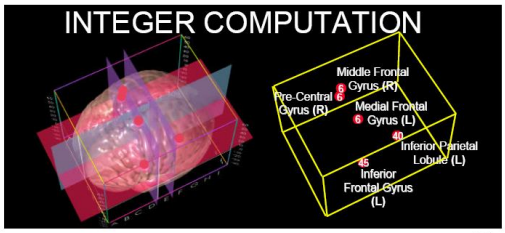
Effects of Poverty on Brain Development and School Success

Martha S. Burns, Ph.D.
GSSA
October, 2017

Key Points

- Children raised in poverty are exposed to millions of fewer spoken words at home
- Income level negatively impacts cognitive functions
- There are links between family income and memory and attention
- Poverty is associated with chronic stress which can have a toxic effect on brain architecture
- ELL's often have a triple jeopardy – language barrier to learning, history of poverty, learning disabilities
- Computer games designed to target the skills that are impacted can turn around some effects of poverty

All cognitive functions apparently involve distinctive networks – mapping out of those networks has been one ongoing goal of recent neuroscience research.

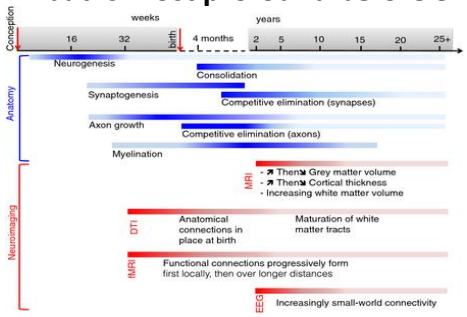


Hirsch, Moreno & Kim, J. Cognitive Neuroscience, 13 (3), 389-405, 2001. Fig 2c

How Experience Changes the Brain (Gopnik, 2015)

- Early in development proliferation prevails – young children make many more new connections than adults
- Later in development pruning is more important – adults shift from a young brain that is good at learning to an older brain that is more effective and efficient but more rigid.
- **We get better and better at fewer and fewer things**

The building starts just before birth but is most profound before 5



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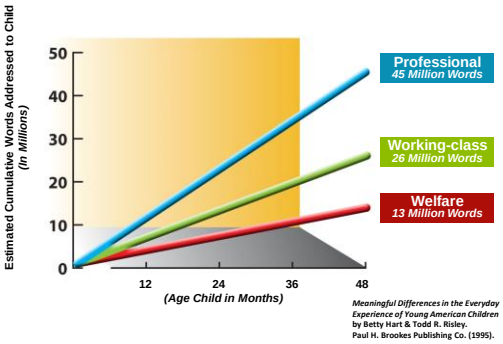
Language Experiences

Language Experiences by Group



Meaningful Differences in the Everyday Experience of Young American Children by Betty Hart & Todd R. Risley. Paul H. Brookes Publishing Co. (1995).

February 22, 2016

INNOVATION WEEKLY

School Districts around the Nation recognize the problem and are looking for solutions

Closing the 30 million word gap

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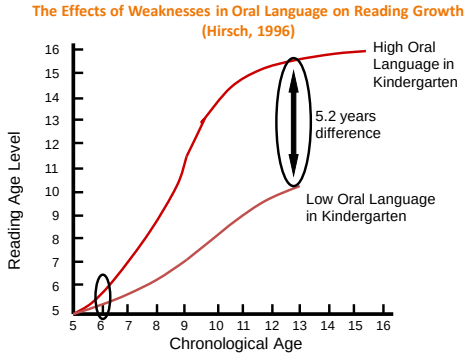
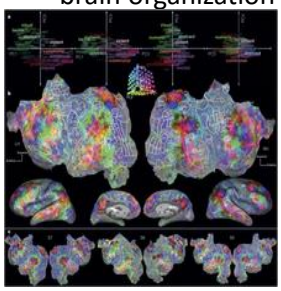


Effects of Language Exposure on the Brain

But language is even more important in brain organization than we thought



- Huth, A., DeHeer, W., Griffiths, T., Theunissen, F. & Gallant, J. (2016)Natural speech reveals the semantic maps that tile human cerebral cortex. *Nature* 532, 453–458 (28 April 2016)

As far as the brain is concerned - Language is everywhere

The Brain Dictionary – How language exposure builds the entire brain

- http://www.nature.com/nature/videoarchive/brain-dictionary/index.html
- Huth, A., DeHeer, W., Griffiths, T., Theunissen, F. & Gallant, J. (2016)Natural speech reveals the semantic maps that tile human cerebral cortex. *Nature* 532, 453–458 (28 April 2016)
- Explore the brain model for yourself here: http://gallantlab.org/huth2016

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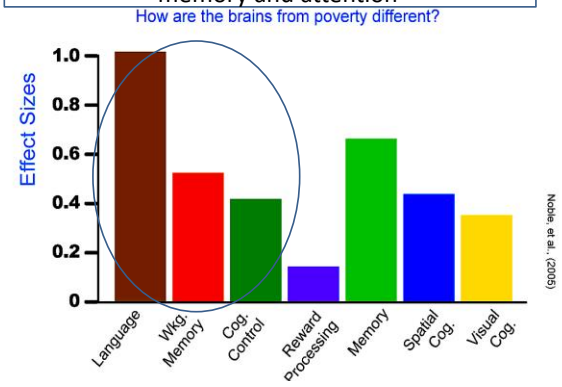
There are links between family income and memory and attention



Understanding Memory Problems in Children

- There are essentially three types of memory
  - Short Term repetition span – tested with repetition tasks
  - Short Term working memory – Alan Baddeley
    - Part of executive function
    - Involves strategies
    - Can occur over minutes, even days
  - Long term memory – storage (learning)
- Children can have problems with one or all three

How working memory problems present in the classroom

- Slow on multiple choice tests even though they know the material
- Re-read passages frequently
- Trouble with memorization activities but get the key ideas
- Take much longer to complete homework and in class assignments
- Word-finding problems
- Problems with spelling

But newer research is specifying why and how the impact of poverty affects learning

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What does poverty affect besides language? Just out in January.

Behavior & Society

Does Poverty Shape the Brain?

Growing up in a poor family can leave a mark on the developing brain. Understanding how and why has important implications for educators and society

By John D. E. Gabrieli, Silvia A. Bunge

SCIENTIFIC AMERICAN MIND

January 2017 Issue

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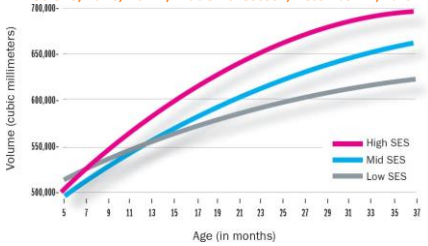
"Family Poverty Affects the Rate of Human Infant Brain Growth" Jamie L. Hanson et al., in *PLOS One*, Vol. 8, No. 12, Article No. e80954; December 11, 2013



Total Gray Matter: Using MRI to track brain development in 77 infants, psychologists at the University of Wisconsin–Madison found that differences associated with socioeconomic status (SES) became increasingly pronounced over time. By age three, toddlers from low-income households showed significantly less gray matter than those raised in wealthier homes.

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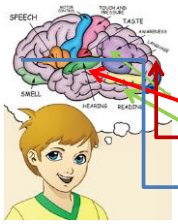
Family income, parental education and brain structure in children and adolescents Noble, et. al.

Nature Neuroscience 30 March 2015

- Among children from lower income families,
  - small differences in income were associated with relatively large differences in surface brain area
- Among children from higher income families, similar income increments were associated with smaller differences in surface area.

Brain structure and poverty (Noble et al, 2015)



- Brain Structure and income level relationships were most prominent in regions supporting
- ***language***
- ***reading,***
- ***executive functions***
- ***spatial skills***

Noble et al 2015 Conclusion

- This research implies that ***income relates most strongly to brain structure among the most disadvantaged children.***

Corroborated by Pollak et al, in June

- 20 percent of the gap in test scores between poor children and middle-class children may be a result of **poor brain development in the frontal and temporal lobes**

Pollak, S., et al. (2015) *JAMA Pediatrics*

Students with Interrupted Formal Education and Chronic Absenteeism

- Focus on language development across disciplines
- Functional Language Analysis

PROMISING LITERACY PRACTICES FOR STUDENTS WITH INTERRUPTED FORMAL EDUCATION IN ACHIEVING COMPETENCE WITH ACADEMIC LANGUAGE ACROSS DISCIPLINES

Lyudmyla Zemlak
Palm Beach County School District

David B. Ross
Nova Southeastern University

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Functional Language Analysis (SIFE)

- 1. Unpack content or experiential meaning of the text. Questions to ask about the text: "Who does what to whom, how when and where? What is the text about?"
- 2. Unpack textual meaning, or text organization. Questions to ask about the text: "How does the text weave meanings into a coherent message? How is the text organized?"

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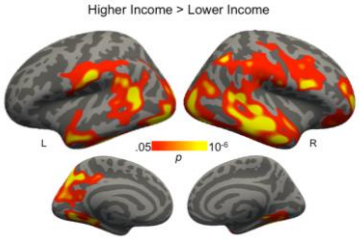
Neuroanatomical Correlates of the Income-Achievement Gap



Mackey, A. P., A. S. Finn, J. A. Leonard, D. S. Jacoby-Senghor, M. R. West, C. F. O. Gabrieli, and J. D. E. Gabrieli. (2015) "Neuroanatomical Correlates of the Income-Achievement Gap." Psychological Science (April 20).

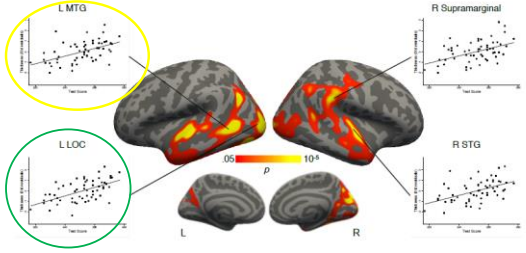
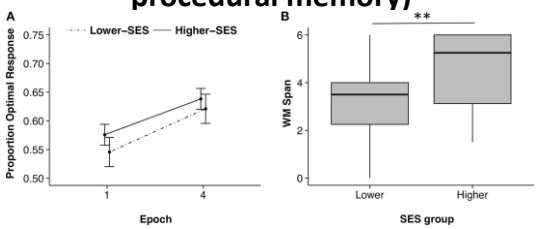


Figure 3. Cortical thickness is positively correlated with test scores. Sex is included as a nuisance regressor. Results are cluster-corrected for multiple comparisons (cluster-forming $p < .05$, cluster-wise $p < .05$, adjusted for both hemispheres). Results are displayed on inflated surfaces, with darker gray indicating sulci, and lighter gray indicating gyri. Scatter plots show cortical thickness values extracted from significant clusters, adjusted for sex (cluster statistics are shown in Table 1).

Mackey, A. P., A. S. Finn, J. A. Leonard, D. S. Jacoby-Senghor, M. R. West, C. F. O. Gabrieli, and J. D. E. Gabrieli. (2015) "Neuroanatomical Correlates of the Income-Achievement Gap." Psychological Science (April 20).

In 2015, differential effects of SES on kinds of memory (working versus procedural memory)



Procedural Memory (probabilistic learning)

Working Memory

Leonard, J., Mackey, A., Finn, A. & Gabrielli, JE (2015) Front. Hum. Neurosci., 08 October

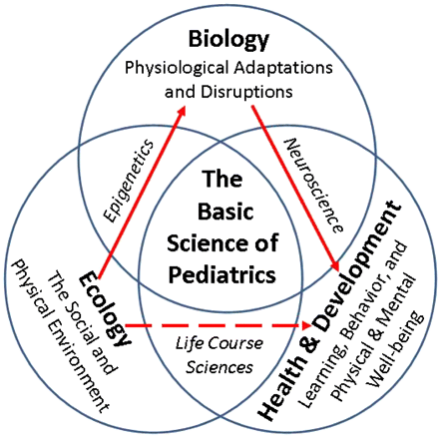
The Lifelong Effects of Early Childhood Adversity and Toxic Stress

Jack P. Shonkoff, Andrew S. Garner, THE COMMITTEE ON PSYCHOSOCIAL ASPECTS OF CHILD AND FAMILY HEALTH, COMMITTEE ON EARLY CHILDHOOD, ADOPTION, AND DEPENDENT CARE, AND SECTION ON DEVELOPMENTAL AND BEHAVIORAL PEDIATRICS

Pediatrics

January 2012, VOLUME 129 / ISSUE 1

From the American Academy of Pediatrics Technical Report



Effects of Stress

- Since brain maturation involves proliferation of synapses and axons
- But this process is competitive based on experience
- So – brain regions that are exercised and get more neuromodulators are prioritized for more proliferation and other areas will be pruned to permit that proliferation

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Stress

- death or serious illness of a loved one,
- a frightening accident,
- an acrimonious parental separation or divorce,
- persistent discrimination,
- or other serious events

Tolerable stress

- Has the potential to negatively affect the architecture of the developing brain,
- but If occurring over limited time periods
  - Allows for the brain to recover and thereby reverse potentially harmful effects
  - *Always in the context of ongoing, supportive relationships with adults*.

Toxic Stress

- Strong, frequent, or prolonged activation of the body's stress management system.
  - Stressful events that are chronic, uncontrollable, and/or experienced without children having access to support from caring adults
  - For example, severe, chronic abuse, especially during early, sensitive periods of brain development

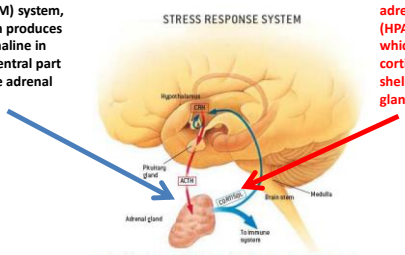
Effects on Brain Development

- **The neural circuits for dealing with stress are particularly malleable (or "plastic") during the fetal and early childhood periods**
  - **the regions of the brain involved in fear, anxiety, an impulsive responses may overproduce neural connections**
  - **those regions dedicated to reasoning, planning, and behavioral control may produce fewer neural connections**

Biology

(1) the sympathetic-adrenomedullary (SAM) system, which produces adrenaline in the central part of the adrenal gland

(2) the hypothalamic-pituitary-adrenocortical (HPA) system, which produces cortisol in the outer shell of the adrenal gland



Both adrenaline and cortisol are produced under normal circumstances and help prepare the body for coping with stressors.

Damage to health and well-being

This wear and tear increases the risk of stress-related physical and mental illness later in life

- Extreme exposure to toxic stress changes the stress response system
  - **Responds at lower thresholds** to events that might not be stressful to others,
  - **Activates more frequently and for longer periods** than is necessary, like revving a car engine for hours every day.

NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD

Excessive Stress Disrupts the Architecture of the Developing Brain

WORKING PAPER 3

http://developingchild.harvard.edu/resources/wp3/

HARVARD UNIVERSITY

Nutrition and the developing brain: nutrient priorities and measurement

Nutrient	Brain Requirement for the Nutrient	Predominant circuitry or process affected
Protein-energy	Cell proliferation, cell differentiation	Global
	Synaptogenesis	Cortex
	Growth factor synthesis	Hippocampus
Iron	Myelin	White matter
	Monoamine synthesis	Striatal-frontal
	Neuronal and glial energy metabolism	Hippocampal-frontal
Zinc	DNA synthesis	Autonomic nervous system
	Neurotransmitter release	Hippocampus, cerebellum
Copper	Neurotransmitter synthesis, neuronal and glial energy metabolism, antioxidant activity	Cerebellum
LC-PUFAs	Synaptogenesis	Eye
	Myelin	Cortex
Choline	Neurotransmitter synthesis	Global
	DNA methylation	Hippocampus
	Myelin synthesis	White matter

2007 American Society for Clinical Nutrition
Nutrition and the developing brain: nutrient priorities and measurement
Michael K Georgieff

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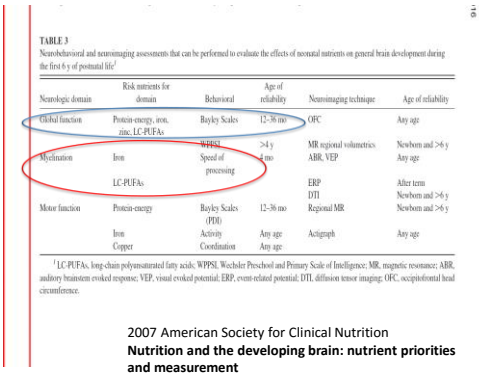

TABLE 3
Neurobehavioral and neuroimaging assessments that can be performed to evaluate the effects of neonatal nutrients on general brain development during the first 6 y of postnatal life[1]

Neurologic domain	Risk nutrients for domain	Behavioral	Age of reliability	Neuroimaging technique	Age of reliability
Global function	Protein-energy, iron, zinc, LC-PUFAs	Bayley Scales	12–36 mo	OFC	Any age
		WPPSI	>4 y	MR regional volumetrics	Newborn and >6 y
Myelination	Iron	Speed of processing	1 mo	ABR, VEP	Any age
	LC-PUFAs			ERP	After term
				DTI	Newborn and >6 y
Motor function	Protein-energy	Bayley Scales (PDI)	12–36 mo	Regional MR	Newborn and >6 y
	Iron	Activity	Any age	Actigraph	Any age
	Copper	Coordination	Any age		

[1] LC-PUFAs, long-chain polyunsaturated fatty acids; WPPSI, Wechsler Preschool and Primary Scale of Intelligence; MR, magnetic resonance; ABR, auditory brainstem evoked response; VEP, visual evoked potential; ERP, event-related potential; DTI, diffusion tensor imaging; OFC, occipitofrontal head circumference.

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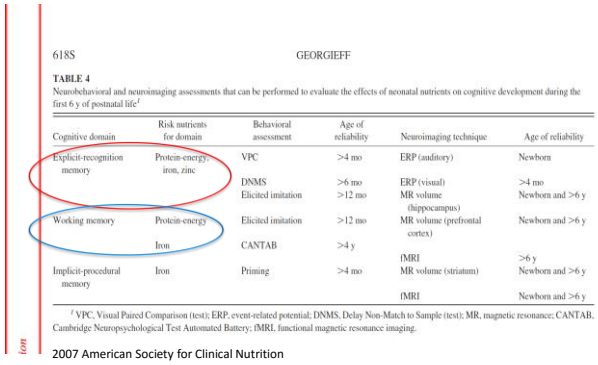

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TABLE 4
Neurobehavioral and neuroimaging assessments that can be performed to evaluate the effects of neonatal nutrients on cognitive development during the first 6 y of postnatal life[1]

Cognitive domain	Risk nutrients for domain	Behavioral assessment	Age of reliability	Neuroimaging technique	Age of reliability
Explicit-recognition memory	Protein-energy, iron, zinc	VPC	>4 mo	ERP (auditory)	Newborn
		DNMS	>6 mo	ERP (visual)	>4 mo
		Elicited imitation	>12 mo	MR volume (hippocampus)	Newborn and >6 y
Working memory	Protein-energy	Elicited imitation	>12 mo	MR volume (prefrontal cortex)	Newborn and >6 y
	Iron	CANTAB	>4 y	fMRI	>6 y
Implicit-procedural memory	Iron	Priming	>4 mo	MR volume (striatum)	Newborn and >6 y
				fMRI	Newborn and >6 y

[1] VPC, Visual Paired Comparison (test); ERP, event-related potential; DNMS, Delay Non-Match to Sample (test); MR, magnetic resonance; CANTAB, Cambridge Neuropsychological Test Automated Battery; fMRI, functional magnetic resonance imaging.

2007 American Society for Clinical Nutrition
Nutrition and the developing brain: nutrient priorities and measurement Michael K Georgieff

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Adverse Childhood Experiences (ACES) (*n* =1007) [Jimenez et al, 2016)

Variable %	(No.)
Child maltreatment	
Psychological	16 (162)
Neglect	13 (132)
Physical	15 (154)
Sexual	0.6 (6)
Household dysfunction	
Maternal depression	12 (121)
Substance use	15 (149)
Incarceration	18 (181)
Violence toward mother	11 (111)

Total ACEs	
0	45 (451)
1	27 (275)
2	16 (158)
3	8 (84)
4	3 (25)
5	1 (11)
6	0.3 (3)

Jimenez et al. Adverse Experiences in Early Childhood (ACES) and Kindergarten Outcomes
PEDIATRICS Volume 137, number 2 , February 2016

Table 3 Teacher Ratings of Below Average Academic Skills – percentages (Jimenez et al, 2016)

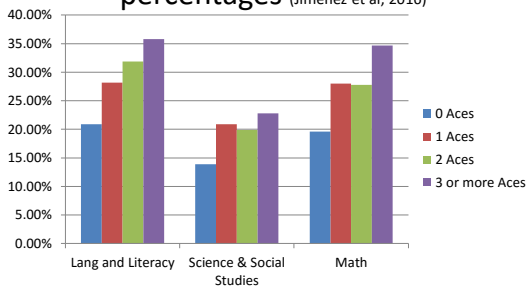
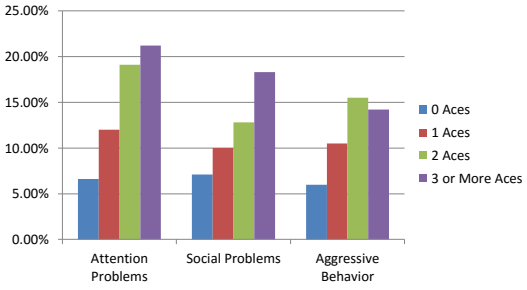


Table 5.Teacher Ratings of Behavior – Percentages (Jimenez et al, 2016)



Conclusion (Jimenez et al, 2016)

- Children experiencing adverse childhood experiences (ACES) places students at significant risk for
  - –Poor school achievement
  - –And is associated with poor health
- Exacerbates Chronic Stress

Neuron
NeuroView

Neuroscience and the Future of Early Childhood Policy: Moving from Why to What and How

Jack P. Shonkoff[1,*] and Pat Levitt[2]
[1]Center on the Developing Child, Harvard University, Cambridge, MA 02138, USA
[2]Zilkha Neurogenetic Institute, Keck School of Medicine of the University of Southern California, Los Angeles, CA 90089, USA
*Correspondence: jack_shonkoff@harvard.edu
DOI 10.1016/j.neuron.2010.08.032

There is a need for greater synergy between advances in neuroscience and the formulation of innovative policies to improve life outcomes for children experiencing significant adversity. Translational developmental neuroscience can inform new theories of change to catalyze more effective interventions that lead to a more productive and healthier society.

Solutions: Neuroscience – Moving from Why to ***What and How***

- Positive experiences after infancy have been shown to compensate to some degree for the negative behavioral consequences
  - Being exposed to an environment rich in opportunities for exploration and social play,
  - Caring and positive relationships with adults
- Computer activities designed to target the skills that are impacted can turn around some effects of poverty
  - *Fast ForWord* exercises, because of their specific emphasis on language, attention and memory are particularly effective and offer a cost effective valuable solution

Supporting Students Who Need More Help – Specific Interventions

- Specific Interventions for Specific Targets
  - Planners
  - Materials
  - Trapper Keeper
  - Locker Organizers with weekly checks
  - Google Docs or email to self to backup
  - TIGERS folder (for younger or students with greater disabilities
  - Reading
  - Warm-ups
  - $10 words

TIGERS (Take Initiative: Get Everything Ready for School) Folders

- For young or struggling older students
  - Special homework folders
  - Place daily work in one pocket and homework in the other pocket
  - Be consistent and organize every day

Building Resilience in Students

- **Sheryl Sandberg: How to Build Resilient Kids, Even After a Loss**
- New York Times
- APRIL 24, 2017

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Each Student Matters

- "Sociologists define "mattering" as the belief that other people notice you, care about you and rely on you.
- It's the answer to a vital question that all children ask about their place in the world starting as toddlers, and continuing into and beyond adolescence:
- Do I make a difference to others?"**(Sandberg, 2017)**

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Students who believe they "matter"

- Adolescents who feel that they matter are less likely to suffer from depression, low self-esteem and suicidal thoughts.
- They're less likely to lash out at their families and engage in rebellious, illegal and harmful behaviors.
- Once they reach college, they have better mental health.(Sandberg, 2017)

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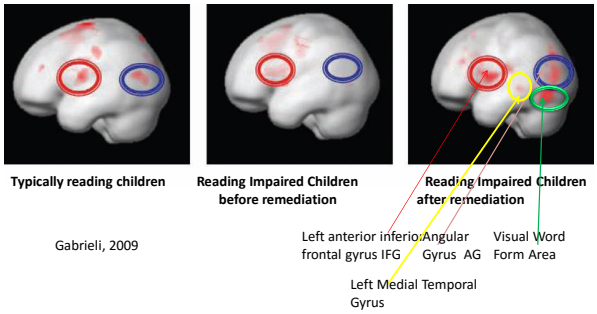
Importance of relationship building

- https://www.ted.com/talks/rita_pierson_every_kid_needs_a_champion

And the Brain Structures affected most by Poverty
LANGUAGE AND READING AREAS ARE ACTIVATED AFTER SIX WEEKS OF FAST FORWORD TRAINING



Gabrieli, 2009

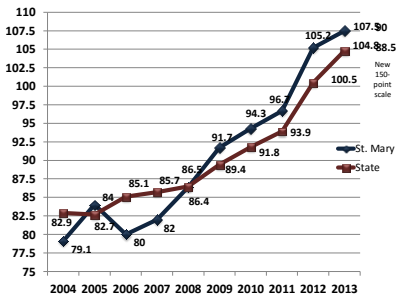
When Brain Training Works – Points of Controversy

Posted on August 23, 2016

5 conditions that make Brain Training effective

- **Condition 1:** It must engage and exercise a core brain-based capacity or neural circuit identified to be relevant to real-life outcomes.
- **The shortfall:** It is insufficient to say that training must target a mental process shown in research to be relevant to real-life performance.
- **Brain training should actually be able to demonstrate improvement in whatever that real-life performance is**.
- his is actually where much brain training falls down.
- It's not that the training can't explain who the exercise relates to a specific neural process, but that it can't demonstrate actual change in real life application.

St. Mary Parish District Performance Score (DPS) Plotted Against State Baseline SPS



Letter grade changing from a 200-point scale to a 150-point scale in 2013.

Condition 2: It must target a performance bottleneck

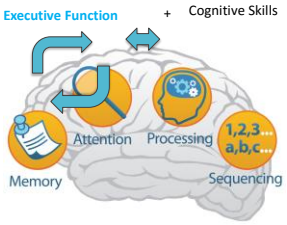
The shortfall: Human Brains are complex systems with multiple processes occurring simultaneously (and hopefully in coordination).

In fact, recent research supports the idea that multiple mental processes are involved in just about everything we do and they have to work together.

Brain training, to be effective, must address the integration of multiple systems.

The Role of Neuroscience Technology- addressing multiple cognitive systems

- Well designed neuroscience-based technology
- **builds the underlying capacities that are reduced in some children of poverty or with learning issues**



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Condition 3. Continued practice is required for continued benefits.

- **The idea behind brain training is that getting skills to the level of automaticity so that they are used in real life, means that real life becomes the practice**

Condition 4: Training must adapt to performance, require effortful attention, and increase in difficulty

- **The shortfall:** This is all true, but it neglects what we know about what actually motivates effortful attention and persistence in training.
- Students don't care how much you know until they know how much you care.
- **The design of the training program needs to be motivational, engaging and reward, not just demand, persistence.**

Protocol

- **Condition 5:** It requires a minimum "dose" of 15 hours total per targeted brain function performed over 8 weeks or less.
- **The shortfall:** It's refreshing, actually, to see a consensus emerging that a few minutes or hours of training here and there won't do much for cognitive fitness.
- **a dramatic impact on multiple brain functions is achieved in 35 to 50 hours of training in an integrated fashion**

Questions?