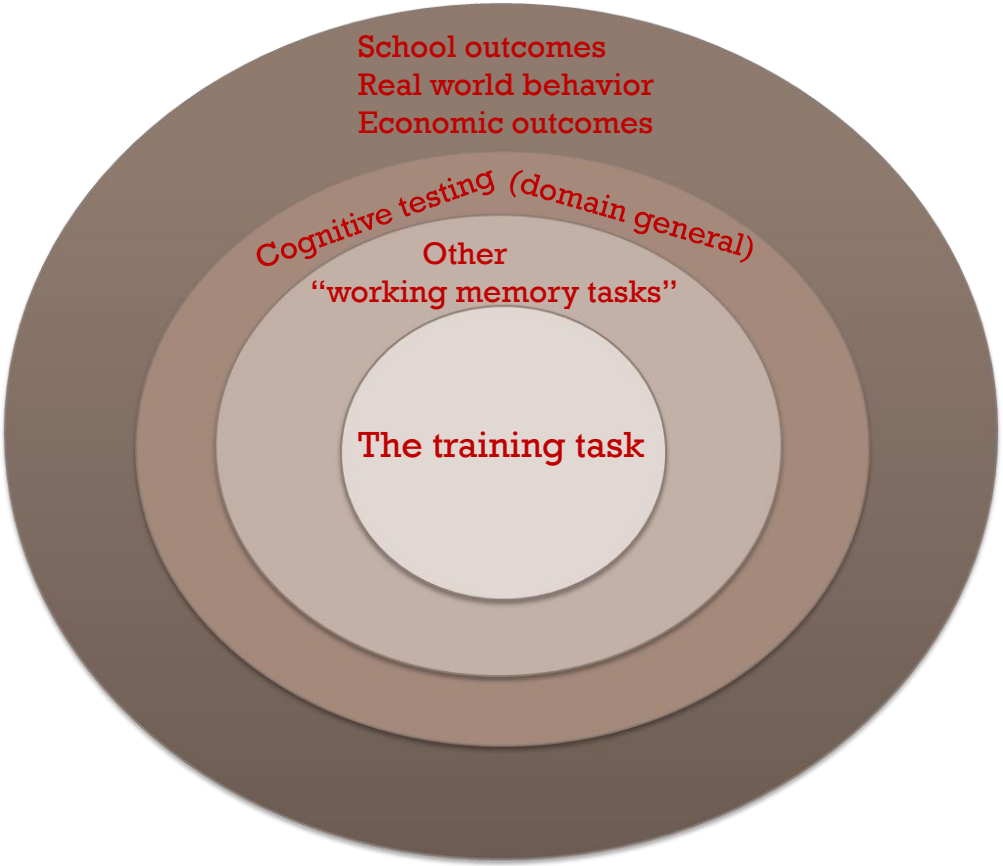
Brain Training

What is Training Transfer ?



Brain Training
- Problems with measuring transfer

Is Working Memory Training Effective?

Zach Shipstead, Thomas S. Redick, and Randall W. Engle
Georgia Institute of Technology

- Shipstead, et al (2012).: "We can't just use one task to measure transfer to a specific ability"

→ Why not?

- Multiple abilities contribute to task performance on any task
- Improvement in one aspect may increase scores, but doesn't mean the underlying ability has improved (task-specific effects).

Several concerns when evaluating a training….

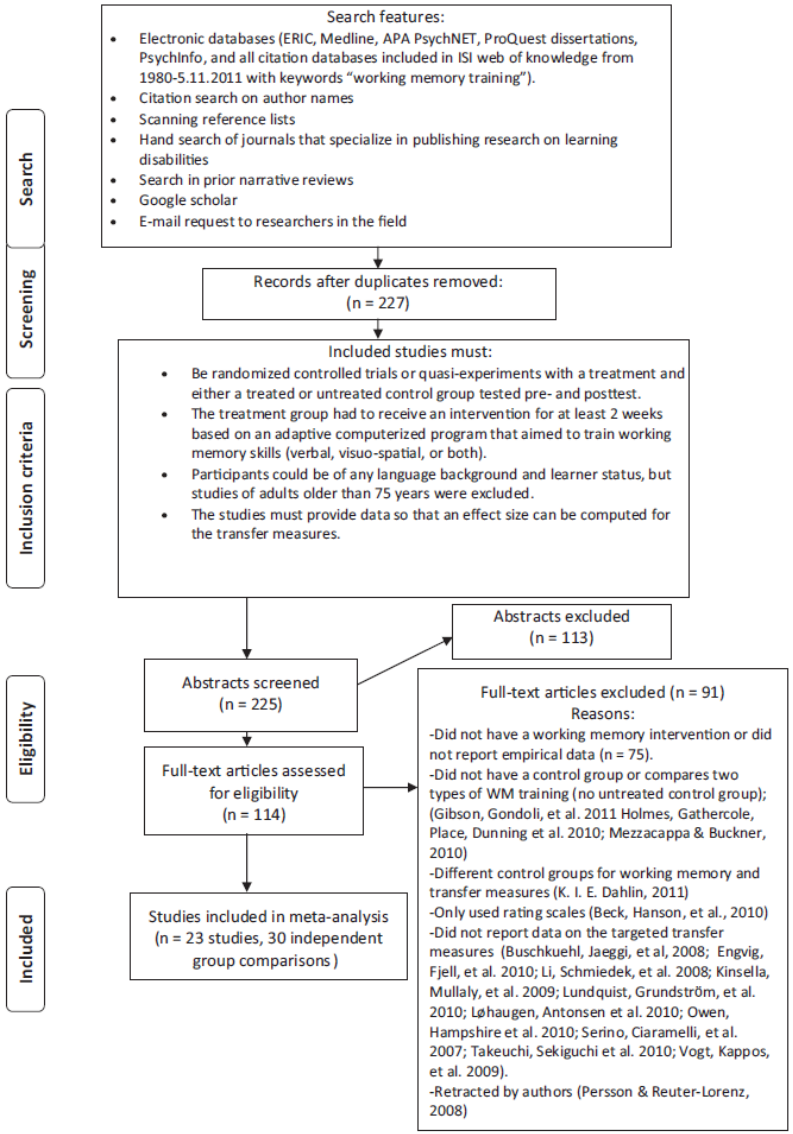
- The tendency for researchers to define change to abilities using single tasks
- Inconsistent use of valid tasks
- Questionable control groups
- Subjective measurement of change
- Placebo effects

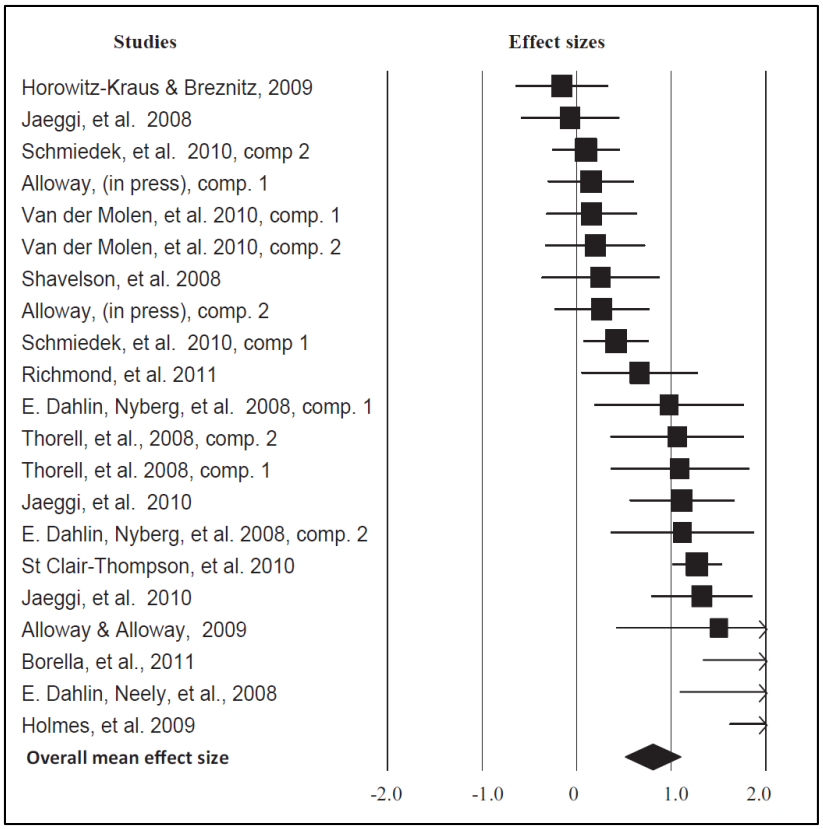
(Shipstead et al., 2012)

Is Working Memory Training Effective? A Meta-Analytic Review

Monica Melby-Lervåg
University of Oslo

Charles Hulme
University College London and University of Oslo





- Some programs produced reliable gains in working memory skills
- Near-transfer effects were not maintained
- No evidence of the generalization of working memory to other skills

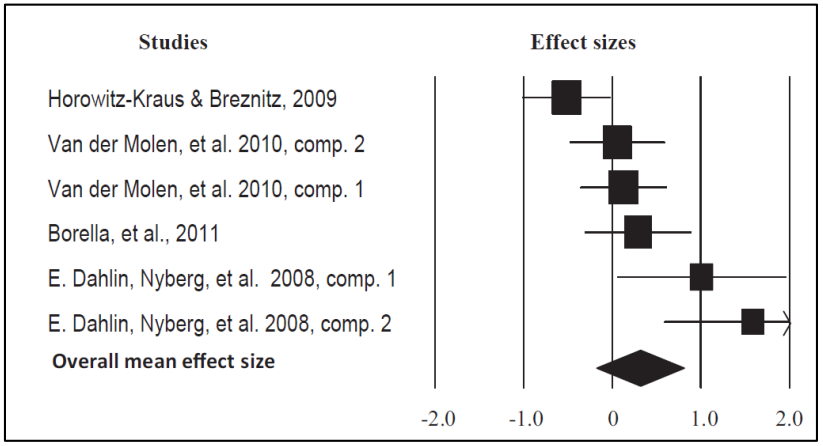


Table 4

Total Number of Participants, Number of Effect Sizes, Time Between Posttest and Follow-Up, and Effect Size With 95% CI Between Pretest and Follow-Up

	Pretest–follow-up group difference				
Variable	Total *N* E (C)	Number of effect sizes (*k*)	Time between posttest and follow-up (months)	Effect size (*d*)	95% CI
Nonverbal ability	138 (120)	6	7.8	−0.06	−0.31, 0.17
Attention	102 (94)	4	5.0	0.09	−0.19, 0.37
Decoding	91 (84)	3	3.7	0.13	−0.17, 0.42
Arithmetic	108 (76)	3	3.33	0.18	−0.11, 0.47

Note. *N* = number of participants; E = experimental training group; C = control group; CI = confidence interval.

Putting brain training to the test

Adrian M. Owen[1], Adam Hampshire[1], Jessica A. Grahn[1], Robert Stenton[2], Said Dajani[2], Alistair S. Burns[3], Robert J. Howard[2] & Clive G. Ballard[2]

A large scale (11,430 participants) test of a six-week online training

Baseline

Measurement on

- reasoning
- verbal short-term memory (VSTM)
- spatial working memory (SWM)
- paired-associates learning (PAL)

Training

Three groups trained on

1. Tasks emphasized reasoning, planning and problem-solving abilities
2. Task of VSTM, attention, visuospatial processing and mathematics
3. obscure questions from six different categories (control)

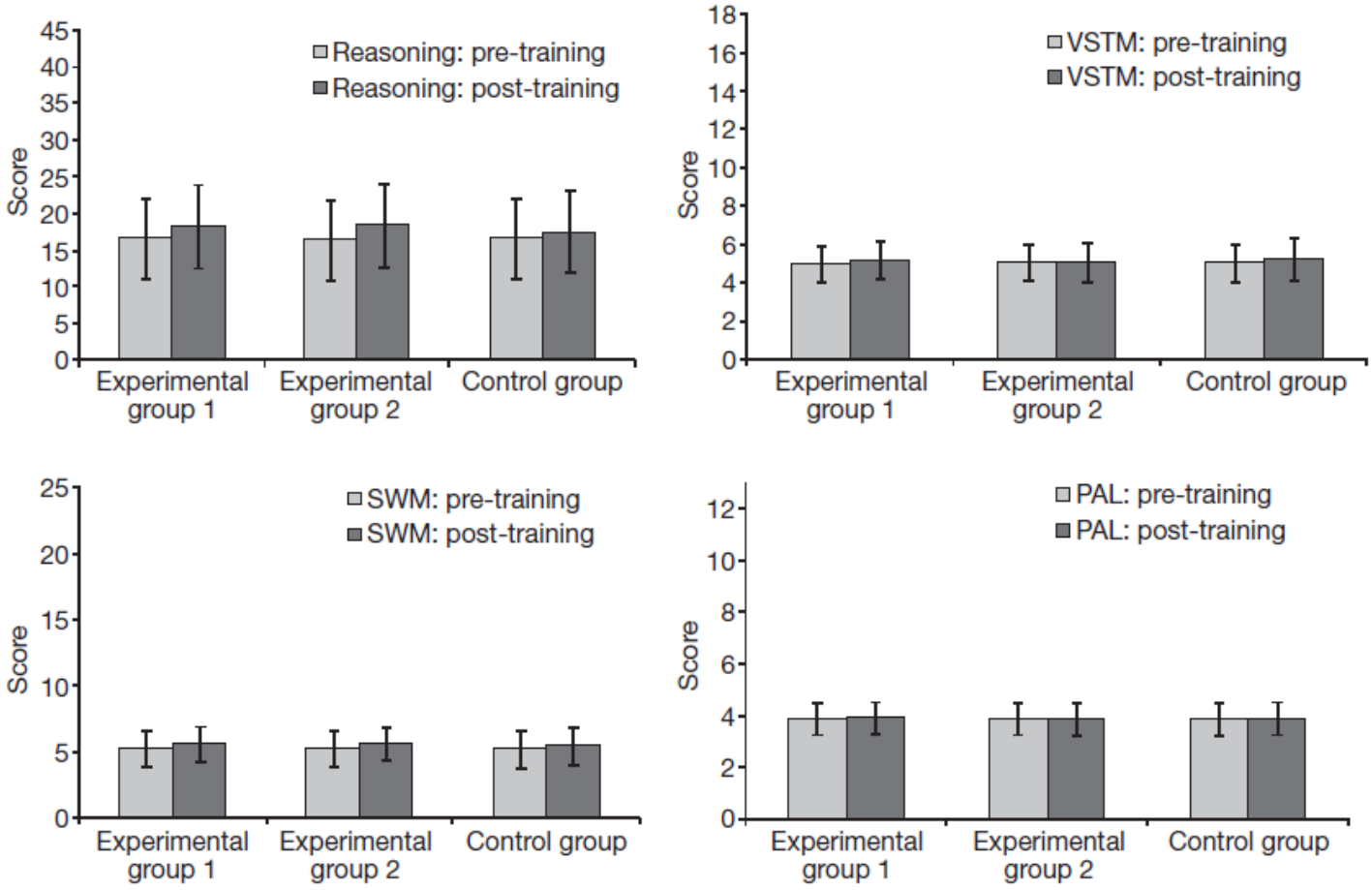
Retest using the same tests

Owen et al., 2010

Putting brain training to the test

nature

Results: little transfer effects to untrained tasks, even when those tasks were cognitively closely related (group2)



Brain Training

Transfer Effects????

Journal of Experimental Psychology: General
2013, Vol. 142, No. 2, 359–379

0096-3445/13/$12.00 DOI: 10.1037/a0029082

No Evidence of Intelligence Improvement After Working Memory Training: A Randomized, Placebo-Controlled Study

Thomas S. Redick, Zach Shipstead, Tyler L. Harrison, and Kenny L. Hicks
Georgia Institute of Technology

David E. Fried and David Z. Hambrick
Michigan State University

Michael J. Kane
University of North Carolina Greensboro

Randall W. Engle
Georgia Institute of Technology

Numerous recent studies seem to provide evidence for the general intellectual benefits of working memory training. In reviews of the training literature, Shipstead, Redick, and Engle (2010, 2012) argued that the field should treat recent results with a critical eye. Many published working memory training studies suffer from design limitations (no-contact control groups, single measures of cognitive constructs), mixed results (transfer of training gains to some tasks but not others, inconsistent transfer to the same tasks across studies), and lack of theoretical grounding (identifying the mechanisms responsible for observed transfer). The current study compared young adults who received 20 sessions of practice on an adaptive dual *n*-back program (working memory training group) or an adaptive visual search program (active placebo-control group) with a no-contact control group that received no practice. In addition, all subjects completed pretest, midtest, and posttest sessions comprising multiple measures of fluid intelligence, multitasking, working memory capacity, crystallized intelligence, and perceptual speed. Despite improvements on both the dual *n*-back and visual search tasks with practice, and despite a high level of statistical power, there was no positive transfer to any of the cognitive ability tests. We discuss these results in the context of previous working memory training research and address issues for future working memory training studies.

Keywords: training, working memory, attention, intelligence, multitasking

Supplemental materials: http://dx.doi.org/10.1037/a0029082.supp

REVIEW

Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old

Adele Diamond[1]* and Kathleen Lee[1]

www.sciencemag.org SCIENCE VOL 333 19 AUGUST 2011

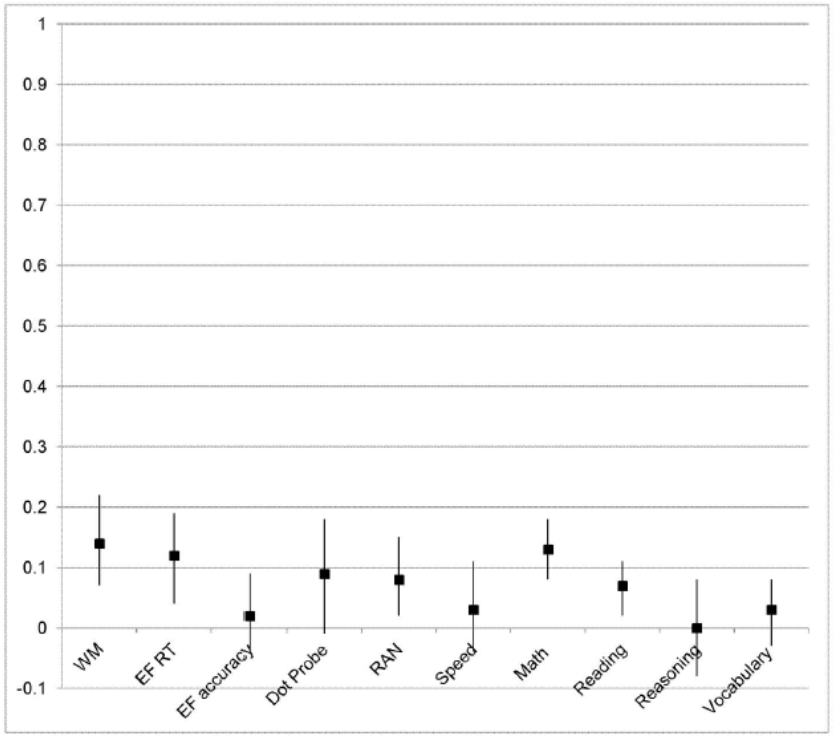
- There are suggestions that computer training and martial arts may benefit children of 8 to 12 more than children of 4 to 5.
- Studies of curricula and curricula add-ons demonstrate that EFs can be improved, even at 4 to 5 years of age, by regular teachers (given training and support) in regular classrooms without expensive equipment.
- Computer training has been shown to improve working memory and reasoning, but it is unclear whether such training can improve inhibitory control
- The largest differences between those programs that improve EFs and control participants are consistently found on the most demanding EF measures.
- Those with the initially poorest EFs gain the most
- EFs must be continually challenged to see improvements.
- EF training appears to transfer, but the transfer is very narrow. EF gains from martial arts or school curriculum may be wider because the programs themselves address EFs more globally; the transfer may not be wider, but rather the programs address more EF components
- Public school curricula hold the greatest promise for accessibility to all and intervening early

Program	Tools of the Mind	Montessori	PATHS	CSRP
Developed by	Bodrova and Leong (*33*)	Montessori (*37*)	Kusché and Greenberg (*43*)	Raver (*47*)
Based on	Vygotsky (*34*)	Montessori (*37*)	Affective-Behavioral-Cognitive-Dynamic (ABCD) model (*7*)	Incredible Years (*46*)
For age (years) and grades	(3–6) Preschool and K	(0–18) Infancy to grade 12	(3–12) Preschool to grade 6	3–5 (Preschool)
Academic content	Yes; a complete curriculum	Yes; a complete curriculum	None	None
Socioemotional content	Yes	Yes	Yes	Yes
EFs challenged all day	Yes	Yes	Yes	No
Connects cognitive, social, and emotional development	Yes	Yes	Yes	Yes
Particular focus on oral language development	Yes	Yes	Yes	No
Self-talk (private speech) encouraged in children	Yes	Yes	Yes	No
Scaffolds (supports) so children succeed	Yes	Yes	Yes	Yes
Reprimand frequency	Rare	Virtually never	Rare	Rare
Extrinsic rewards used	No	No	No	Yes
Planning by child is emphasized	Yes	Yes	Yes (but not in preschool)	No
Individualized pacing and instruction	Yes	Yes, pronouncedly so	No	No
Child-to-child tutoring	Take turns as doer and checker	Cross-age tutoring	No	No
Teacher as scientist and observer (dynamic assessment)	Yes	Yes	No	No
Teacher training	12 days of workshops over 2 years; 12 days of in-classroom follow up	1 to 2 years full-time plus in-service refreshers	2 days of workshops; classroom observations for 30 min/week for 30 weeks	12 days over 20 weeks; 30 hours of workshops; 4 hours/week for 20 weeks of mentoring
Play is given a prominent role	Yes; especially social dramatic play	Playfulness, creativity encouraged; but rather than play at activities like cooking, children cook; no social dramatic play	Play in preschool and K only	No
Active, hands-on learning even preschoolers work in groups of 2 or 3, or alone*	Yes	Yes	Somewhat in preschool and K, but not later	No
Character development (kindness, helpfulness, empathy) emphasized	Yes	Yes	Yes	Yes
Labeling and identifying feelings emphasized	Somewhat	No	Yes, high priority	Yes
Awards and honors received	An Exemplary Innovation, International Bureau of Education of UNESCO	The widest geographical spread of any education program. Currently in 117 countries across six continents	Seven awards and honors†	

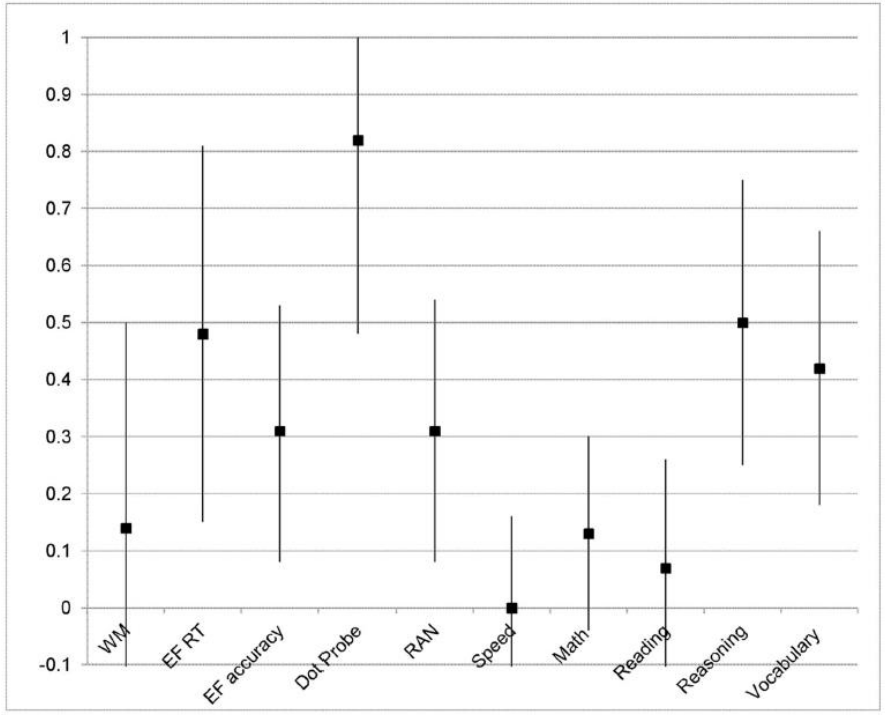
Closing the Achievement Gap through Modification of Neurocognitive and Neuroendocrine Function: Results from a Cluster Randomized Controlled Trial of an Innovative Approach to the Education of Children in Kindergarten

Clancy Blair*, C. Cybele Raver

- A large RCT of Tools of the Mind in Boston



Effect size: all schools



WM = working memory; EF = executive functions, RT = reaction time; RAN = rapid automatic naming

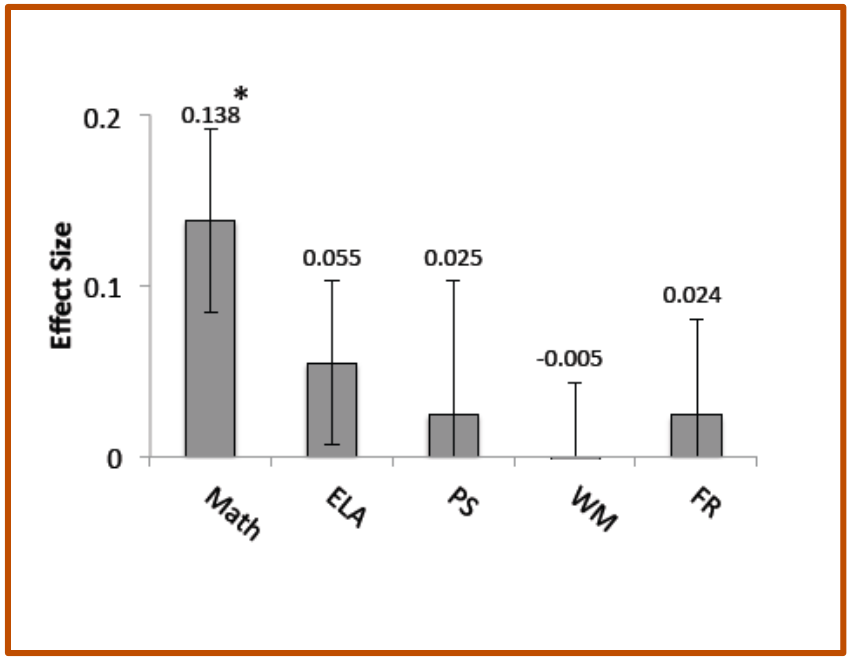
Effect size: high poverty schools

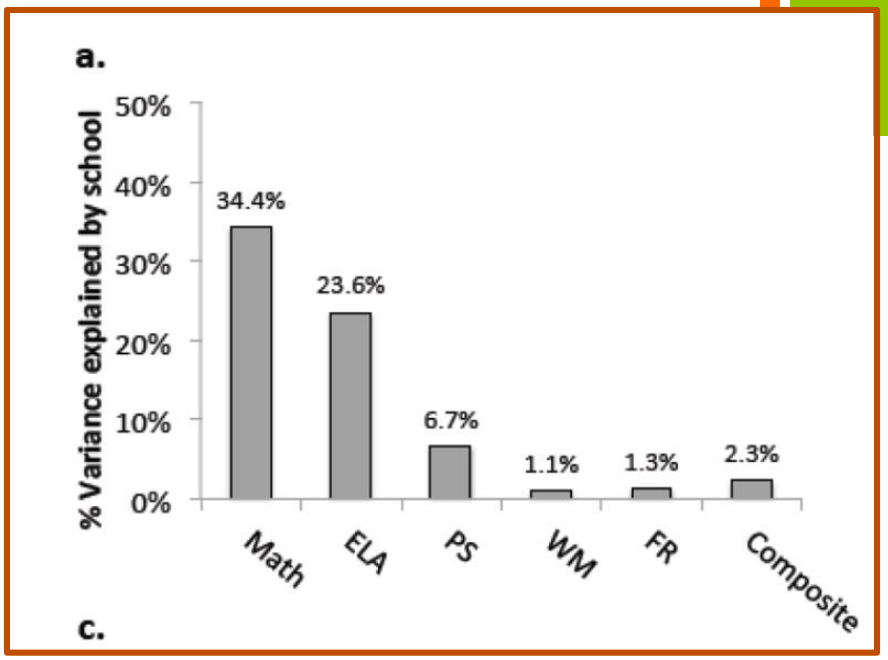
Cognitive Skills, Student Achievement Tests, and Schools

Amy S. Finn[1,2,3], Matthew A. Kraft[4], Martin R. West[5], Julia A. Leonard[1,2], Crystal E. Bish[6], Rebecca E. Martin[1,2,7], Margaret A. Sheridan[3], Christopher F. O. Gabrieli[5,6], and John D. E. Gabrieli[1,2,5]

- Charter Schools
  - Random assignment by 'lottery'
  - N =1,367
  - Often in high poverty neighborhoods most families enroll in these lotteries
  - Many charter schools are very focused on constructing rule-oriented structured environments
  - Does this shape EF in adolescence?

- Change in EF?





- Despite wide variation in test scores across schools, differences in cognitive skills across schools were negligible after controlling for 4th-grade test scores.
- Random offers of enrollment to over-subscribed charter schools resulted in positive impacts of such school attendance on math achievement, but had no impact on cognitive skills.
- These findings suggest that schools that improve standardized achievement tests do primarily through channels other than cognitive skills.

Brain Training

On-going debates on the effect of these brain training tools

- Lumosity claims:
  - Fixes (almost) everything
  - Reduces aging effects
- CogMed claims:
  - Improves ADHD symptoms
  - Improves 'attention' and 'focus'
- MindSparke claims:
  - Makes you smarter
- etc……

Brain Training - Lumosity

- Facts about Lumosity: www.lumosity.com (Lumos Labs)
- Lumosity co-founder Michael Scanlon started up the company in 2005 with Kunal Sarkar and David Drescher, after dropping out of his neuroscience Ph.D. at Stanford. Since then the company has reached more than 35m people and this time last year the company's mobile app was being downloaded nearly 50,000 times a day.
- "Lumosity is based on the science of neuroplasticity," the commercials say, and Lumosity's website advertises its ability to "train memory and attention" through a "personalized training program." This plan includes more than 40 games designed to boost memory, flexibility, attention, processing speed, and general problem-solving ability.
- Lumosity provides documents describing the science behind their games and changes in individuals' BPT (brain performance test) scores before and after training.

Brain Training - Lumosity

Improvement of Visual Attention and Working Memory through a Web-based Cognitive Training Program

Michael Scanlon
Lumos Labs, Inc.

David Drescher
Lumos Labs, Inc.

Kunal Sarkar
Lumos Labs, Inc.

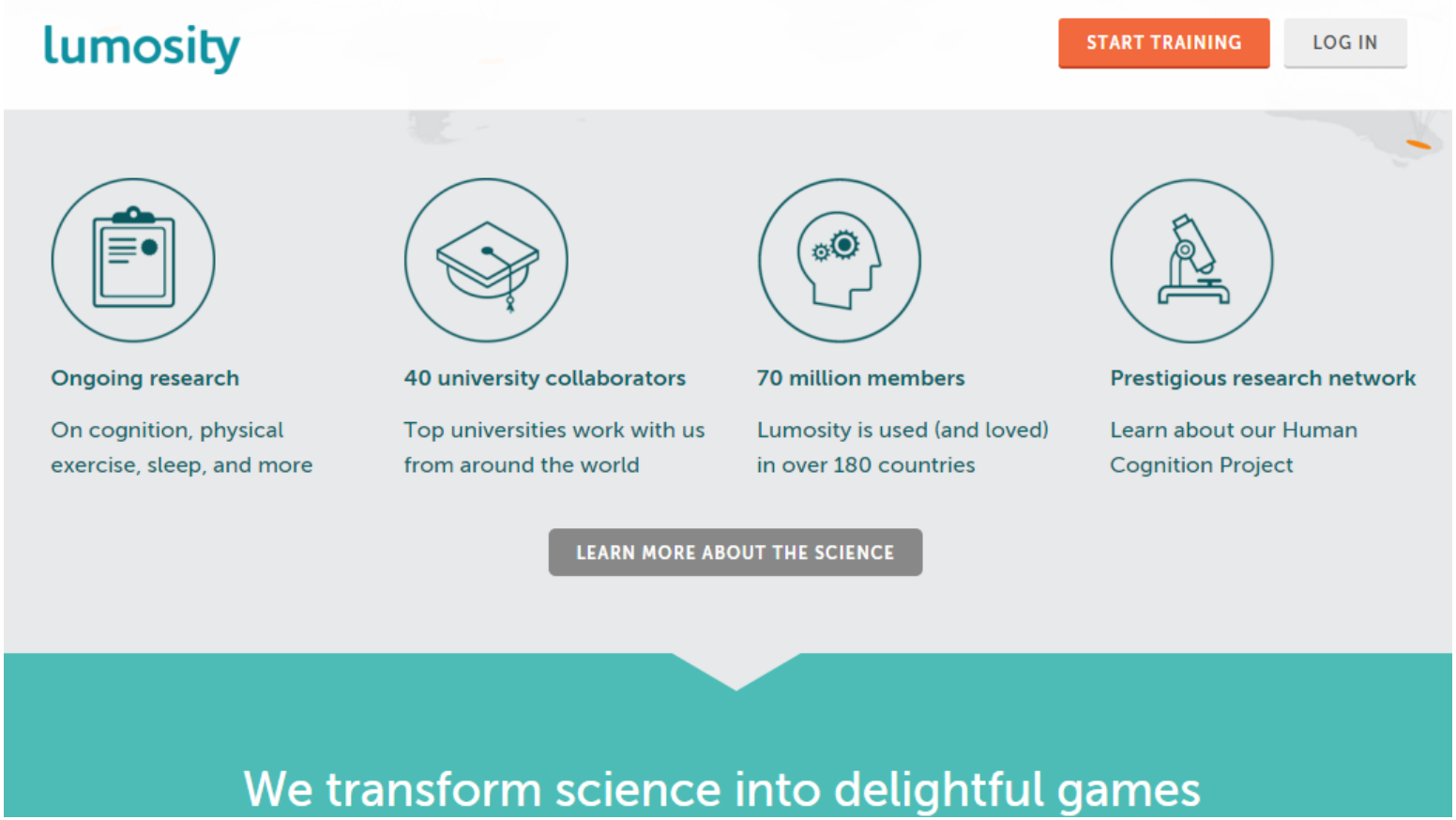
Context: Prior work has revealed that cognitive ability is adaptive and can be improved with cognitive behavioral training methods; however, use of these methods is limited outside of the lab.

Objective: To investigate the efficacy of *Lumosity*, a web-based cognitive training program developed by Lumos Labs to improve attention and memory in healthy adults.

Design, Settings, and Participants: Randomized, controlled experiment consisted of assessment, training intervention, and post-training assessment. Volunteer participants (n=23, mean age=54) were recruited from various locations across the US. Training and testing were conducted on each participant's personal computer to simulate conditions of actual use. Both groups used computers on a regular basis. Results and compliance data were captured automatically via the online program.

Intervention: Online cognitive training for twenty minutes once daily for five weeks. Trained participants completed an average of 29.2 sessions, and control participants received no training. Training sessions consisted of five distinct exercises.

Brain Training - Lumosity



lumosity

GET STARTED NOW LOG IN

Our scientists research the efficacy of Lumosity

We conducted a randomized study on Lumosity, using crossword puzzles as an active control.

What we did

Our scientists had 4,715 participants complete the study. Half trained with Lumosity, while the rest did online crossword puzzles to control for placebo effects.

What we found

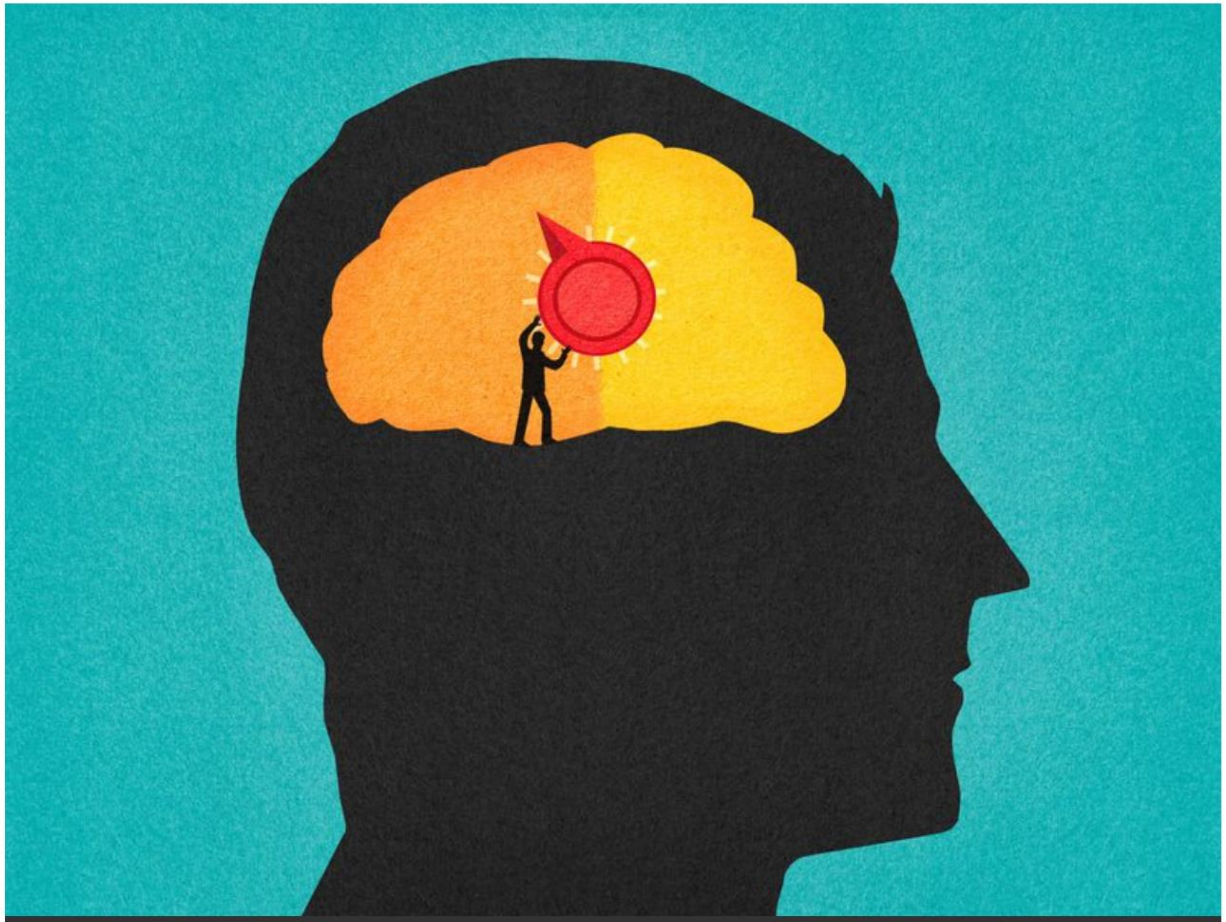
After 10 weeks, the Lumosity group improved more than the crosswords group on an aggregate assessment of cognition.

Next questions

These results are promising, but we need to do more research to determine the connection between improved assessment scores and everyday tasks in participants' lives. That's our next focus.

Popular Brain Game Maker Luminosity Faces a Fine for False Advertising

The science doesn't back up the claims that playing memory and attention games can prevent mental decline



(Marcus Butt/Ikon Images/Corbis)

A Consensus on the Brain Training Industry from the Scientific Community

STANFORD CENTER ON LONGEVITY | Max-Planck-Institut für Bildungsforschung Max Planck Institute for Human Development

October 20, 2014

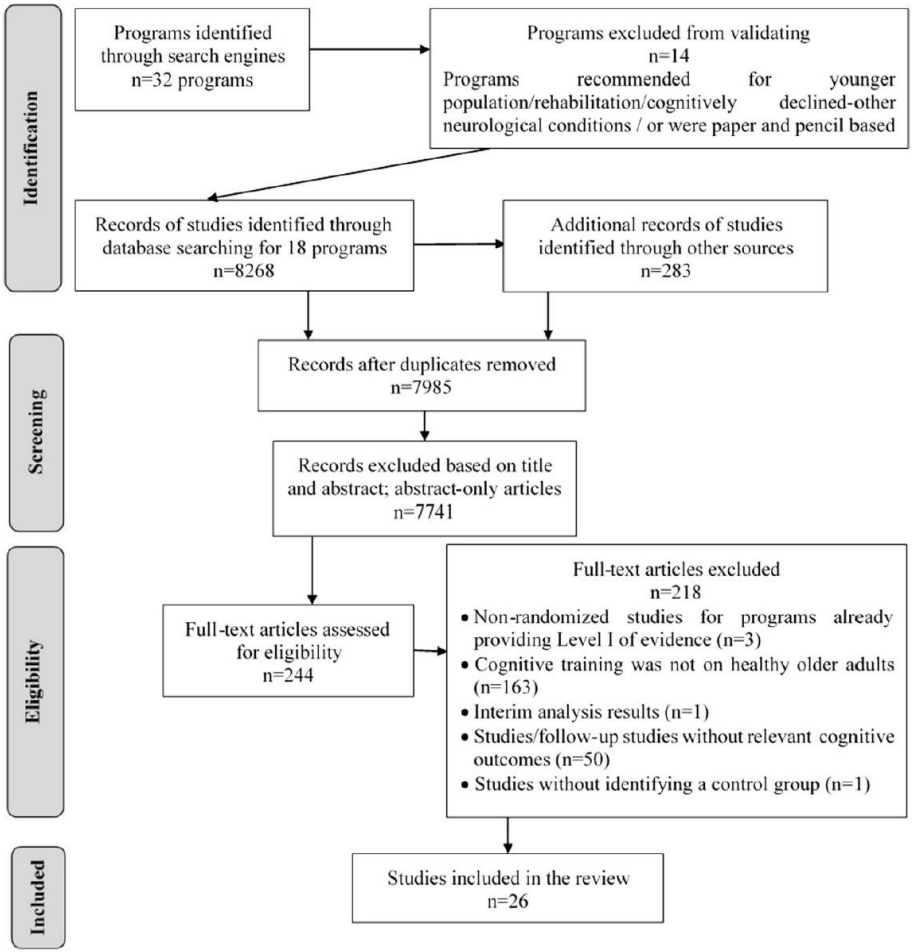
As the baby boomers enter their golden years with mounting concerns about the potential loss of cognitive abilities, markets are responding with products promising to allay anxieties about potential decline. Computer-based cognitive-training software –popularly known as brain games– claim a growing share of the marketplace. The promotion of these products reassures and entices a worried public.

Consumers are told that playing brain games will make them smarter, more alert, and able to learn faster and better. In other words, the promise is that if you adhere to a prescribed regimen of cognitive exercise, you will reduce cognitive slowing and forgetfulness, and will fundamentally improve your mind and brain.

It is customary for advertising to highlight the benefits and overstate potential advantages of their products. In the brain-game market, advertisements also reassure consumers that claims and promises are based on solid scientific evidence, as the games are “designed by neuroscientists” at top universities and research centers. Some companies present lists of credentialed scientific consultants and keep registries of scientific studies pertinent to cognitive training. Often, however, the cited research is only tangentially related to the scientific claims of the company, and to the games they sell. In addition, even published peer-reviewed studies merit critical evaluation. A

Enhancing Cognitive Functioning in Healthly Older Adults: a Systematic Review of the Clinical Significance of Commercially Available Computerized Cognitive Training in Preventing Cognitive Decline

Tejal M. Shah[1,2,3] · Michael Weinborn[1,2,4] · Giuseppe Verdile[1,2,3,5] · Hamid R. Sohrabi[1,2,3] · Ralph N. Martins[1,2,3]



Brain fitness programs

Neuropsychol Rev

Table 3 List of computerized brain fitness programs and their features (in alphabetical order)

Program	Website	Specifications	Training exposure	Web references
BFP/Insight	www.positscience.com www.brainhq.com	NP, BFP - SAAGE™ design protocol, Insight - UFOV technology/web based	BFP - 60 min for 5 days/week for 8–10 weeks, total 40 sessions; Insight - 60–90 min of 10 sessions for 2–3 times/week	(Brainhq.com)
Brain Age 2	www.brainage.com www.brainage2.com	Increases blood flow to the prefrontal cortex/played on a palm device	Few minutes per day	(Brainage.com; Brainage2.com)
Cogmed	www.cogmed.com	NP/CD-ROM/web based	30-45 min, 1 session for 5 days/week for 5 weeks	(Cogmed.com)
Cognifit	www.Cognifit.com,	NP/web based	20 min, 3 times/week	(Cognifit.com)
Dakim (m) Power	www.dakim.com	Use it or lose it?/web based	20-25 min, 3–5 times/week	(Dakim.com)
Lumosity	www.lumosity.com	NP/web based	Full workout in 10 min/day/daily 30 min sessions	(Lumosity.com)
My Brain Trainer	www.mybraintrainer.com	Elementary cognitive tasks to stimulate neurons, increases blood flow to the brain/web based	10 min twice per day, daily	(Mybraintrainer.com)

BFP Brain Fitness Program, *NP* Neuroplasticity, *SAAGE* Speed, Accuracy, Adaptability, Generalizability and Engagement, *UFOV* Useful Field of View, *CD-ROM* Compact Disc-Read Only Memory

(Shah et al., 2016)

Table 1 Evidence quality and characteristics for studies included in this review

Program identified with eligible trials	Level of evidence	Study	PEDro score[a]	Author/s designed program/company employee	Study funded by company
Posit science	I	Mahncke et al. (2006)	8	Yes	Yes
		Smith et al. (2009)	9	Yes	Yes
		Ball et al. (2002a)	9	Yes	NA
		Wolinsky et al. (2013)	9	Yes	NA
		Berry et al. (2010)	8	Yes	Yes
		Edwards et al. (2013)	5	Yes	NA
		O'Brien et al. (2013)	7	Yes	NA
		Barnes et al. (2013)	7	Allowed program access	
		Anderson et al. (2013)	7	NA	not funded by company
		Leung et al. (2015)	5	NA	not funded by company
		Peretz et al. (2011)	9	Yes	Yes
Cognifit		Shatil (2013)	5	Yes	NA
		Shatil et al. (2014)	6	Yes	NA
Cogmed		Brehmer et al. (2011)	7	Allowed program access	
Brain age	II	Nouchi et al. (2012)	9	Yes	NA
My brain trainer		Simpson et al. (2012)	7	NA	not funded by company
Dakim	III	Miller et al. (2013)	5	Yes	Yes
Lumosity		Ballesteros et al. (2014)	5	NA	not funded by company

PEDro Physiotherapy Evidence Database, *NA* not available

[a] PEDro score: >6 = high; 5–6 = moderate and <5 = poor methodological quality

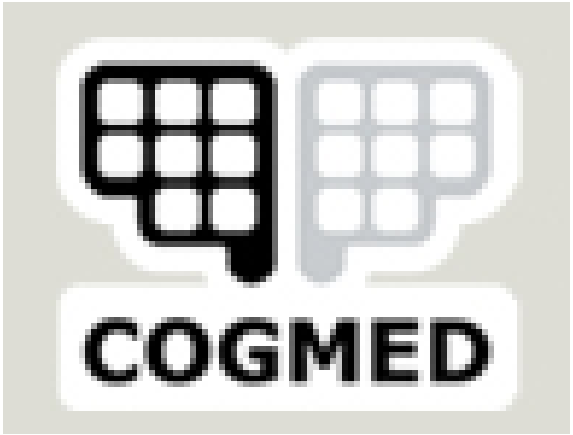
(Shah et al., 2016)

Factors to consider

- Cognitively impaired individuals were not included
- Randomized Control trials often not specific to older age group
- Most studies are funded/conducted by company affiliated individuals. More independent studies needed but funding sources for these studies are rare.

Brain Training - Cogmed

- Cogmed: www.cogmed.com (Computerized Training)
- Working memory training



Brain Training

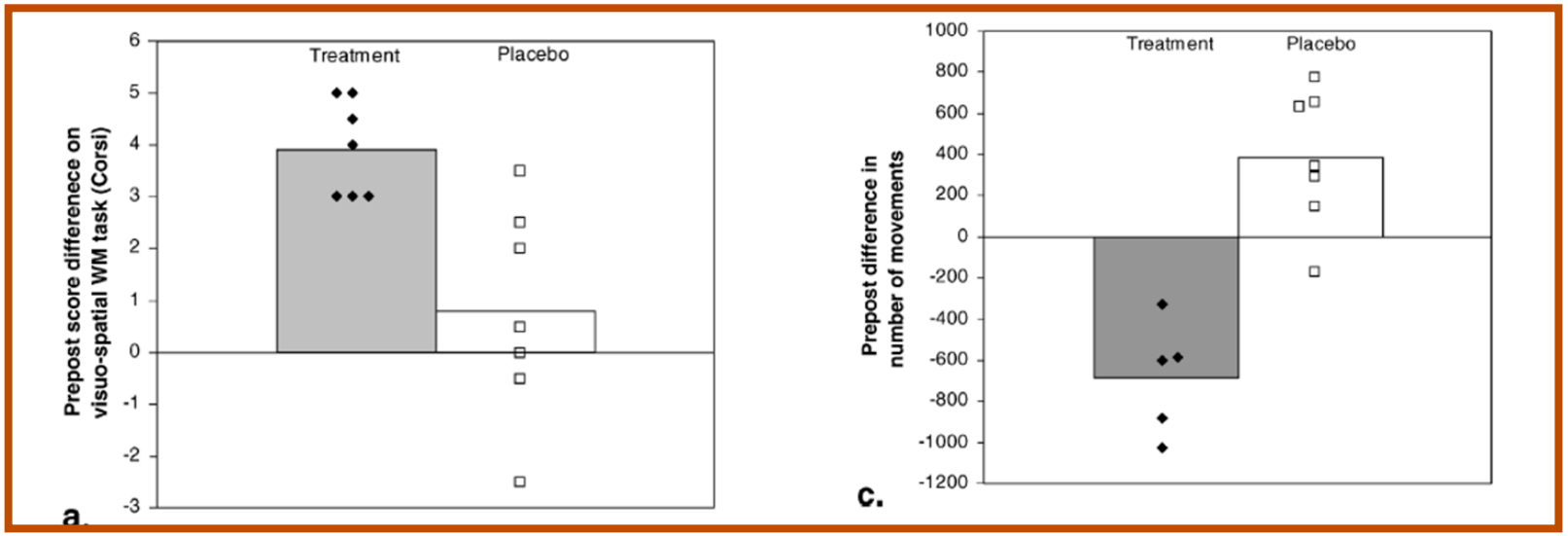
Example: Cogmed – children with ADHD

- Does training working memory improve math test performance?
  - 25 min per day, ~5 weeks
  - Training vs. non-adaptive training
  - 14 children: 7 training; 7 control
  - Selected for ADHD
- Directly following improvements in
  - Working memory
  - Head Movement

Klingberg, et al., 2002

Brain Training

Example: Cogmed – children with ADHD



Klingberg, et al., 2002

Brain Training

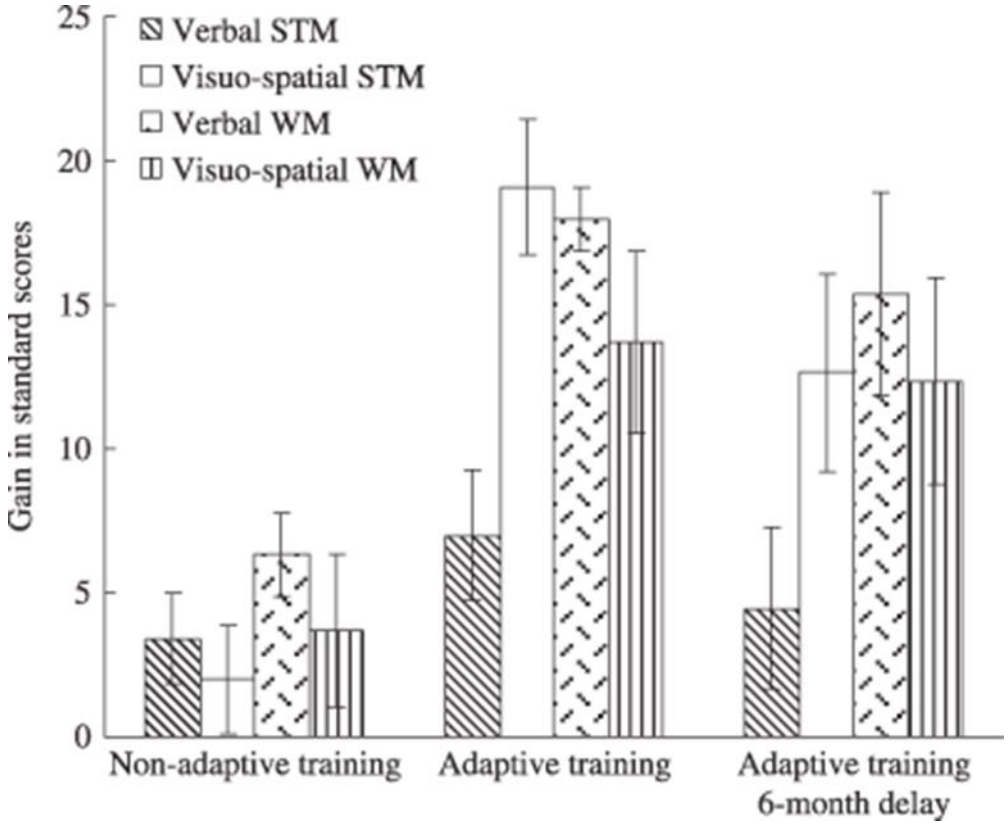
Example: Cogmed

- Does training working memory improve math test performance?
  - 35 min per day, 25 days, 5 weeks
  - Kids did training vs. non-adaptive training
  - 42 children: 22 training; 20 control
  - Selected for low working memory (out of N=354)
- Directly following training → improvements in working memory
- 6 months later improvements in working memory & mathematical reasoning

Holmes, et al., 2009

Brain Training

Example: Cogmed



Gains were maintained for 6 months

Additional significant change in Mathematical reasoning with a small to medium effect size (d=.49)

No change in Verbal IQ, Performance IQ, or Word Reading

Holmes, et al., 2009

Brain Training

Training of ADHD

Training program (by group characteristic)	Authors	Control group	Near: STM	Near: WMC BS	Near: WMC CS	Far: Gf	Far: Ach.	Far: Attn.	Far: ADHD Obj.	Far: ADHD Subj.	*n*	Age in years *M* (*SD*)
Children with ADHD and/or low WMC												
Cogmed (ADHD)	Beck et al. (2010)	No contact								?	51	11.75 (32.59)
Cogmed (ADHD)	Gibson et al. (2011)	None							–	✓	37	12.59 (1.21)
Cogmed (ADHD)	Holmes et al. (2010)	None	✓	✓	✓	–	–				25	9.75 (.92)
Cogmed (ADHD)	Klingberg et al. (2002)	Nonadaptive task	✓			✓		✓	?		14	11.20 (2.55)
Cogmed (ADHD)	Klingberg et al. (2005)	Nonadaptive task	✓			✓		✓		?	44	9.80 (1.30)
Cogmed (ADHD)	Mezzacappa & Buchner (2010)	None	✓	✓						✓	8	8.75 (.89)
Cogmed (cochlear implants)	Kronenberger et al. (2011)	None	✓	?							9	10.20 (2.2)
Cogmed (low WMC)	Holmes et al. (2009)	Nonadaptive task	?		✓	–	–				42	8–11[c]
Cogmed (special education)	K. I. E. Dahlin (2011)	Klingberg et al. (2005)	✓	✓		–	?	–			57	10.71 (1.09)
JungleMemory (learning disability)	Alloway (in press)	Learning support			✓		✓				15	13.00 (.78)
OddYellow (borderline IQ)	Van der Molen et al. (2010)	Response time task	?	–	–	–	–	–			93	15.21 (.69)

Training of Children

Training program (by group characteristic)	Authors	Control group	Near: STM	Near: WMC BS	Near: WMC CS	Far: Gf	Far: Ach.	Far: Attn.	Far: ADHD Obj.	Far: ADHD Subj.	*n*	Age in years *M* (*SD*)
Typically developing children												
Cogmed	Bergman Nutley et al. (2011)	Nonadaptive task	?		✓	–					101	4.30 (.25)
Cogmed	Shavelson et al. (2008)[b]	Nonadaptive task	✓		–	–					37	13.50 (.70)
Cogmed	Thorell et al. (2009)	Computer games	✓			–		?			62	4.70 (.43)
n-back	Jaeggi et al. (2011)	Knowledge training				?		DNR			62	9.03 (1.49)
Running span[a]	Zhao et al. (2011)	Computer games				✓					33	9.76 (.61)

Note. ✓ = significant transfer remained; ? = mixed transfer; dash = transfer regressed; STM = short-term memory; WMC = working memory capacity; BS = backward span; CS = complex span; Gf = general fluid intelligence; Ach. = achievement.
[a] Training task did not adapt to performance.

Shipstead, Redick & Engle, 2012)

Brain Training

Training of Adults

Training program	Authors	Control group	Near STM	Near WMC CS	Near WMC *n*-back	Far Gf	Far Attn	*n*	Age in years *M* (*SD*)
Simple/complex span training									
Complex span	Chein & Morrison (2010)	No contact		✓		–	?	42	20.10 (1.74)
Complex/simple span[a]	Colom, Quiroga, et al. (2010)	Speed/attention tasks				–		288	20.10 (3.40)
Cogmed	Klingberg et al. (2002; E2)	Children w/ADHD	✓			✓	✓	4	23.50 (3.40)
Cogmed	McNab et al. (2009)	None	✓			DNR	DNR	13	20–28[c]
Cogmed	Olesen et al. (2004; E1)	No contact	✓			✓	✓	3[d]	20–23[c]
Cogmed	Olesen et al. (2004; E2)	No contact	–				✓	8[d]	29.30 (2.1)
Cogmed	Westerberg et al. (2008)[b]	Nonadaptive task	✓			–	?	55	26.23 (2.83)[e]
n-back training									
Dual *n*-back	Jaeggi et al. (2008)	No contact	✓	–		✓		69	25.6 (3.30)
Dual/single *n*-back	Jaeggi, Studer-Luethi, et al. (2010)	No contact		–	✓	?		89	19.4 (1.50)
Single *n*-back[a]	Li et al. (2008)	No contact		–	✓			46	25.95 (2.57)
Dual *n*-back	Seidler et al. (2010)	Knowledge training		✓	✓	–	DNR	56	21.4 (4.82)
Running span training									
Running span	E. Dahlin, Nyberg, et al. (2008)	No contact	–	–	✓	–		28	23.59 (2.62)
Running span	E. Dahlin, Stigsdotter Neely, et al. (2008, E1)	No contact			✓		–	22	23.59 (2.54)
Other WM training									
Various tasks[a]	Schmiedek et al. (2010)	No contact		–	✓	✓		145	25.47 (2.64)

Shipstead, Redick & Engle, 2012)

Brain Training

The Promise and Perils

- Brain plasticity ≠ Brain training
- Cognitive changes vs. brain changes
- Some training programs do work for certain people
- However, a lot of existing tools are not fully tested and the effects of these tools are exaggerated since companies want to make profits.
- Should the Food and Drug Administration (FDA) do the quality control of these training tools since they charge people huge amount of money?
- Overall, a dearth of research on brain training tools provides weak evidence that these tools have a lasting effect.

Brain Training - MindSparke

- MindSparke: www.mindsparke.com
- Testimonies online: http://www.mindsparke.com/brain_fitness_pro.php?id=benefits
- Research: http://www.mindsparke.com/research.php

Brain Training - MindSparke


Martin G. Walker
MA Oxford University, UK
mind evolve Founder, CEO

mind evolve founder Martin Walker is an Oxford-trained scientist, author, and technologist. A member of The British Neuroscience Association, Learning and The Brain, and MENSA, Walker has a passion for helping people achieve their brain fitness goals.

MindSparke develops highly innovative and effective brain training programs that stand apart from the pack. By focusing always on brain exercises that work, MindSparke ensures that brain training efforts translate to brain fitness gains. Our creative approach to brain training leads to truly revolutionary innovations such as the incorporation of meditation into the training process.

source: https://mindsparke.com/brain_fitness_pro_jr.php?id=benefits

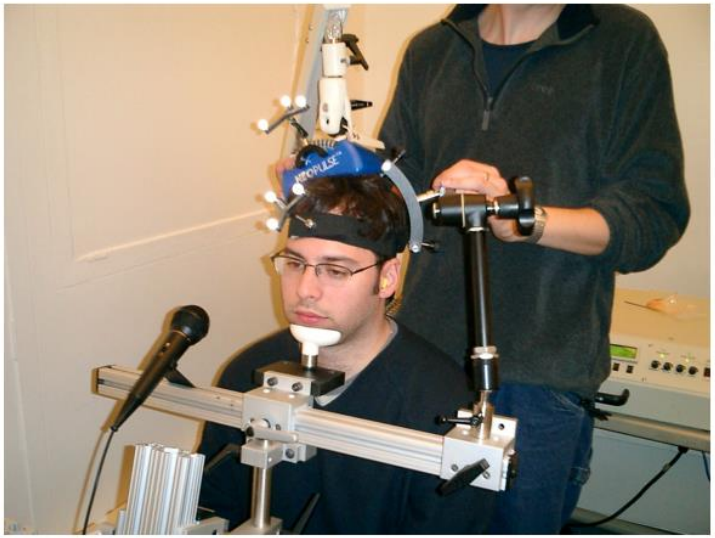
Overview

- Brain plasticity
- Brain training: helpful, harmful, deceiving?
- Navigating the brain training maze
- Educating Educators: the role of basic and applied science

Navigating the Brain training maze

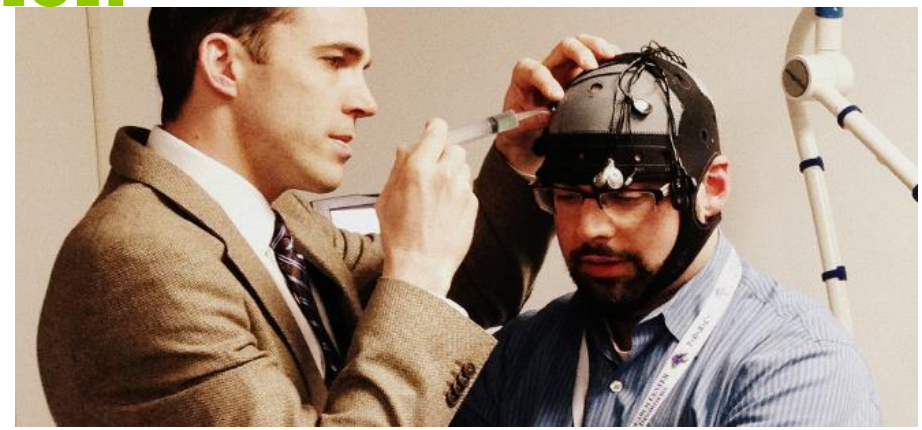
- **Scientific Credentials**: Are there scientists behind the designed training? Does the company have an active, credible scientific advisory board? Are there published, peer-reviewed scientific papers in high impact journals on the training's efficacy?
- **Methodology**: Is the experiment well designed? Appropriate methods chosen? Are claims justified? Is this the best training?
- **Target group:** For whom is the training designed? What are the targeted benefits? Does it work for everyone?
- **Operation Training**: What type of training is required to run the training and who will provide the necessary training?
- **Costs:** Which costs are involved? One-time fees, up-front fees, ongoing fees, hardware fees, software fees, training/staff fees
- **Evaluation and Interpretation**: Who will evaluate the program? Who will interpret the results? What are the implications of certain results (ethics)?

Transcranical Magnetic Stimulation



- Magnetic field induces electrical current in brain, changes firing of synapses
- Primarily a research tool
- Limited use as an intervention (e.g.depression)
- Methodological problems (e.g., Parkin et al., 2015)

Transcranical Direct Current Stimulation

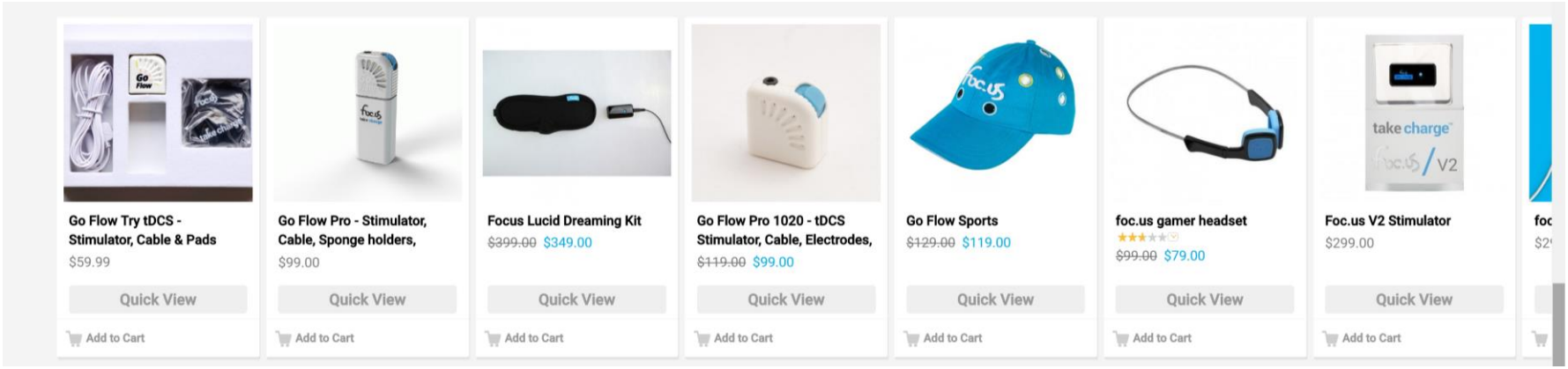


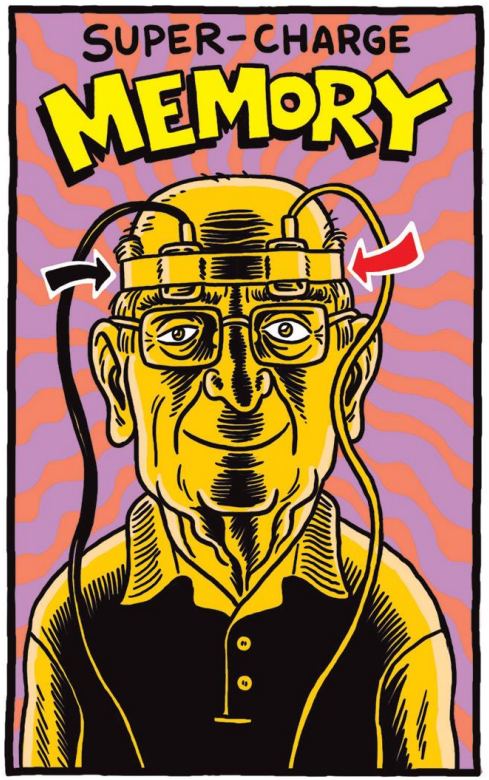
- Weak electrical field induces electrical current in brain, changes firing of synapses
- Can excite or depress activity
- Primarily a research tool
- Limited use as an intervention (rehabilitation after stroke)
- Methodological problems

Neurofeedback

- is a type of biofeedback that uses neuroimaging methods (most commonly EEG) to train 'self-regulation' over your 'brain function'.
- Uses real-time displays of brain activity and a reward system (e.g. in form of a video game)
- Very controversial
- [See also real-time fMRI for pain or other applications]

The ethics of brain training





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foc.us v2 tDCS Device

Last Chance to Own The Worlds Most Advanced Electrical Brain Stimulator. tDCS, tACS, tPCS and tRNS - all included. CE certified safe - featuring triple current regulation, voltage control and safety timers. Don't miss out!

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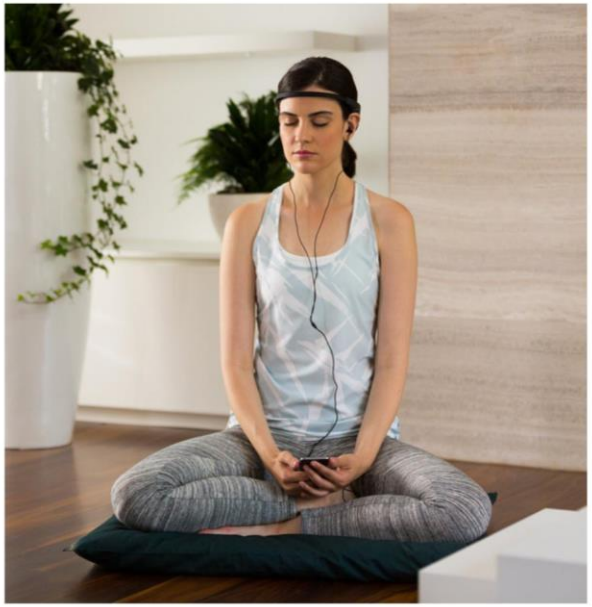
Home > Meditation Accessories > Muse: The Brain Sensing Headband



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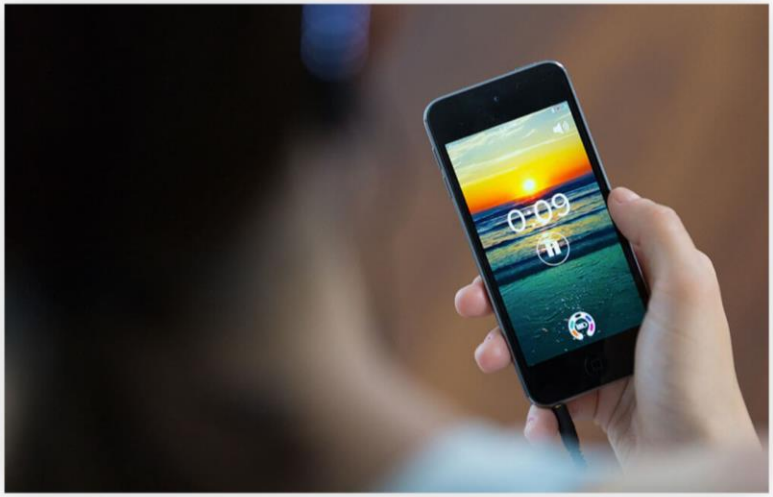

meditate

Muse gives you feedback about your meditation in real time by translating your brain signals into the sounds of wind.

When your mind is calm and settled, you hear calm and settled winds. When your mind is active the winds will pick up and blow.

Hear an example of our Beach soundscape

0:00 / 0:25

Attentional and Affective Consequences of Technology Supported Mindfulness: a Randomised Trial
Dr. Norman Farb's laboratory at the University of Toronto showed that six weeks' regular use of Muse in healthy adults resulted in improvements in attention, as well as reduced somatic symptoms (headaches, pain, discomfort, etc.) on the Brief Symptom Inventory.

Read the Paper in BMC Psychology

Neuroscientists Study Meditation-Related Changes in Brain Performance
Neuroscientists at the University of Victoria and the University of British Columbia use Muse in their field work in Nepal to study the brains of Buddhist monks, who are highly expert meditators, to better understand how training affects the way the brain makes decisions.

Watch the video

Identifying Mental States with Machine Learning
Researchers at the University of Memphis and IBM Watson Research Center found that by using machine learning to analyse brainwave signals from Muse, while participants watched different videos, they could determine what type of content (emotional or educational) each participant was seeing.

Characterizing Population EEG Dynamics throughout Adulthood
A study by researchers at McMaster University involving more than 6000 participants found population-level effects in brain data related to age and gender, giving scientists unparalleled resolution into how EEG brain dynamics change with age.

Read the Paper in eNeuro

Identifying Pain with an Adaptive Brainwave Learning System
Researchers at MIT and Harvard used machine learning to detect and distinguish signals associated with pain when participants wore Muse.

See paper 1 | **See paper 2**

Vigilance Lapse Identification With Muse
Researchers from McMaster University used EEG machine learning tools to detect lapses in vigilance (sustained attention) state of participants wearing Muse.

Read the paper on IEEE Xplore

Novel Speed-of-Learning Effects Detected in Neurofeedback
A study by Dr. Randy McIntosh's lab at the Rotman Research Institute demonstrated previously unreported speed-of-learning effects in MyVirtualDream, a virtual neurofeedback environment powered by Muse. This effect, being subtle, was detectable only using a technology capable of testing a very large number of people (600) in a short time (twelve hours).

Read the Paper in PLOS One

Using Muse to Measure Event-Related Potentials Outside the Lab.
At the University of Victoria, in Canada, scientists are using Muse to measure event-related potentials (ERPs) in cognitive tasks. This research is also being applied to measure changes in decision making in response to fatigue – in ER doctors in the Emergency Room.

Read the paper in Frontiers in Neuroscience

See the project | **Watch the video**

Integration of Muse with Virtual Reality
Students, scientists, and makers from around the world use Muse to create engaging and immersive experiences. One great example is **PsychicVR**, a virtual reality experience powered by Muse, that was created by Judith Amores Fernandez, Pattie Maes, and Xavier Benavides Palos, which won a **Fast Company Innovation** By Design award.

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Former CEO of the American
Psychological Association

Dr. Dean Ornish, MD
Preventive Medicine Research

Dr. Rudy Tanzi, PhD
Massachusetts General Hospital

Child Development, xxxx 2017, Volume 00, Number 0, Pages 1–8

The title for this Special Section is **Contemporary Mobile Technology and Child and Adolescent Development**, edited by Zheng Yan and Lennart Hardell

Electromagnetic Fields, Pulsed Radiofrequency Radiation, and Epigenetics: How Wireless Technologies May Affect Childhood Development

Cindy Sage
Sage Associates

Ernesto Burgio
International Society of Doctors for Environment (ISDE) Scientific Office

Mobile phones and other wireless devices that produce electromagnetic fields (EMF) and pulsed radiofrequency radiation (RFR) are widely documented to cause potentially harmful health impacts that can be detrimental to young people. New epigenetic studies are profiled in this review to account for some neurodevelopmental and neurobehavioral changes due to exposure to wireless technologies. Symptoms of retarded memory, learning, cognition, attention, and behavioral problems have been reported in numerous studies and are similarly manifested in autism and attention deficit hyperactivity disorders, as a result of EMF and RFR exposures where both epigenetic drivers and genetic (DNA) damage are likely contributors. Technology benefits can be realized by adopting wired devices for education to avoid health risk and promote academic achievement.

Distinguishing polemic from commentary in science: Some guidelines illustrated with the case of Sage and Burgio, 2017

David Robert Grimes
School of Mathematics and Physics
Queen's University Belfast, BT7 1NN
D.R.Grimes@qub.ac.uk

Dorothy V. M. Bishop
Department of Experimental Psychology
University of Oxford, OX1 3UD
dorothy.bishop@psy.ox.ac.uk

Exposure to non-ionizing radiation used in wireless communication remains a contentious topic in the public mind - while the overwhelming scientific evidence to date suggests that microwave and radio frequencies used in modern communications are safe, public apprehension remains considerable. A recent paper in Child Development has caused concern by alleging a causative connection between non-ionizing radiation and a host of conditions, including autism and cancer. In this work, we outline why these claims are devoid of merit, and why they should not have been given a scientific veneer of legitimacy. We also outline some hallmarks of potentially dubious science, with the hope that authors, reviews and editors might be better able to avoid suspect scientific claims.

Table 1: Questions to ask of causal claims

1. Is there a plausible mechanism for the effect?
2. Does evidence come from peer-reviewed sources?
3. Are all relevant studies considered?
4. Are results of specific studies misrepresented?
5. Are there claims of impacts on multiple diseases and disorders?
6. Are causal claims based on experiment, correlation or analogy?
7. Is technical, scientific terminology used to obfuscate rather than clarify?
8. What are the academic credentials and track record of the authors?
9. Is there conflict of interest?

Grimes & Bishop, 2017

Overview

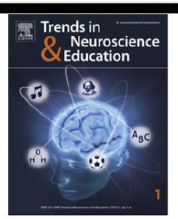
- Brain plasticity
- Brain training: helpful, harmful, deceiving?
- Navigating the brain training maze
- Educating Educators: the role of basic and applied science

What kind of evidence is important for educators?

Contents lists available at SciVerse ScienceDirect

Trends in Neuroscience and Education

journal homepage: www.elsevier.com/locate/tine



Discussion

Educational neuroscience in the near and far future: Predictions from the analogy with the history of medicine

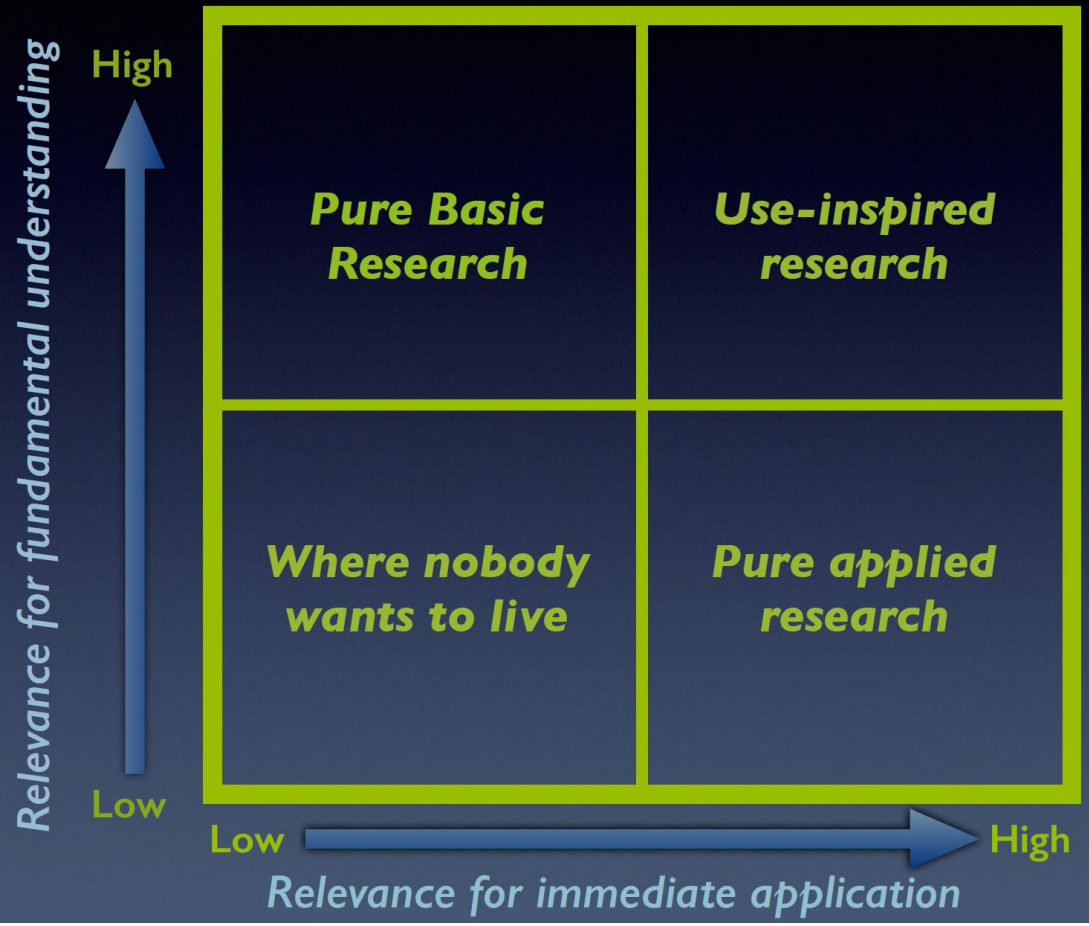
Michael S.C. Thomas *

"If you were given the choice right now of visiting a doctor who had memorized a list of symptoms and their linked treatments, or a doctor who understood the reasons why diseases produce the symptoms they do and why treatments work, which one would you choose? " (Thomas, 2013, p.25)

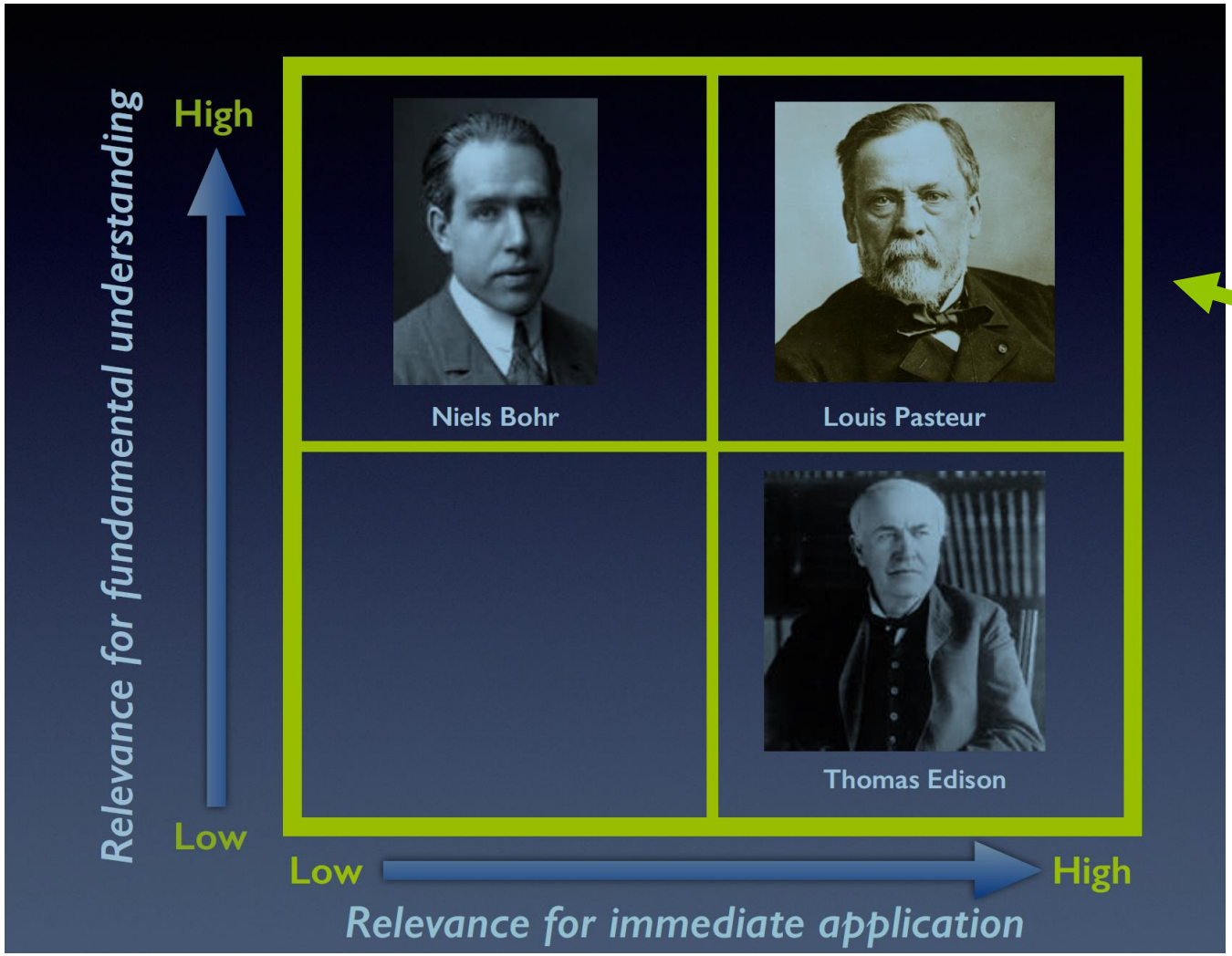
Slide: Daniel Ansari

Different categories of research

(Stokes, 1997)



Slide: Daniel Ansari

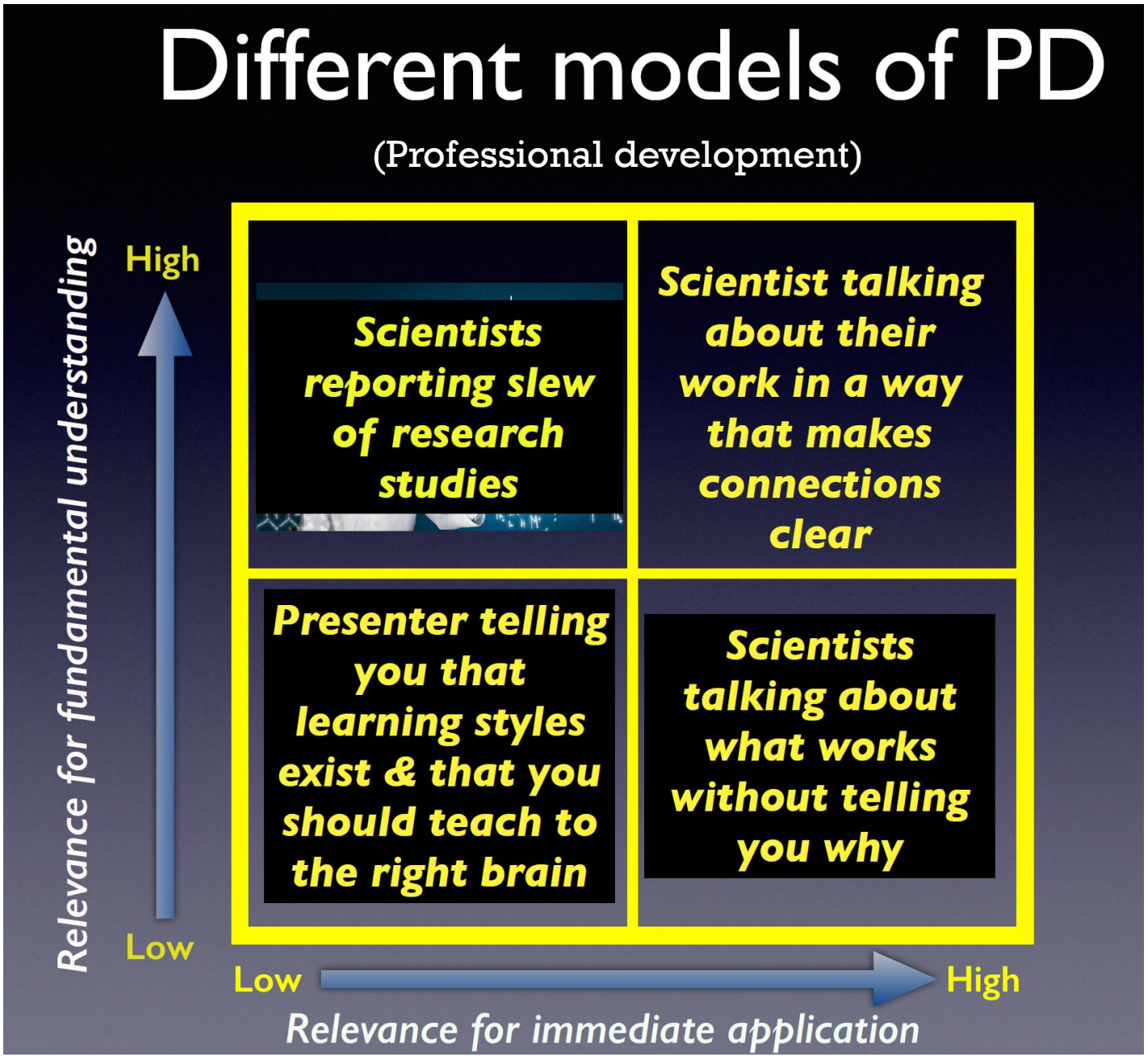


'Pasteur's Quadrant'

Slide: Daniel Ansari

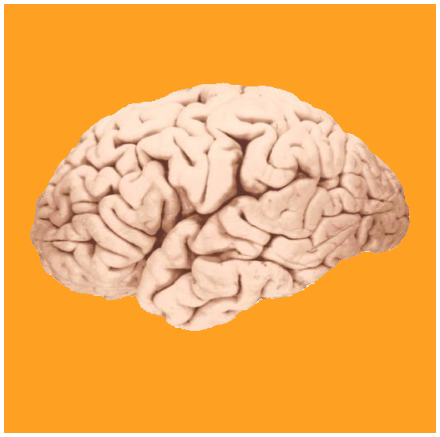
Different models of PD

(Professional development)



Slide: Daniel Ansari

Neural Plasticity and Training in the Brain

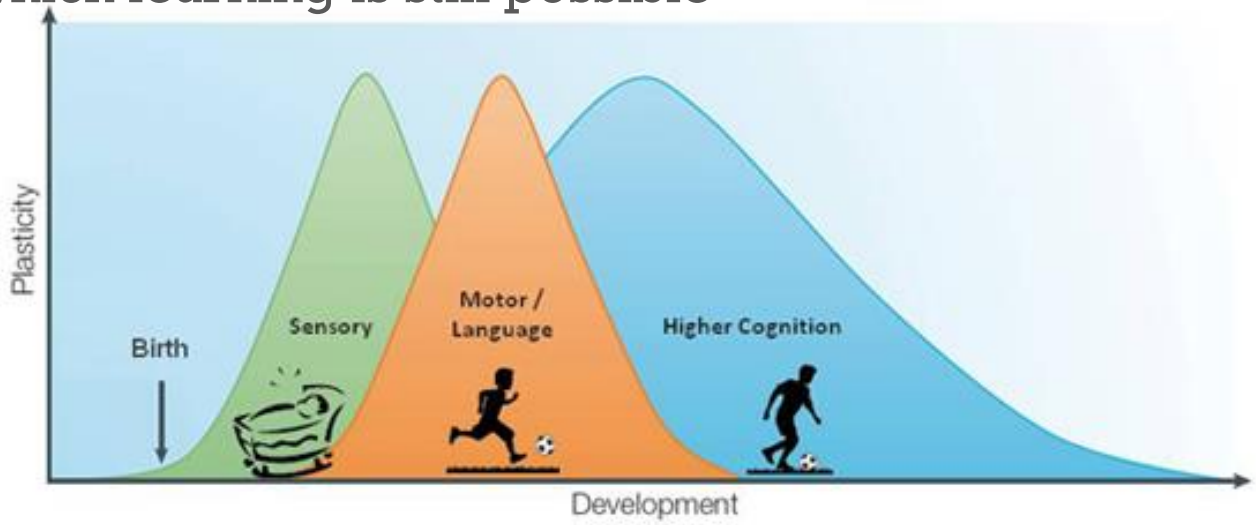


H-126 Typical and Atypical Neurodevelopment
November 13th, 2017

Extra Slides

Sensitive Periods

- Are limited time periods during which the effect of experience on the brain is particularly strong
- Allow experience to instruct neural circuits to process information in an adaptive way
- Provide information that is essential for normal development and may alter performance permanently
- ‘Critical' and 'sensitive' periods are often differentiated, defining 'sensitive' periods as those which are more extended, and after which learning is still possible



Can we reopen sensitive periods?

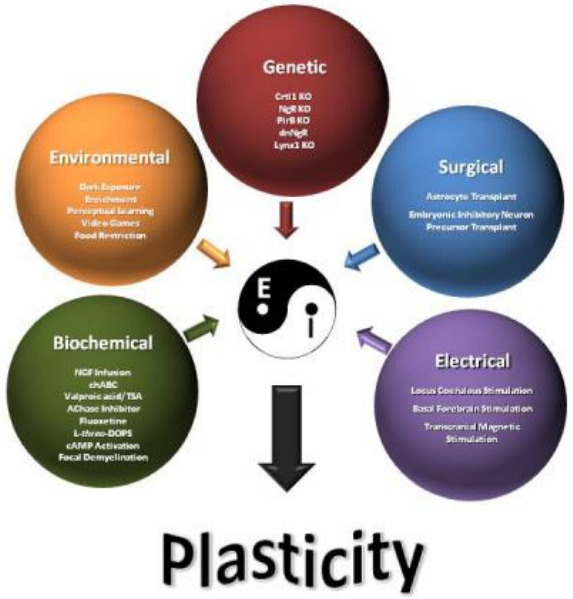
The question no longer is, "Are there CPs?" but rather what processes open them, keep them open, close them, and allow them to be reopened.

→ decreased plasticity after the critical period involves the action of histone-deacetylase inhibitors (HDAC), an enzyme that acts as an epigenetic "brake" on critical-period learning

Valproate reopens critical-period learning of absolute pitch

Judit Gervain[1,2], Bradley W. Vines[3†], Lawrence M. Chen[4†], Rubo J. Seo[5], Takao K. Hensch[6], Janet F. Werker[7] and Allan H. Young[8]*

Fig 3: Factors that affect critical period timing

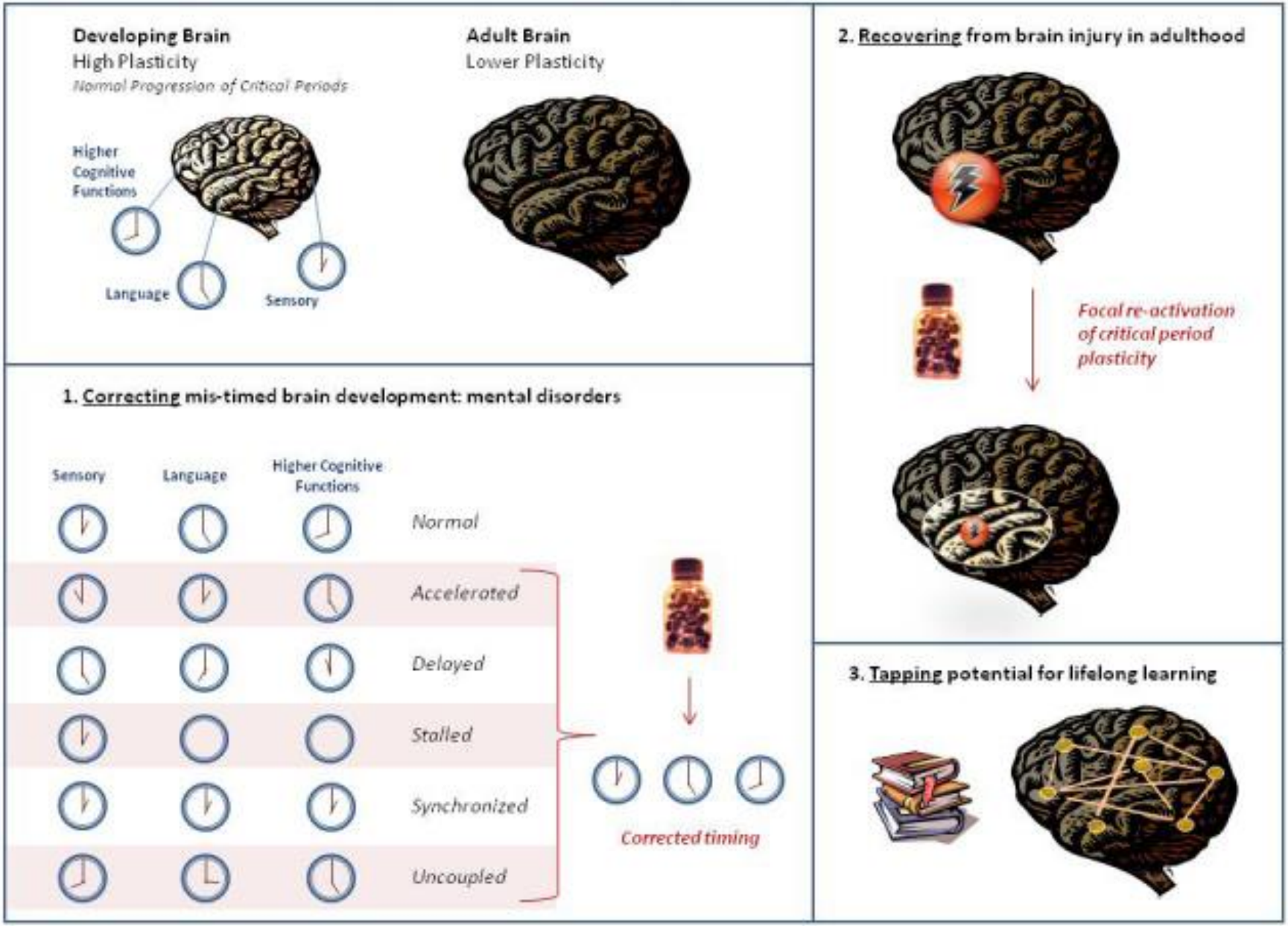


Based on figures in Baveller, D., Levi, D. M., Li, R. W., Dan, Y., & Hensch, T. K. (2010). Removing brakes on adult brain plasticity: From molecular to behavioral interventions. *Journal of Neuroscience*, 30(45), 14964–14971.

As well as data from Spolidoro, M., Baroncelli, L., Putignano, E., Maya-Vetencourt, J. F., Viegi, A., & Maffei, L. (2011). Food restriction enhances visual cortex plasticity in adulthood. *Nature Communications*, 2, 320.

Takao Hensch

Fig 2: Consequences of manipulating critical period plasticity



(Hensch & Bilimoria, 2012)

- Crossed eyes or congenital cataracts leading to unequal visual inputs in childhood can cause amblyopia, a condition affecting two to five percent of the population, in which vision through one eye, the "lazy eye," is poor despite the eye itself being perfectly healthy. Patching the better eye can restore the quality of vision through the lazy eye, but only if it's done during the critical period (Hensch & Bilimoria, 2012)

General Conclusions about Sensitive Periods

- Collectively, in most cases sensory/perceptual development proceed normally if such systems are "set" correctly during a sensitive period of development—(e.g. Hubel and Wiesel)
- There is also evidence for sensitive periods in specific domains of language and perception
- The human brain "expects" certain types of input at particular times in development.
- It is not clear what aspects of cognitive or social and emotional development requires experience at particular (e.g., sensitive) points in time. Inferences drawn from intervention studies suggest some advantage to early experience.

Slide: N. Fox