

# Poverty's Impact on the Brain



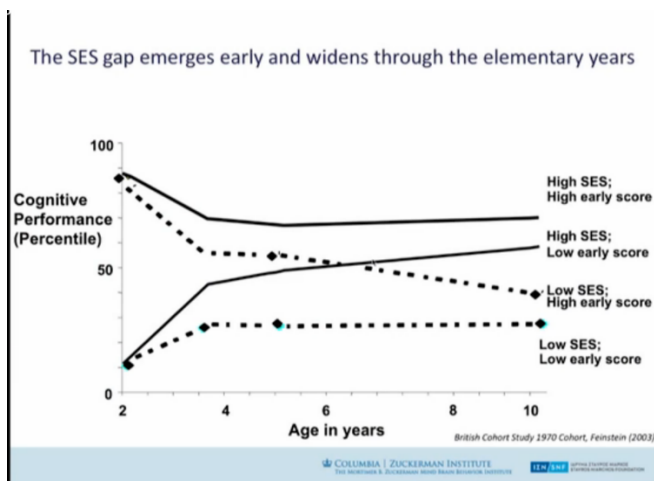
*Horacio Sanchez*

## How Do We Know Poverty Is to Blame?

- Electroencephalogram (EEG)
  - We can measure the electrical activity of the human brain by placing electrodes on the scalp and amplifying the signal
  - This signal can be decomposed into oscillations occurring in different frequency bands
- Children at-risk for learning and attention disorders tend to exhibit
  - Excess low-frequency oscillations
- No socioeconomic disparities in brain function at birth
- Family income associated with increased high-frequency power in the first year of life
  - Brito, Fifer, Myers, Elliott, & Noble, 2016 Developmental Cognitive Neuroscience

## How Do We Know Poverty Is to Blame?

- These differences weren't present at birth
  - Age 1 - infants' brains were basically the same
  - Age 4 - gray matter in infants in low-income families less
  - Hanson and Wolfe 2013

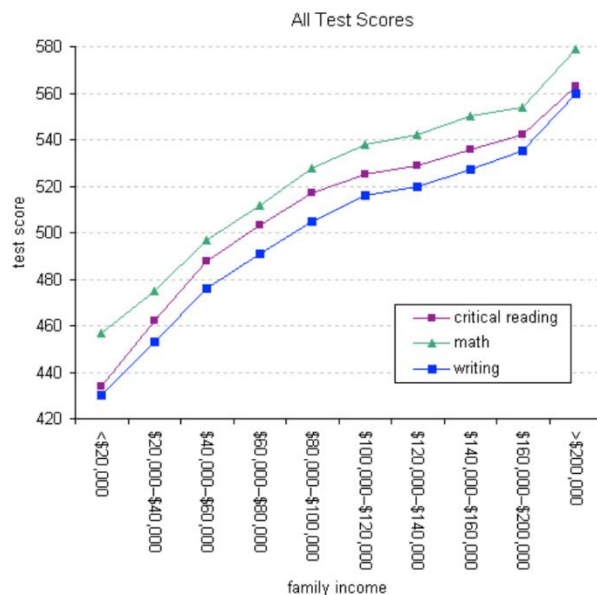


## Socioeconomic status is strongly associated with cognitive ability and achievement during childhood and beyond.

- Predicts IQ
  - (Liaw & Brooks-Gunn, 1994; Smith, Brooks-Gunn & Klebanov, 1997)
- Achievement test scores
  - (Brooks-Gunn, Guo & Furstenberg, 1993)
- Grade retentions and functional literacy
  - (Baydar, Brooks-Gunn & Furstenberg, 1993)
- Stronger associations with cognitive performance than health and behavior
  - (Duncan, Yeung, Brooks-Gunn & Smith, 1998)

## What Poverty Does to the Human Brain

- A study found children living in households just above the federal poverty level had
  - Gray matter volumes 3 to 4 percentage points below the norm
- Children living below the federal poverty line
  - Gray matter volumes were 8 to 10 percent below the norm
- On average, these kids performed 4 to 7 points worse on standardized tests.
  - Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2016). Association between child poverty and academic achievement-in reply. *JAMA Pediatrics*, 170(2), 180.



## The Attack on The Prefrontal Cortex

- Another study found families with a yearly income of less than \$25,000
  - 6 percent less total brain surface area than kids from families reporting more than \$150,000
- As parental income dropped, so did performance on cognitive tests.
- The gap was especially pronounced in areas involved in language, reading, executive functions, and spatial skills

- Noble, Kimberly & Houston, Suzanne & Brito, Natalie & Bartsch, Hauke & Kan, Eric & M Kuperman, Joshua & Akshoomoff, Natacha & Amaral, David & S Bloss, Cinnamon & Libiger, Ondrej & Schork, Nicholas & S Murray, Sarah & J Casey, B & Chang, Linda & M Ernst, Thomas & Frazier, Jean & Gruen, Jeffrey & Kennedy, David & van zijl, Peter & R Sowell, Elizabeth. (2015). Family Income, Parental Education and Brain Structure in Children and Adolescents. Nature Neuroscience. 18. . 10.1038/nn.3983.

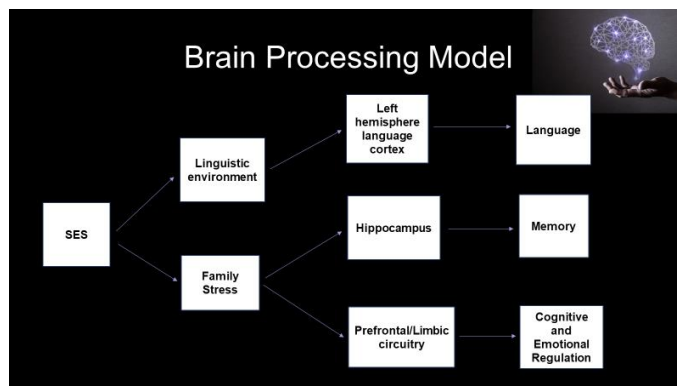
### Greater Surface Area Associated with Intelligence

“By age 10, more intelligent children tend to have greater brain surface area than less intelligent children.”

- Kimberly Noble, MD, Ph.D. 2015

### Which core cognitive systems are most highly impacted by SES?

- Executive function
- Visuospatial skills
- Memory
- Language



### Poverty Requires a Three-Prong Approach

1. Modify how we provide instruction
2. Build skills to overcome specific skill deficits
3. Address capacity issues

### Modify How We Provide Instruction

### Neuroscience Big Takeaways Concerning Learning

#### 1. The Importance of Repetition In Learning

#### The Brain Utilizes More Energy When Engaged in New Learning

- There is a spike in energy, especially in the regions primarily responsible for the task.
- As mastery improves, the energy required will diminish.

- We all have a limit to the level of energy we can generate at one time or over an extended period of time.

### The Human Brain Cannot Multitask

### The NIH Study on Learning

- For every section of learning, there are core elements which must be automated for students' brains to be able to grasp advanced concepts.
- If it is not automated, all additional information taught will require too much energy resulting in reduced comprehension.

### What Are Teachers Required to Do?

- Identify essential core information for every section of learning in the curriculum
- Conduct quick reviews while teaching the section
- Have an efficient way for information to achieve automation

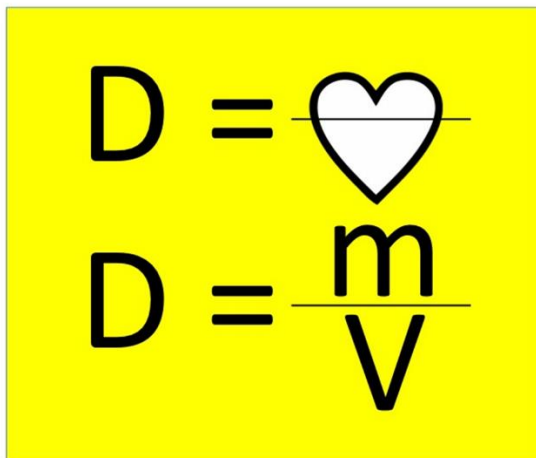
### Learning

- A change in the connection of neurons
- Enhanced learning is the ability to strengthen the connection between neurons
  - LTP (long-term potentiation) – the process by which neurons are activated together
  - Over time resulting in the activation of one produces the activation of the network
  - The brain can bring back information at increased speeds with minimal effort

### Neurons That Fire Together Wire Together

- Long-term potentiation
- Max Cynader
  - [1] Cynader, M (2013) “Enhancing the plasticity of the brain: Max Cynader at TEDxStanleyPark” <https://www.youtube.com/watch?v=Chr3rQ6Vpcw>
- Strategies
  - Chunk, symbols, rhythmic patterns, movement

### New to Familiar



## **Bloom's Five Year Study**

In 1986 a study of genius in six fields (concert pianists, sculptors, tennis stars, Olympic swimmers, research mathematicians, and research neurologists) found striking similarities

- Top 25 in their field under the age of 35
  - Took at least 12 to 16 years to get there
  - 25 to 50 hours of practice per week
  - All began learning-related skills very early

## **Bloom's Conclusions**

- Only at a level of automaticity can the brain make new and profound connections
  - Higher level connections cannot take place until certain related functions are automatic
- Numerous other researchers have also concluded that the clearest index of automaticity is that other conscious cognitive processes take place simultaneously (Barrick and Shelly 1958; LaBerge and Samuels 1974)
  - It is not automatic until other conscious cognitive processes take place

## **2. Abstract Concepts Are Best Taught in a Brain-Compatible Manner**

### **Advanced Comprehension of Concepts Through Embodied Cognition**

#### **The Brain Cannot Fully Comprehend an Emotion Without Reenacting**

- A 2009 study used electromyography to measure facial muscle activity.
- Reading emotional words triggered subtle facial muscle activity that people express when experiencing those emotions.
  - Words that typically evoke disgust such as vomit, foul, anger, murder; stimulated increased activity in the facial muscles.
    - Lip
    - Nose
    - Brow
- No movement – no meaning
  - After you have done the movements repeatedly, there is cognitive understanding.
    - Niedenthal



#### **Reduce the Body's Signals to the Brain and Lose Valuable Information**

- In 2009 neurologists gave participants Botox injections to the forehead.
  - Muted activity in the amygdala
  - Participants asked to mimic unhappy expressions
- Thwarting muscle activity jammed the neural circuits needed to fully process negative emotion.
  - No movement – lost meaning
  - Bernhard Haslinger and his colleagues at the Munich University of Technology

## Abstract Concept of Time

- 2010 study using motion sensors to detect tiny movements
- Participants thought about something in the past or future.
  - Thinking about the past caused people to sway about two millimeters backward.
  - Thinking about the future caused them to sway imperceptibly forward.
    - Psychologist Lynden Miles of the University of Aberdeen in Scotland

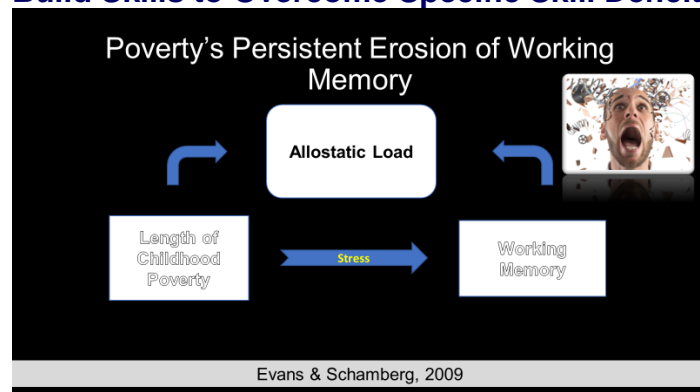
## Gestures as a Teaching Strategy

- Students said aloud, "I want to make one side equal to the other side."
- Some students repeated the words and made hand movements that grouped two of the addends: for  $8 + 3 + 5 = \_ + 5$ .
  - Children made a V and placed it under the 8 and the 3.
  - Then they pointed at the blank with the same hand.
- Students who gestured solved the most problems.
- Even students who gestured wrong, got more correct answers than did those who did not gesture about grouping at all.
  - A study published in 2009 Susan Goldin-Meadow

## 3. Higher Level Thinking Should Be an Exercise in Connecting Prior Learning

- Some of the Greatest Discoveries by the Act of Putting Information Together
  - James D, Watson (Nobel Prize winner)
- Discovered the structure of DNA
  - "In place of pencil and computers, the main working tools were molecular models superficially resembling the toys of preschool children. All we had to do was construct sets of models and begin to play."

## Build Skills to Overcome Specific Skill Deficits



## Nurturance and Stress

- Childhood parental nurturance influences hippocampal development
  - Rao et al, 2010, Neuroimage
- Childhood parental nurturance influences stress reactivity
  - Daniel Hackman
- Preschool and elementary school nurturance seems to be a stress reducer.

## Memorization Technique

- Expression Mnemonics
  - "Every Good Boy Does Fine" can help you remember the lines of the treble clef in music (EGBDF).
- Music Mnemonics
  - Learned the alphabet through the ABC song
- Rhyming Mnemonics
  - "30 days hath September, April, June, and November"
- The Rhyming Peg System
  - For each number, you memorize an image of a word that rhymes with it.

## Create a Memory Palace

- You associate a location you're familiar with – such as your apartment, the block you grew up on, or the route you take to work or school—with the items you're trying to remember.
  - Visually pegging (or "placing") to remember in places you already have strong memories of.
  - Mentally walk through this palace noticing distinctive features you can use to store things you want to remember.
  - The more visual, animated, and outrageous you can make your memories, the better.

## Address Capacity Issues

### Poverty Results in Loss of Grey Matter

- Build grey matter – speed repetitive tasks
  - Juggle three-balls for three months increased brain gray matter in the cortex (Draganski, B., et al. 2004).

### Why Is Poverty Today Different?

- The most stressful part of lower socioeconomic status might not be deprivation but the subjective perception of our lower social standing.
- A lower subjective perception of one's own social status correlated with reduced gray matter in the anterior cingulate.



### Anterior Cingulate Processes Feelings of Empathy

- Empathy is almost as important as procreation
- Sociopaths and psychopaths

### Empathy Definition

The observation of an action or perception or emotional state in an individual that activates a corresponding representation in the observer.

### Self-Reported Empathy Dropped over Last 30 Years



- Analysis of some 14,000 college students surveyed over the last three decades. - Steve Mirsky; Sara H. Konrath of the University of Michigan at Ann Arbor
  - A healthier segment of the population
- Empathy really took a nosedive in the last 10 years. - Jamil Zaki, “What, Me Care?”
  - The dramatic change in how young people communicated

### **Empathy Is Important**

- Key in social interaction
- Imperative to learning
- Regulator of emotions and violent outbursts

### **Facial Expressions**

- Most highly differentiated and versatile set of neuromuscular mechanisms in man
- The face reflects at least nine major emotions: interest, enjoyment, surprise, distress, disgust, anger, shame, fear, and contempt.
- As emotions get higher, the amygdala takes control of facial muscles and nerves by configuring automated chemical responses to how the stimuli are being perceived.
- Experiment

### **Facial Expressions Impact Mood and Communicate Strong Messages**

- Communicate safety or threat
- Numerous studies have found that we remember faces better if they look like yours.
- Insight into moods
  - Mimicking elicits empathy
- Alter mood – by changing facial expressions

### **Hand Gestures**

- The limbic system takes control of hands quicker and more directly than any part of the body.
- Subconscious interpretation of truth
- First formal language in infants and in history
  - Improves infant language acquisition (Goodwyn, Acredolo, and Brown 2000)
  - Improves the number of verbal commands that a dog can learn



### **Body Movement and Posture**

- Dramatic movements and sustained body positions
  - Sustained more than two seconds a body movement becomes a posture
  - Mimicking someone's posture provides insight into their emotional state.
  - Mimicking body posture is a method to build rapport.

### **Self-Touch**

- Arousal level of the sympathetic nervous system—fight-or-flight response
- Cue that someone is stressed
- Method of self-medication



- Sexual predators identifying victims with low self-esteem
- Significant role in mating rituals (studies validated in bars across the country)

### **Tone**

- Limbic system can unconsciously tighten the alimentary canal changing tone
  - That is why voice qualities change under emotional conditions
  - There is a hidden battle for dominance in every conversation -- modulating the lower frequencies
- Humans are preprogrammed to react to certain tones:
  - Crying
  - Screaming, startle reflex
- People with their amygdalae removed can no longer react to tones of fear and anger.

### **Empathy Imperative to Learning**

- What embodied cognition taught us
  - The subconscious actions of the brain are always at work to help give us meaning our world
- Imagine never having literature move us to laughter or tears
- Imagine all history having the same emotional value
- Imagine motor neurons never reacting to help us feel and understand what we were feeling when engaged in learning

### **Increased Communication Through Technology**

- Empathy is developed through interpersonal interaction
  - Like a muscle
    - Skill is rewiring during adolescents
- Babies and language

### **Lower Empathy Increases Mistreatment of Others**

There is evidence that empathic responses are dampened when the observer is a different race than the observed (Cikara, Bruneau, & Saxe, 2011).

### **The Second Layer to Poverty That Is Often Overlooked**

America is one of a few countries where race and poverty have such a close correlation.

### **Longitudinal Studies Tracking Poverty over Six Years**

- One-quarter of the white children lived in families that experienced poverty.
- Two-thirds of black children lived in families that experienced poverty.
  - Panel study of income dynamics
- Blacks are also 20 times more likely to live in concentrated poverty.
  - 40% or more of a neighborhood is poor

### **The Association of People of Color to Poverty Has Created a Bias**

Misleading many to associate the conditions of poverty to be inherent parts of the culture of people of color

## **The Brain Learns by Making Associations**

- Implicit Bias
  - Things paired regularly – you think of one; the brain automatically brings up the other
  - Without this ability, you could not navigate the world
  - The problem is that the brain automatically connects things you would not consciously want to be connected.

## **The Outcomes of Poverty Have Been Well Documented**

- Poorer academic performance
- Bad decision making
- Emotional and behavioral problems
- Aggression and drug use
- Greater risk of emotional disorders

## **Yale Child Study Center**

- Found that early education staff members tend to closely observe black students, especially black boys because challenging behaviors are expected.
  - Microsaccades
- Preschool teachers expected negative behaviors even when no such behaviors were present.

## **Bias Creates Behavioral Expectations**

- Researchers presented school teachers with two fictional male student disciplinary records (Okonofua, & Eberhardt, 2015).
  - Records labeled with either a stereotypical black name or stereotypical white name.
  - Both fictional students had engaged in the same minor school violations.
    - Teachers felt more “troubled” by the offenses of the black student and recommended severe punishment for the black student after the second infraction even though the white student had the same identical record.

## **Bias Outcomes**

- School data indicates disproportionate rates of disciplinary referrals and exclusionary practices for black boys that are not accounted for by other factors (Skiba, et al. 2011).
  - Black preschoolers are 3.6 times as likely to receive one or more suspensions than white preschoolers (U.S. Department of Education, Office of Civil Rights, 2016).
    - Black children comprise only 19% of preschool enrollment but comprise 47% of preschoolers suspended one or more times (Gilliam, W.S. et al. 2016).
- The data only becomes more disparaging as black male students become older.

## **Curriculum and Bias**

- Educators must consider how curriculums create collective memory and have, therefore, biased students unwittingly.

- It is clear that the lessons of the past have not reshaped our collective conscious from the biases that plague American society.
- If education maintains the status quo, it will pass on to the next generation a future that perpetuates the past.

### Brody Conducted a Neuroimaging Study

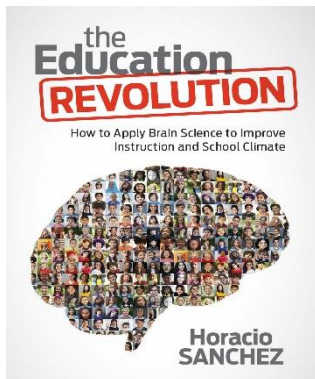
- 119 blacks age 25
  - Families living in poverty received a 7-week in-home training during the child's early adolescence.
    - Help parents/caregivers learn nurturing skills
    - Teach effective ways to discipline their youth
    - Give youth a healthy future orientation and an increased appreciation of their parents/caregivers
    - Teach youth skills for dealing with stress and peer pressure
- Outcomes
  - Larger volume size of hippocampus and amygdala into adulthood
  - Correlating with better life outcomes

### Synthetic Happiness

Our psychological immune system designed to help us overcome trauma and regain contentment.



**Horacio Sanchez**  
 President and CEO  
 Resiliency Inc.  
 Office Phone: 919-544-0616  
 Cell: 919-308-4298



*The Education Revolution is a timely book because it takes relevant findings in neuroscience and bridges the gap between brain science and education. The book illustrates how discoveries in neuroscience can be directly used to modify instruction and improve school climates to advance academic achievement and student behavior. The Education Revolution not only provides a clear explanation of relevant findings in neuroscience but also provides guidance through lesson plans that illustrate how the science can be incorporated into classroom management and instruction. The practical application of neuroscience illustrates that it is time for every teacher to join the Education Revolution!*

#### Book Review

*"Horacio Sanchez combines expertise in education, psychology, and neuroscience with extensive teaching experience and extraordinary insight into what makes us all behave the way we do. If we follow his expert advice in this book, a genuine Education Revolution is truly possible--one that reveals the greatest learner each of us can be. Our best hope for the future is having each youth learn and live up to his full potential. This is a revolution we all need."*



**DAVID L. KATZ MD, MPH, FACPM, FACP**, is the founding director (1998) of Yale University's Yale-Griffin Prevention Research Center, and current President of the American College of Lifestyle Medicine.

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