What do we know about the effects of poor neighborhoods on children's neurological development and lifelong health?

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AFTER THOMPSON: Getting Kids Out of Harm's Way - Implications for the Wellbeing of Children

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Three Core Concepts of Development

1 Brain Architecture Is Established Early in Life and Supports Lifelong Learning, Behavior, and Health

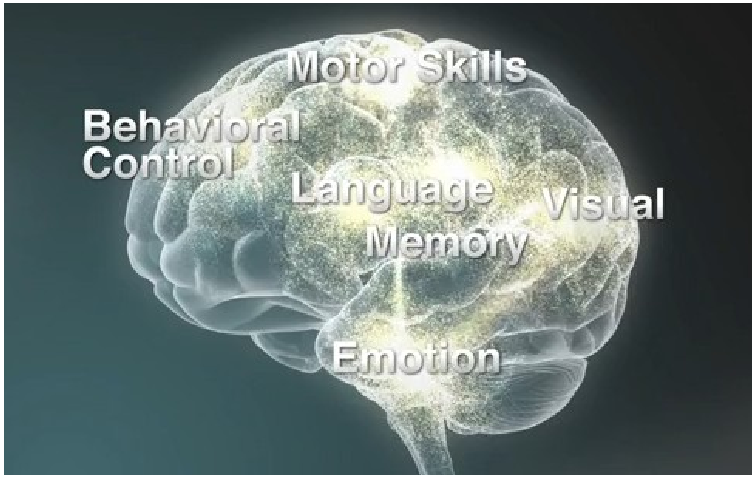
2 Stable, Caring Relationships and “Serve and Return” Interaction Shape Brain Architecture

3 Toxic Stress in the Early Years of Life Can Derail Healthy Development

Experiences Build Brain Architecture

Brain Architecture Supports Lifelong Learning, Behavior, and Health

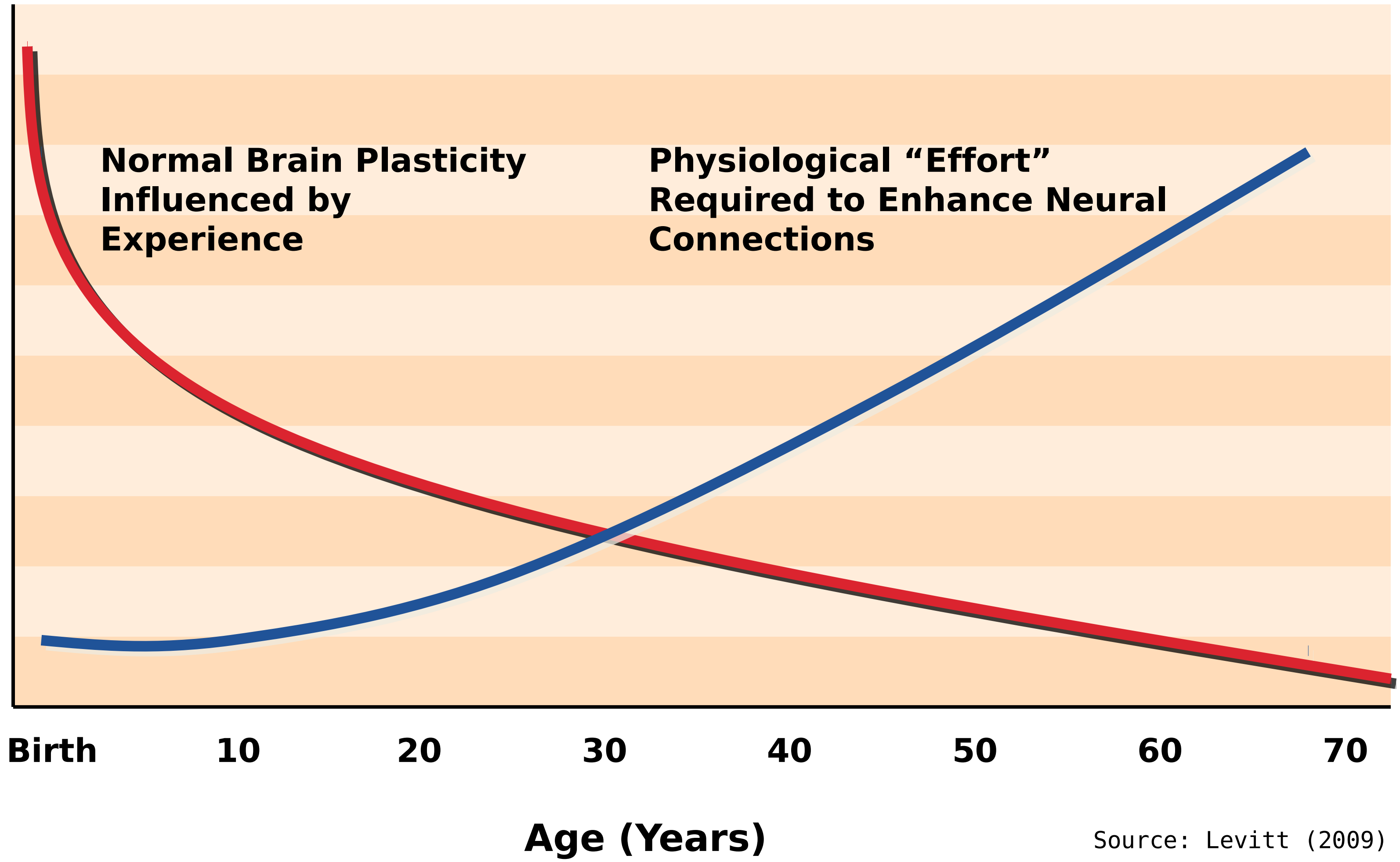
Brains are built over time, starting in the earliest years of life. Simple skills come first; more complex skills build on top of them.



Cognitive, emotional, and social capabilities are inextricably intertwined throughout the life course.

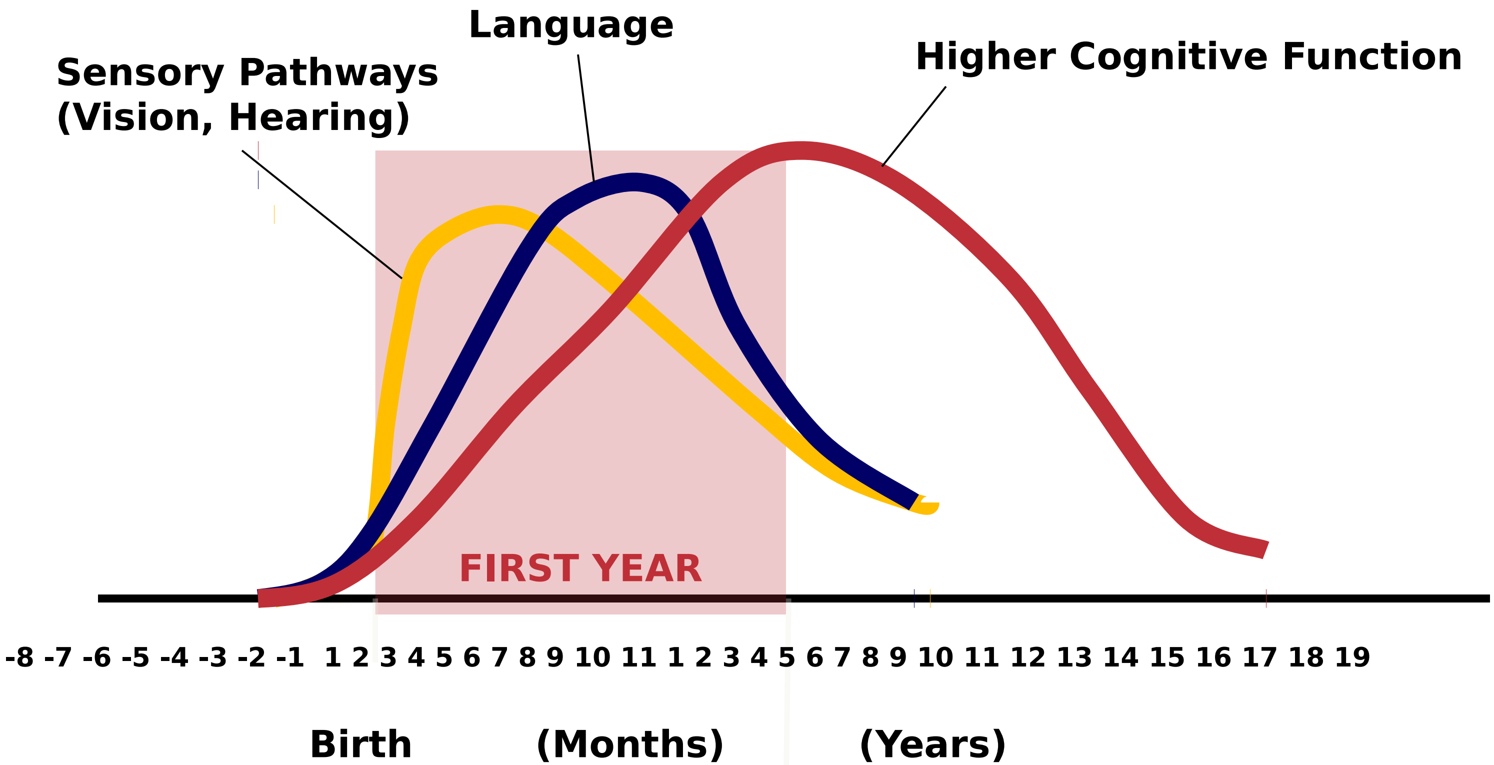
A strong foundation in the early years improves the odds for positive outcomes and a weak foundation increases the odds of later difficulties.

The Ability to Change Brains Decreases Over Time



Source: Levitt (2009)

Neural Circuits are Wired in a Bottom-Up Sequence



Source: C.A. Nelson (2000)

Critical Period, Brain Architecture & Interventions

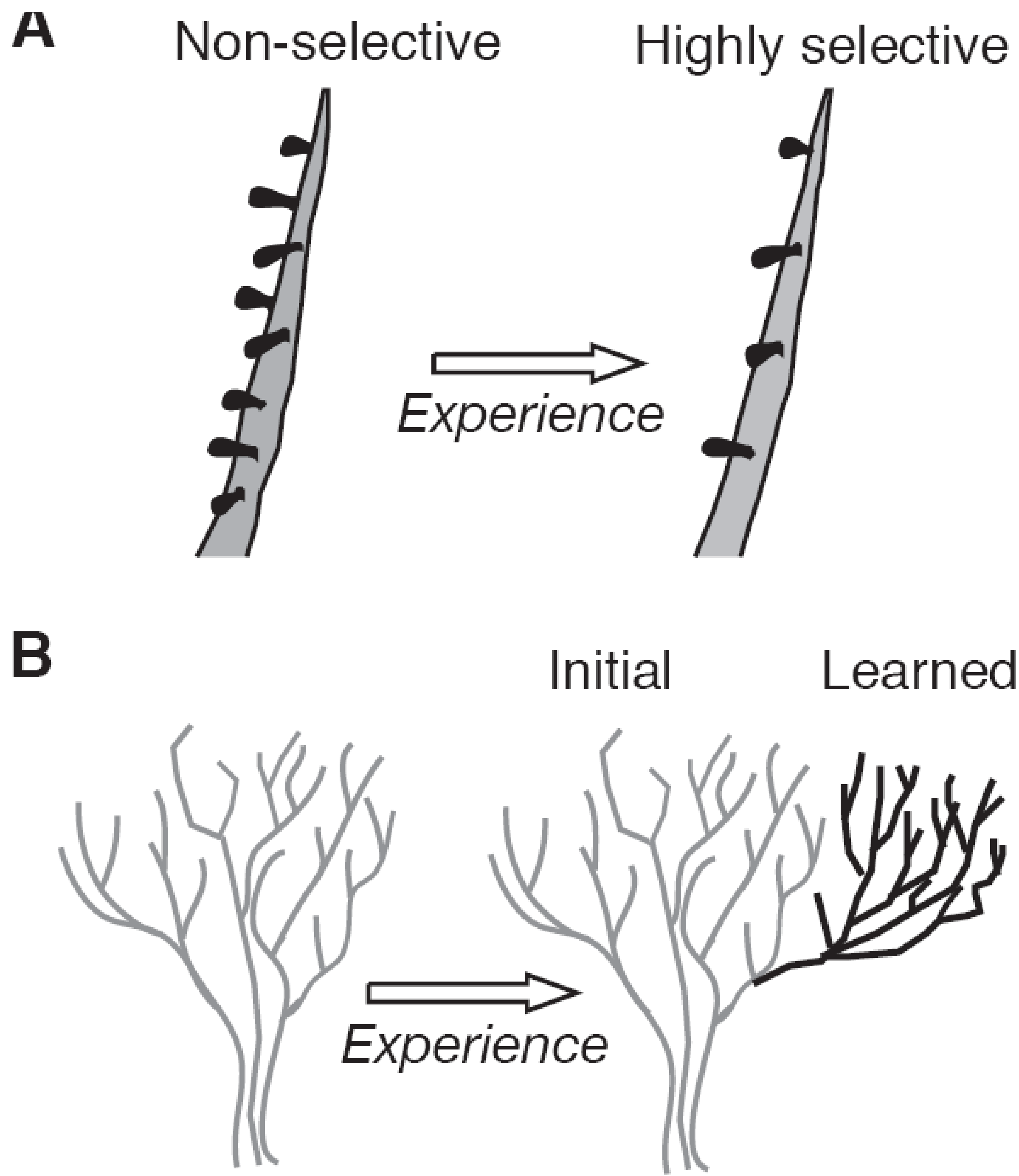
Critical Period

time during development when a reversal of architectural change, caused by a manipulation, can occur; the period ends when reversal is no longer possible

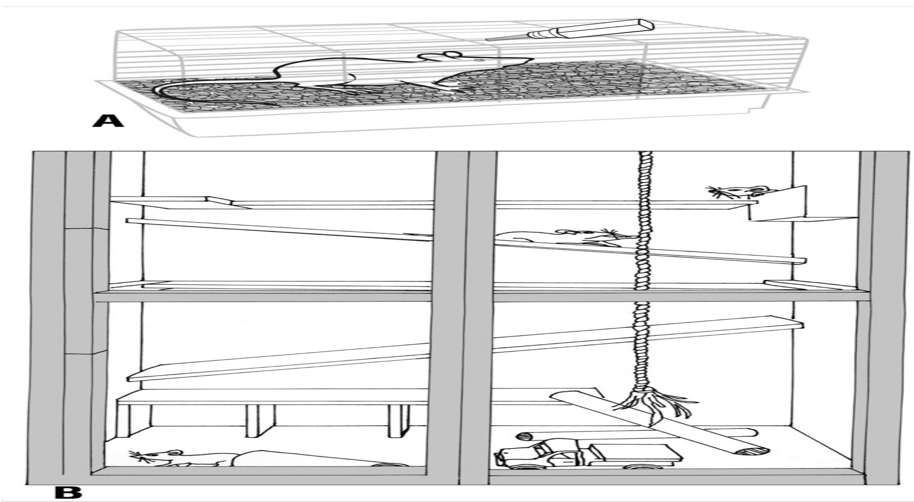
Sensitive Period

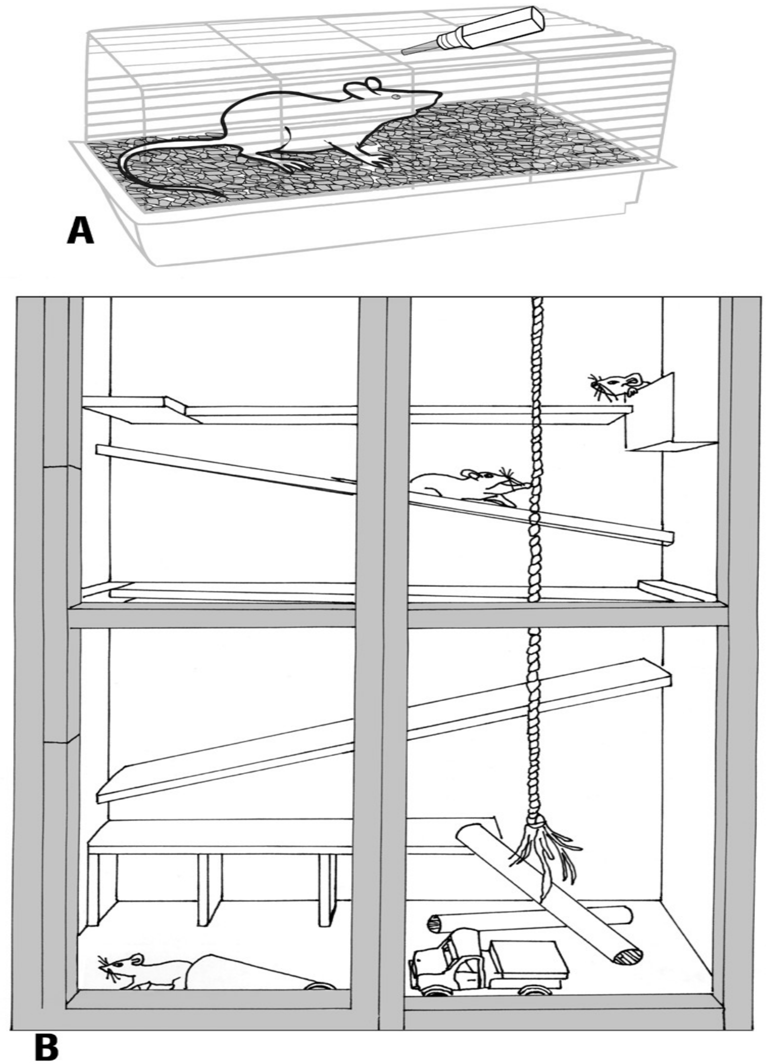
the time during development when a specific manipulation changes the brain structure

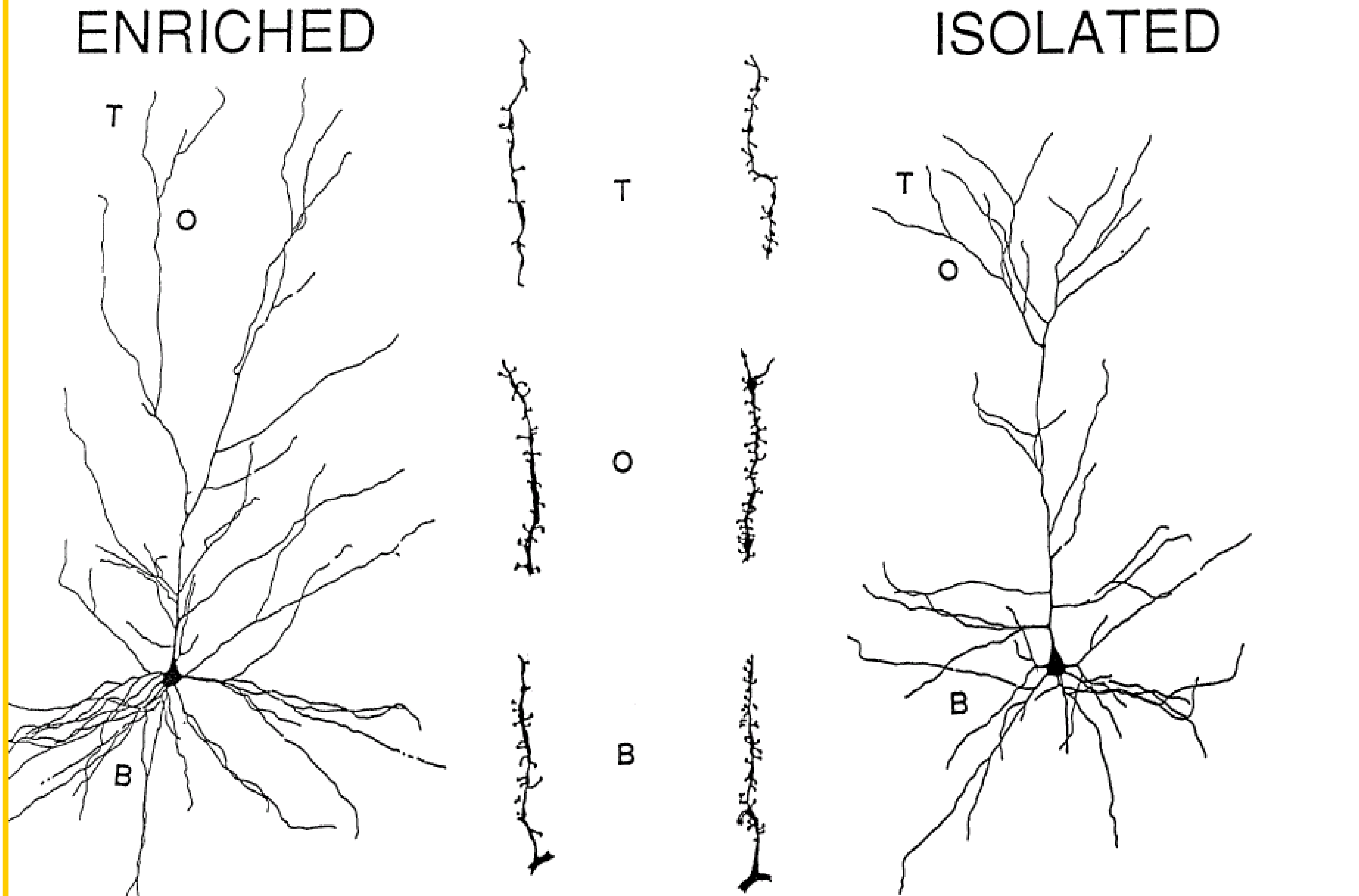
Window of opportunity


A
Non-selective
Highly selective
Experience
B
Initial
Learned
Experience

Early Experience Changes Brain Architecture – The Tale of Two Environments






ENRICHED
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Experience Shapes Brain Architecture by Over-Production Followed by Pruning

(700 synapses formed per second in the early years)

birth

Interaction Shapes Brain Circuitry

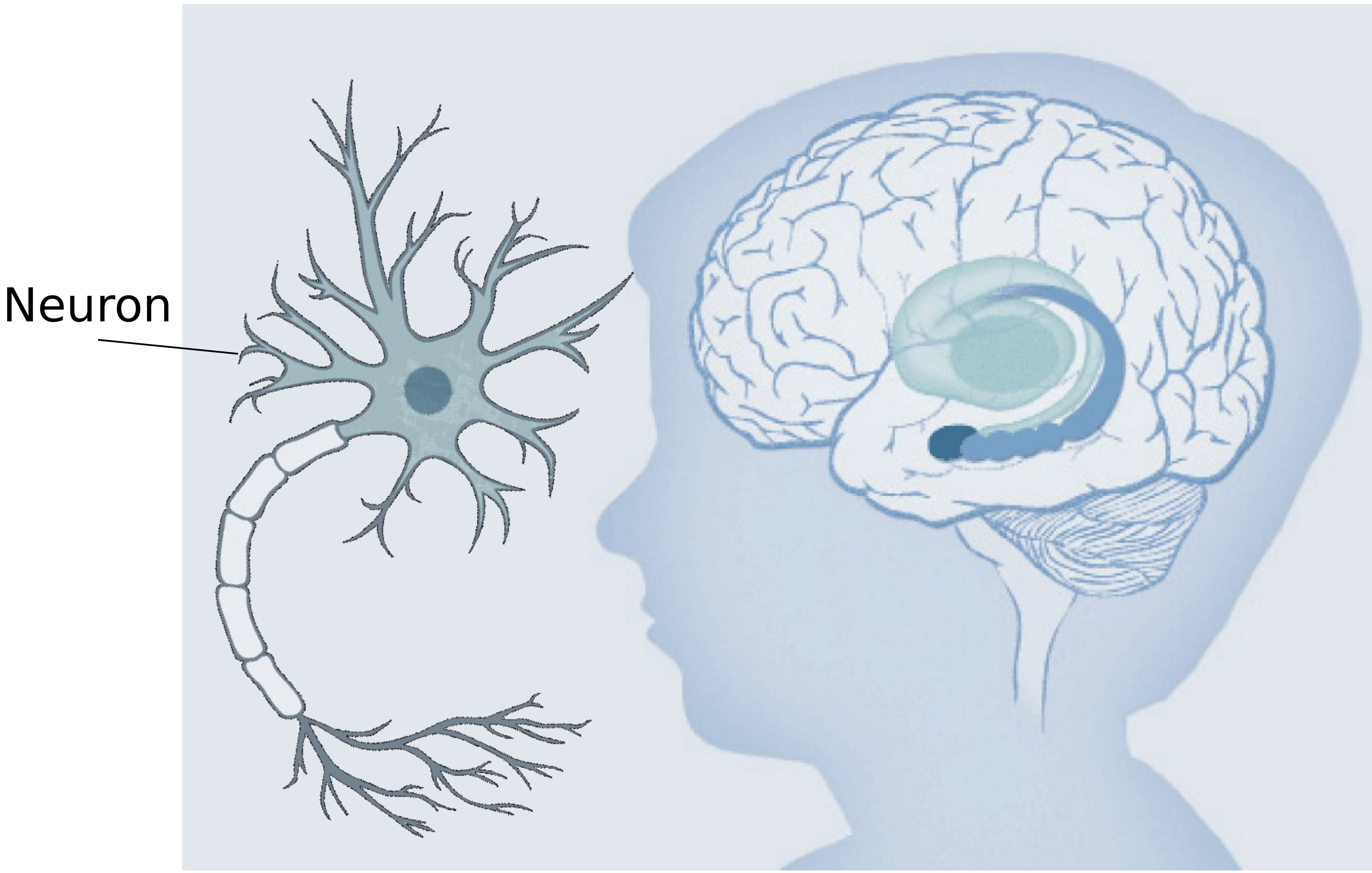
Serve & Return Builds Brains and Skills

Young children naturally reach out for interaction through babbling, facial expressions, and gestures, and adults respond in kind.

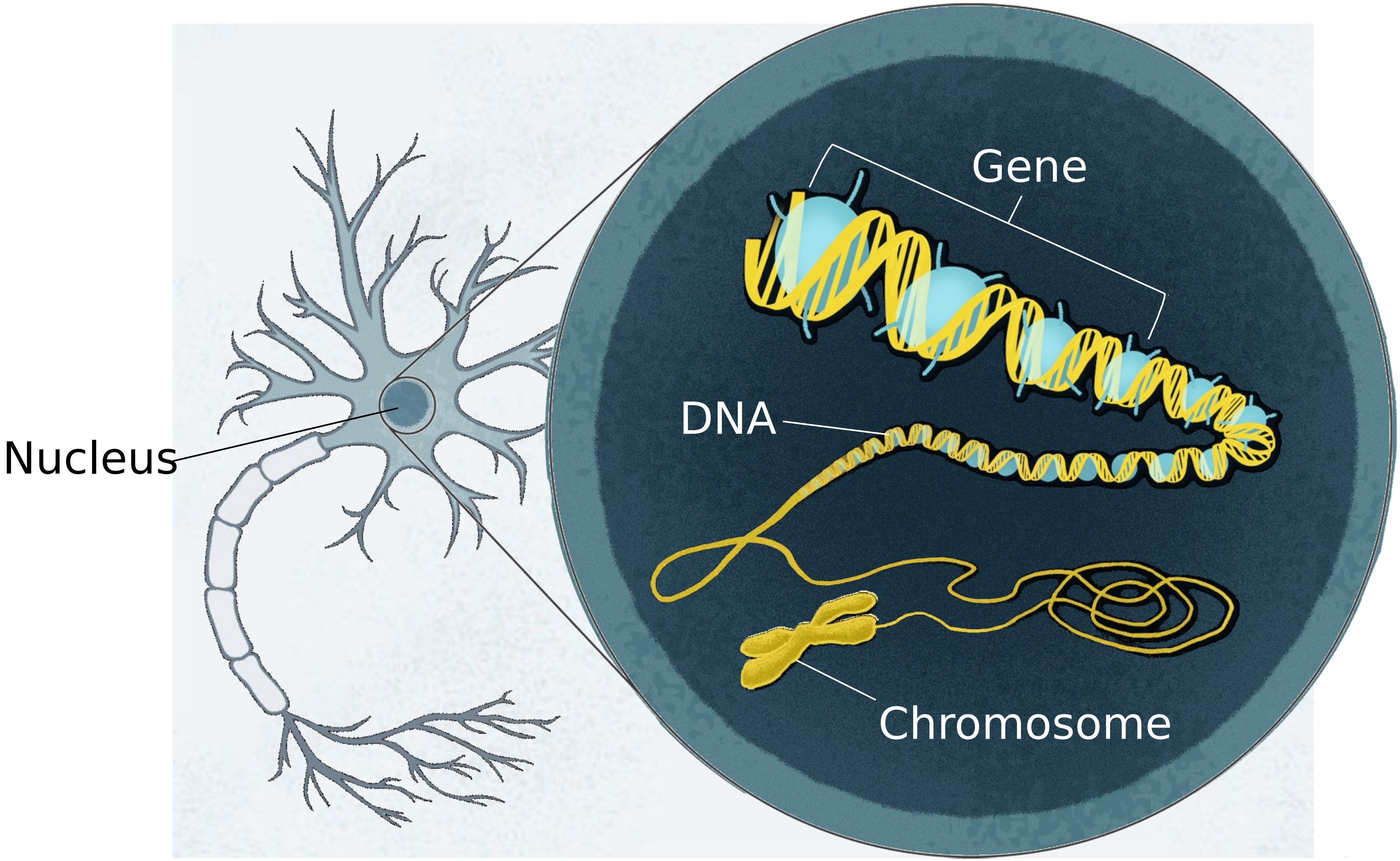
These “serve and return" interactions are essential for the development of healthy brain circuits.

Therefore, systems that support the quality of relationships in early care settings, communities, and homes also support the development of sturdy brain architecture.

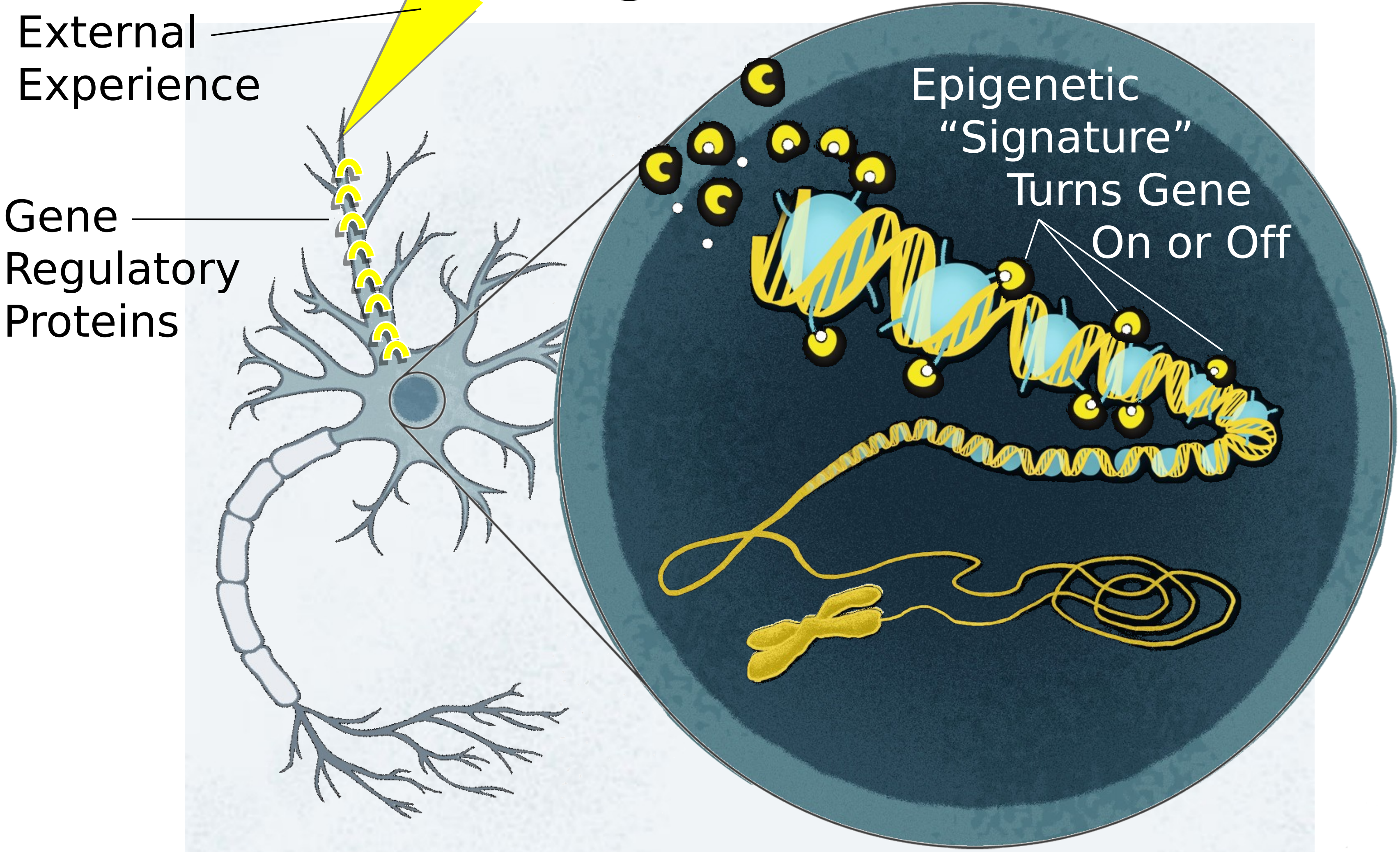
How Early Experiences Alter Gene Expression and Shape Development



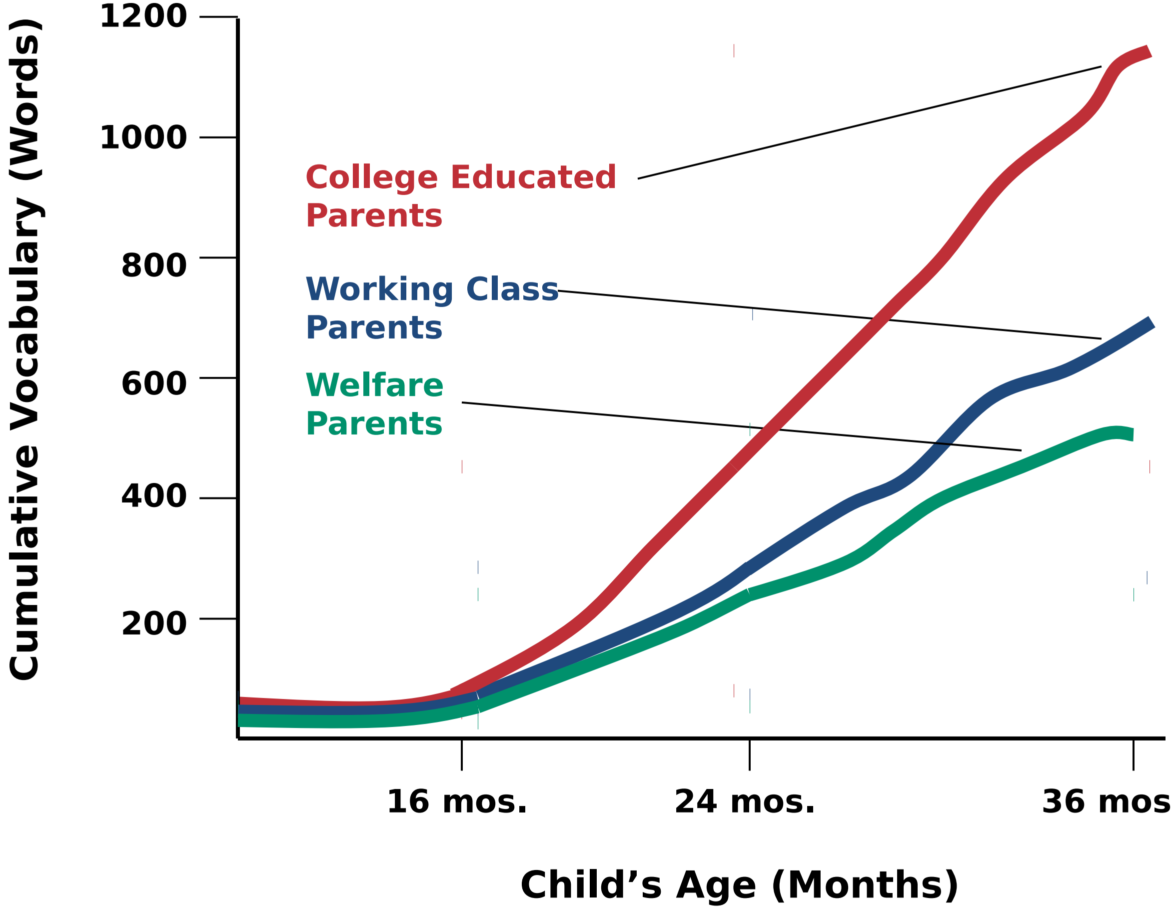
Genes Carry Instructions that Tell Our Bodies How to Work



Early Experiences Leave Lasting Chemical "Signatures" on Genes



Barriers to Educational Achievement Emerge at a Very Young Age



Source: Hart & Risley (1995)

Developmental Science

Developmental Science 16:2 (2013), pp 234–248 DOI: 10.1111/desc.12019

PAPER

SES differences in language processing skill and vocabulary are evident at 18 months

Anne Fernald, Virginia A. Marchman and Adriana Weisleder

Department of Psychology, Stanford University, USA

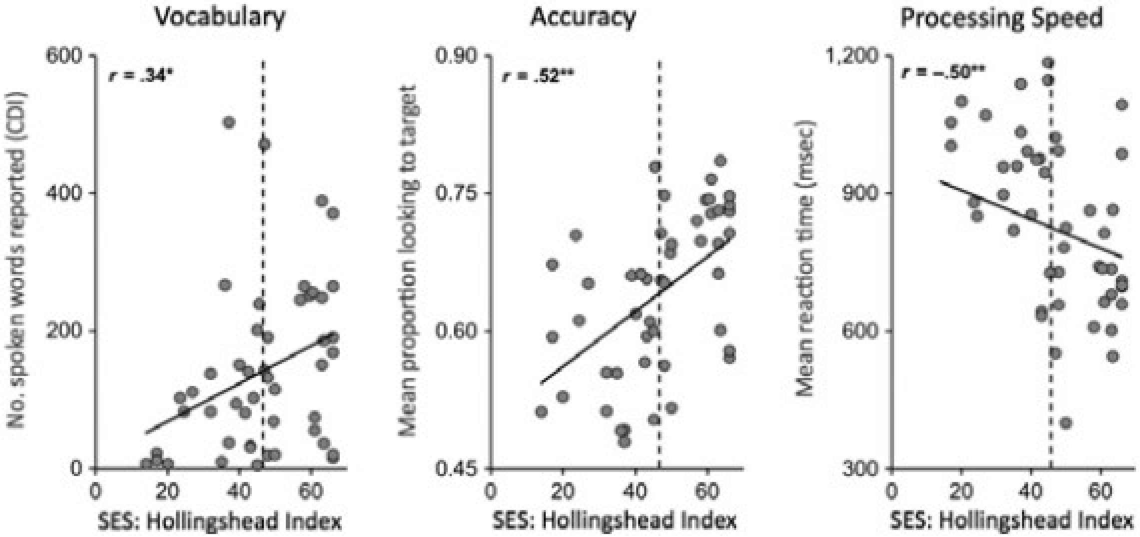
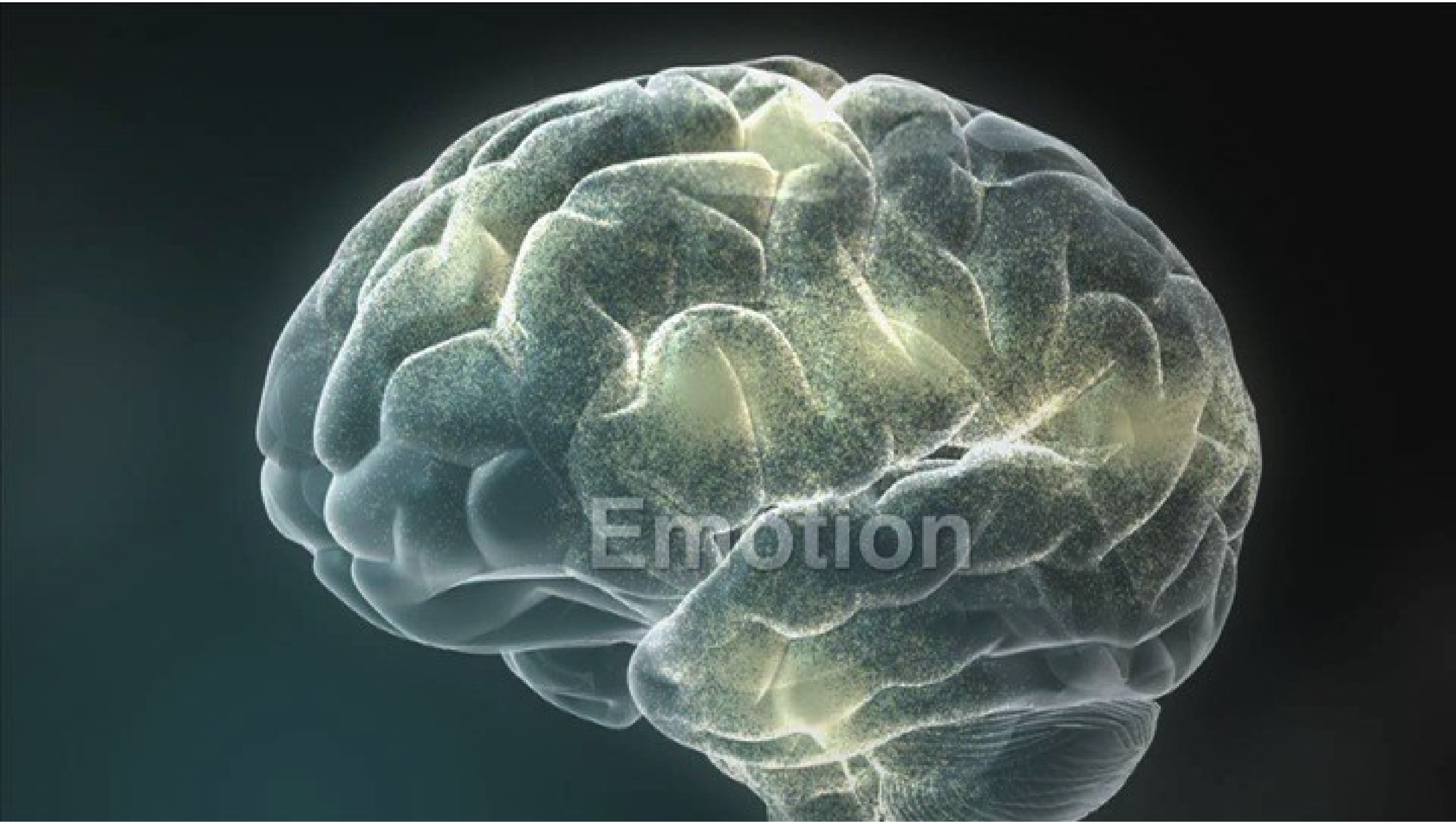


Figure 1 *Scatter plots of Vocabulary, Accuracy and RT at 18 months with SES (HI). Dashed vertical line indicates median split of HI values.*

Fernald et al (2013) Developmental Science

Toxic Stress Derails Healthy Development



The Biology of Adversity: Three Levels of Stress

Positive
Brief increases in heart rate,
mild elevations in stress hormone levels.

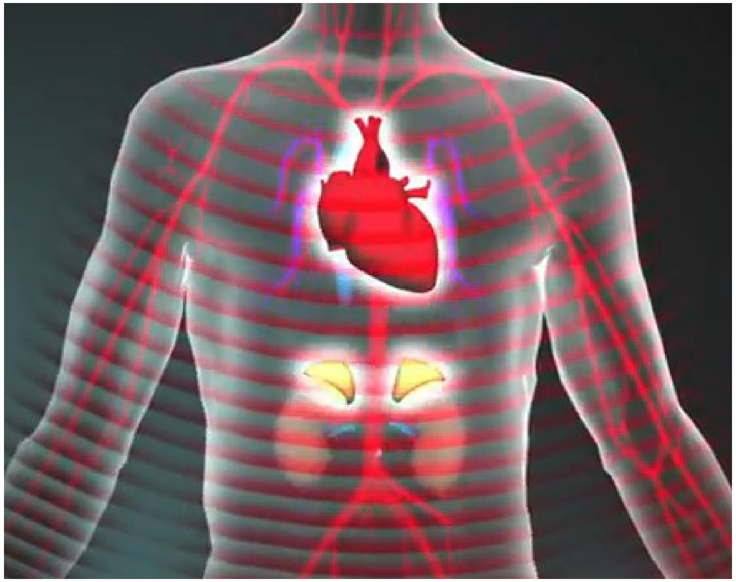
Tolerable
Serious, temporary stress responses,
buffered by supportive relationships.

Toxic
Prolonged activation of stress response systems
in the absence of protective relationships.

Relationships Buffer the Effects of Stress

Learning how to cope with moderate, short-lived stress can build a healthy stress response system.

Toxic stress—when the body's stress response system is activated excessively—can weaken developing brain architecture.

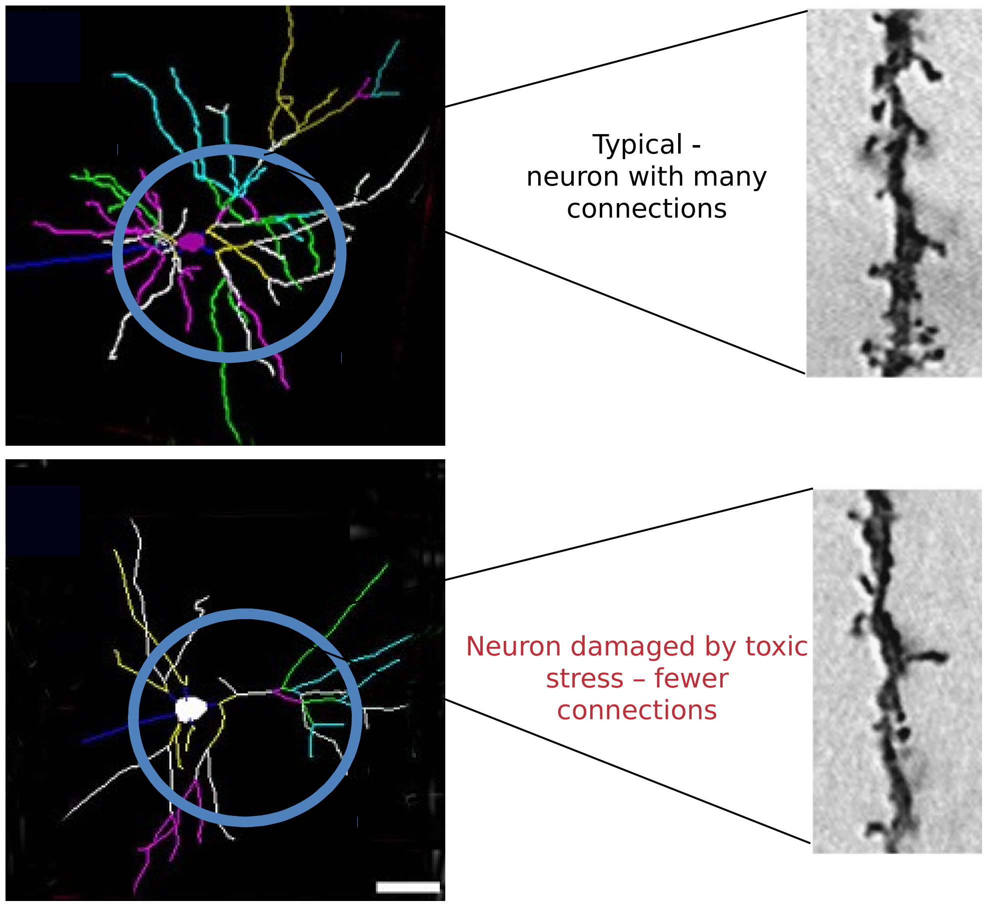


Without caring adults to buffer children, toxic stress associated with extreme poverty, neglect, abuse, or severe maternal depression can have long-term consequences for learning, behavior, and both physical and mental health.

Persistent Stress Changes Brain Architecture

Normal

Chronic stress

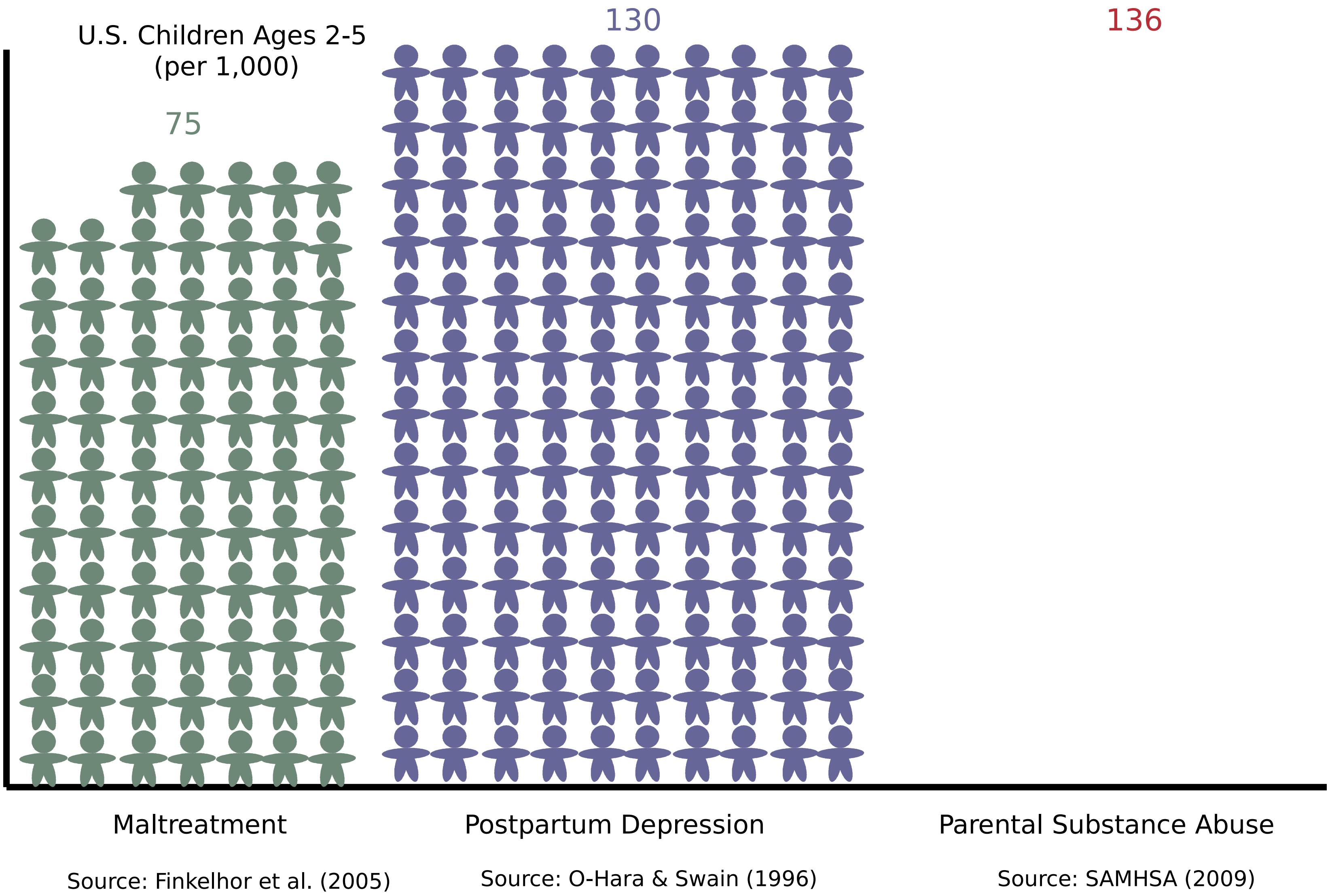


Prefrontal Cortex and Hippocampus

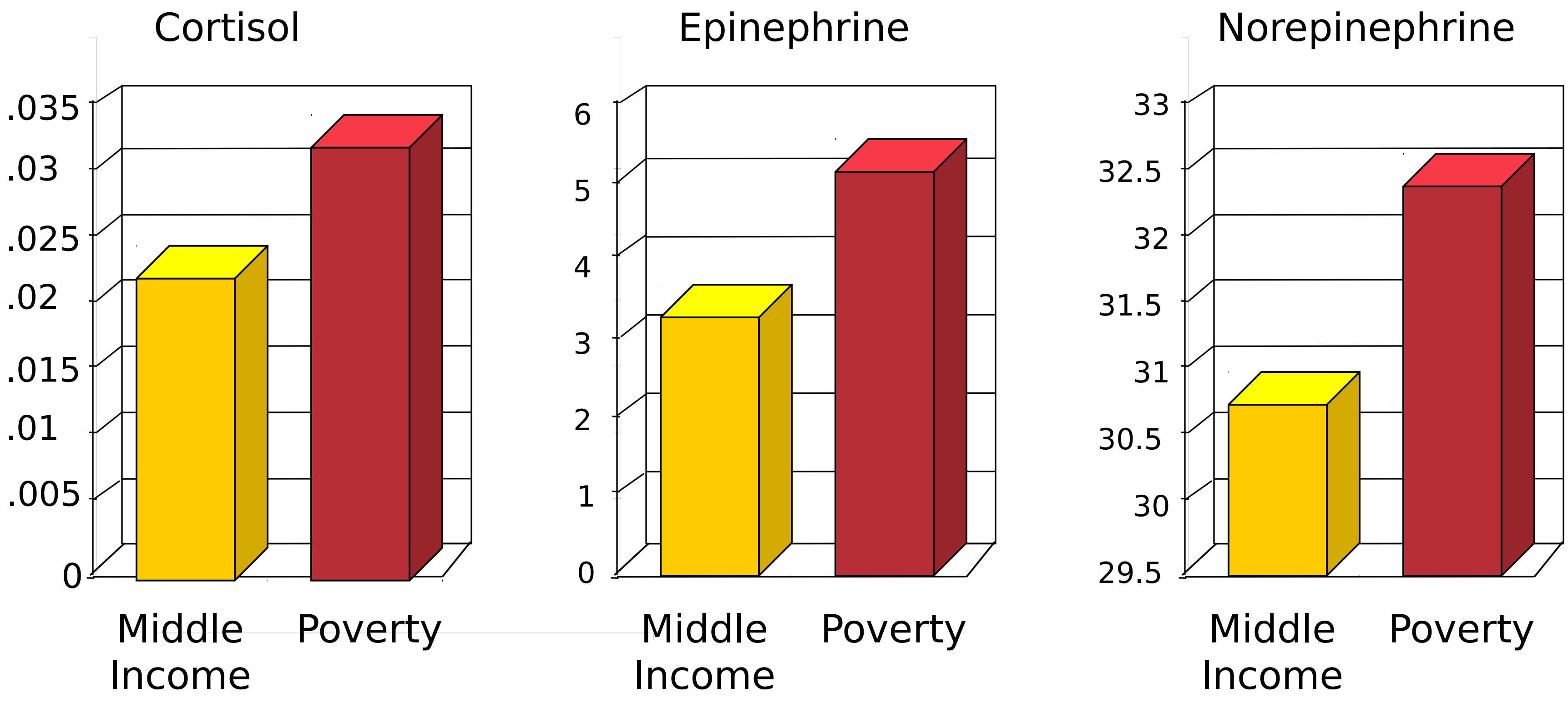
Source: C. Nelson (2008)

Bock et al Cer Cort 15:802 (2005)

Sources of Toxic Stress in Young Children



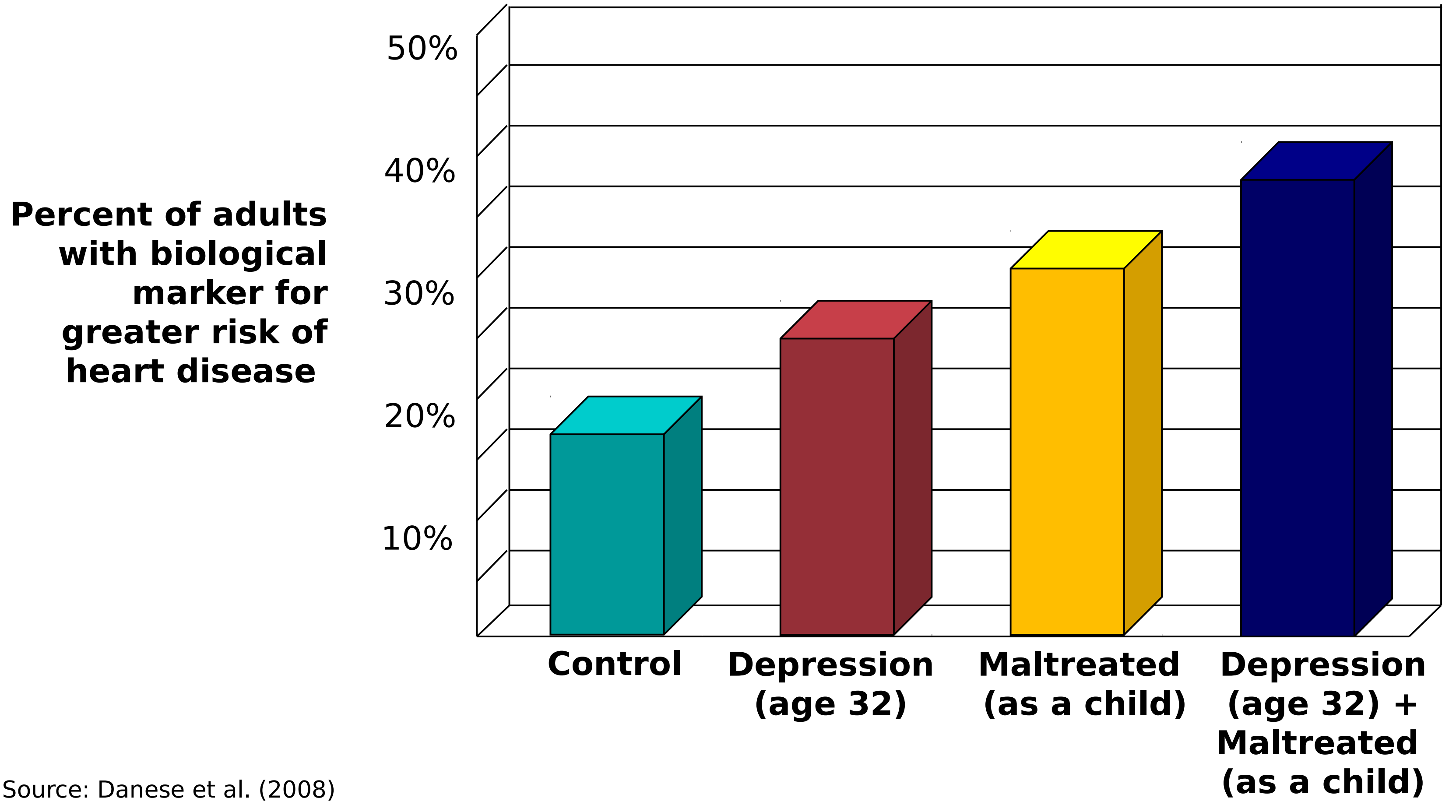
Poor Children Experience Elevated Stress



Overnight levels in rural 9-year-old white children

Source: Evans, GW and English, K. (2002)

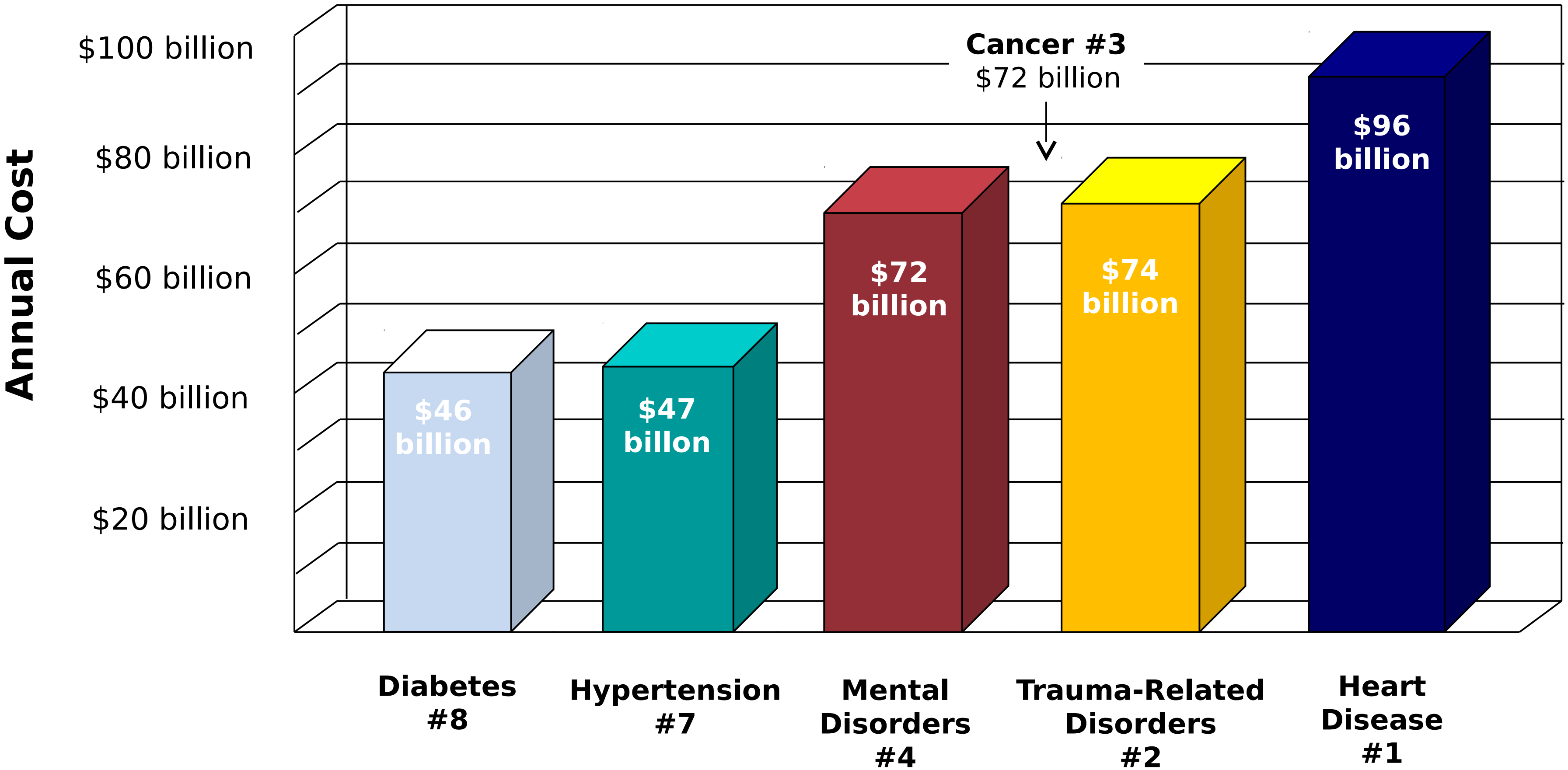
New Biological Evidence Links Maltreatment in Childhood to Greater Risk of Adult Heart Disease



Source: Danese et al. (2008)

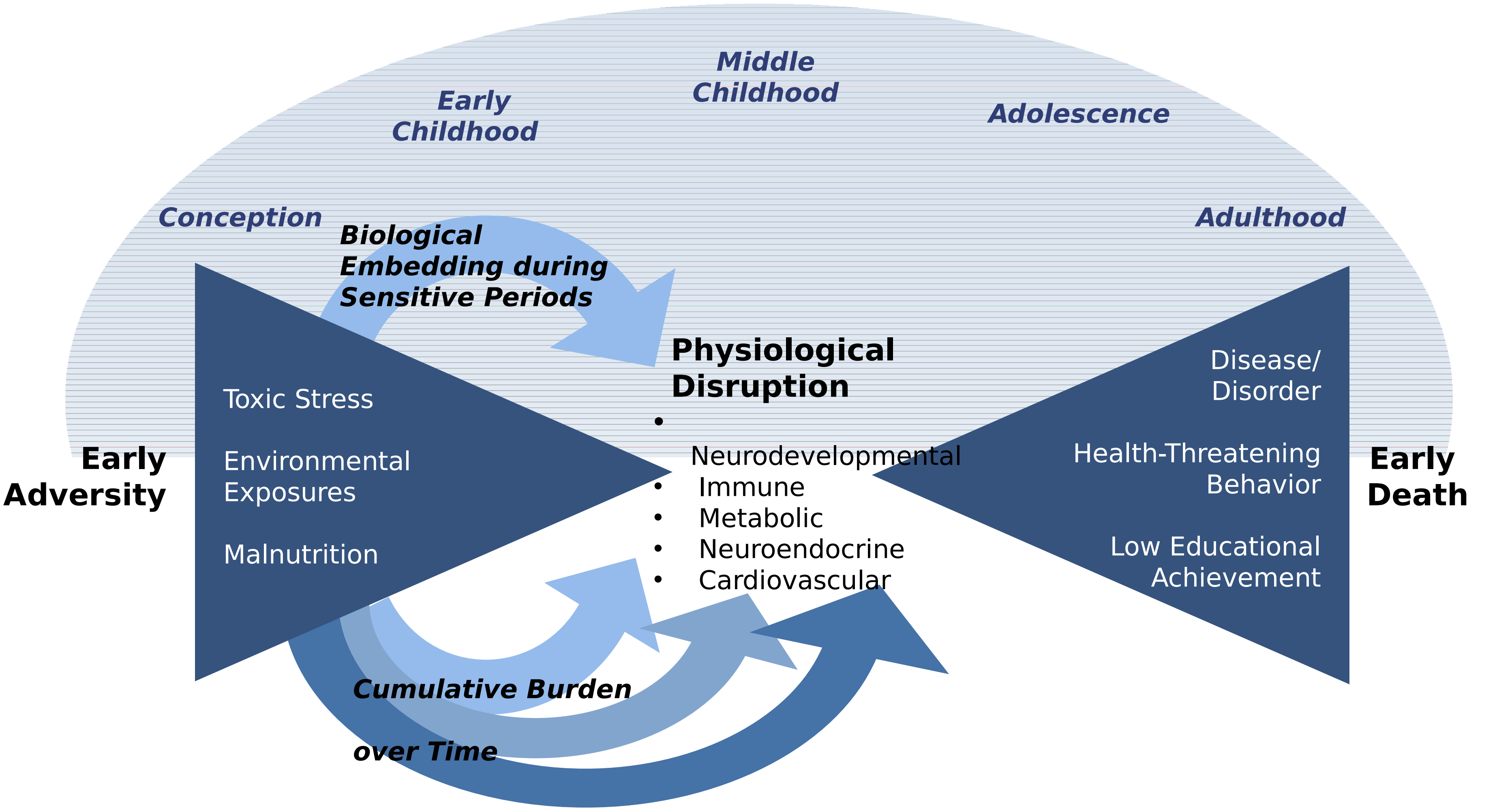
Chronic Diseases Associated With Childhood Adversity Dominate U.S. Health Care Costs

Five of Top Ten Diagnoses for Direct Health Expenditures = $335 billion



Source: Agency for Healthcare Research and Quality (2008)

The Childhood Roots of Health Disparities: How Adversity is Built Into the Body



Source: Shonkoff, Boyce & McEwen (2010)

What do we know about the effects of SES on brain development?

- Correlational studies
- Brain imaging studies

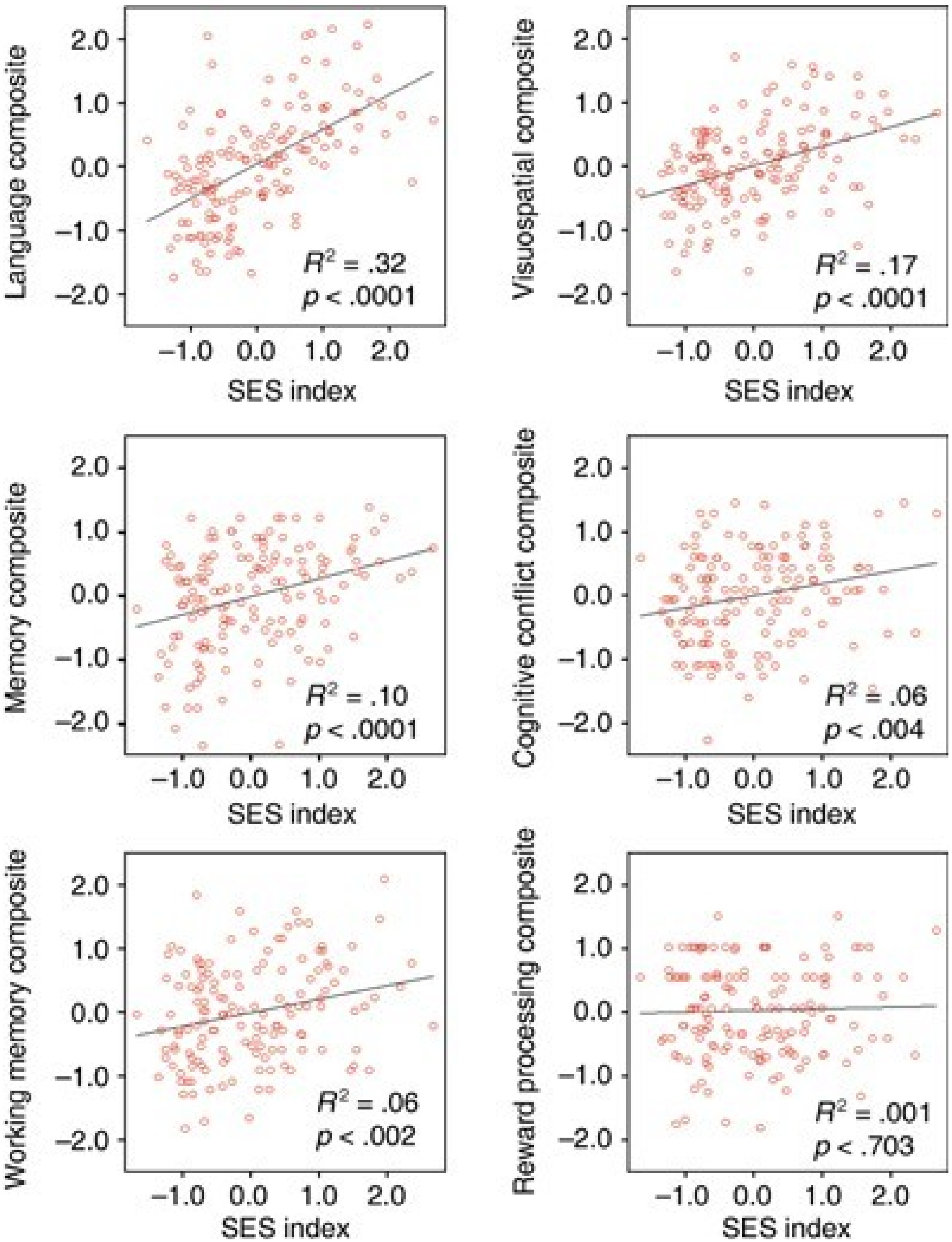
- Correlational studies

Study by Kim Noble and Martha Farrah was one of the first to examine the correlations between different cognitive skills and SES

- 150 New York City 1st graders from 9 socioeconomically diverse public elementary schools
- Behavioral testing
- Language (Left perisylvian)
- Executive Function (PFC)
  - Cognitive control – (ACC) ability to self-regulate, cognitive flexibility
  - Working memory - (DLPFC) ability to hold items in the mind
  - Reward processing - (OFC) ability to delay gratification
- Declarative Memory (hippocampus)
- Visuospatial skills (R parietal)

SES composite

- Parental education
- Occupation
- Income



Language

Visuospatial

Memory

Cognitive conflict

Working memory

Reward processing

Noble, McCandliss, Farah (2007)

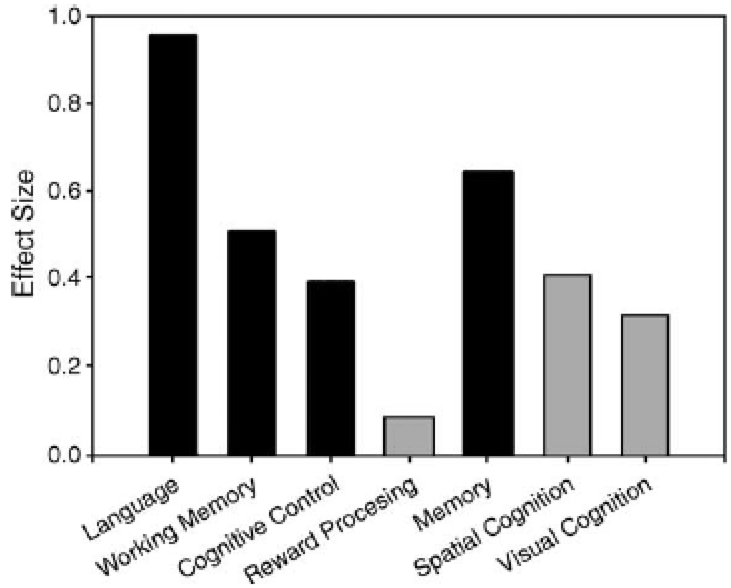


Fig. 1 – Effect sizes, measured in standard deviations of separation between low and middle SES group performance, on the composite measures of the seven different neurocognitive systems assessed in this study. Black bars represent effect sizes for statistically significant effects; gray bars represent effect sizes for nonsignificant effects.

Farah et al (2006) Brain Research

Consistencies across studies

- SES disparities are not uniform across different neurocognitive systems
- Language system tends to show the strongest effects
- Memory and certain aspects of executive function tend to show smaller but consistent effects

- Brain imaging studies

Family Poverty Affects the Rate of Human Infant Brain Growth

Jamie L. Hanson[1,2*], Nicole Hair[3,4], Dinggang G. Shen[5,6,7], Feng Shi[5,6,7], John H. Gilmore[8], Barbara L. Wolfe[3,4,9], Seth D. Pollak[1,2]

- Repeated assessment of brain development between 5 months and four years of age
- Economically diverse sample (n=77)
- MRI—structural imaging
- Study published in 2013 in PLoS One

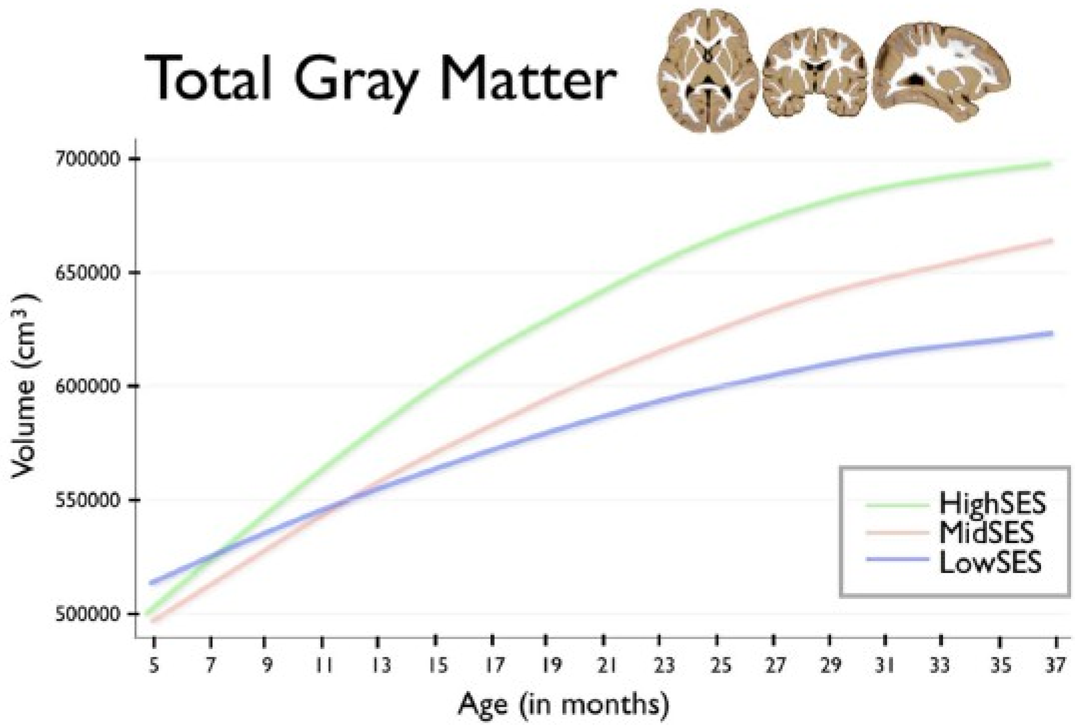


Figure 2. This figure shows total gray matter volume for group by age. Age in months is shown on the horizontal axis, spanning from 5 to 37 months. Total gray matter volume is shown on the vertical axis. The blue line shows children from Low SES households; children from Mid SES households are shown in red. The green line shows children from High SES households.
doi:10.1371/journal.pone.0080954.g002

Hanson et al (2013) PLoS One

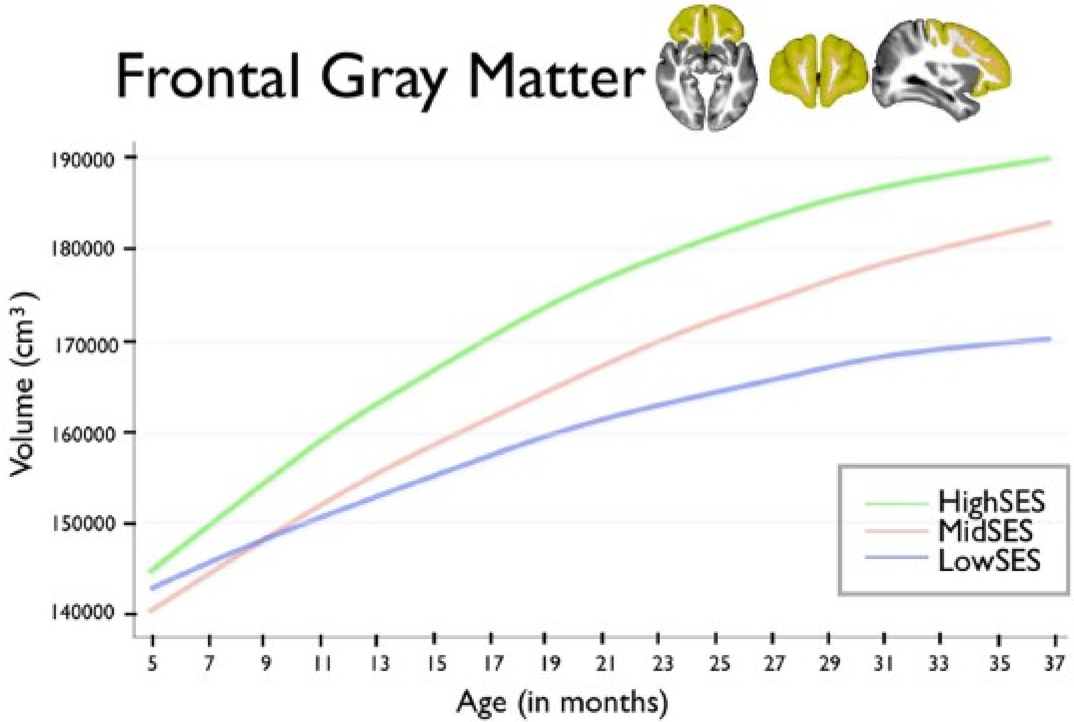


Figure 3. This figure shows frontal lobe gray matter volumes for group by age. Age in months is shown on the horizontal axis, spanning from 5 to 37 months. Total gray matter volume is shown on the vertical axis. The blue line shows children from Low SES households; children from Mid SES households are shown in red. The green line shows children from High SES households.
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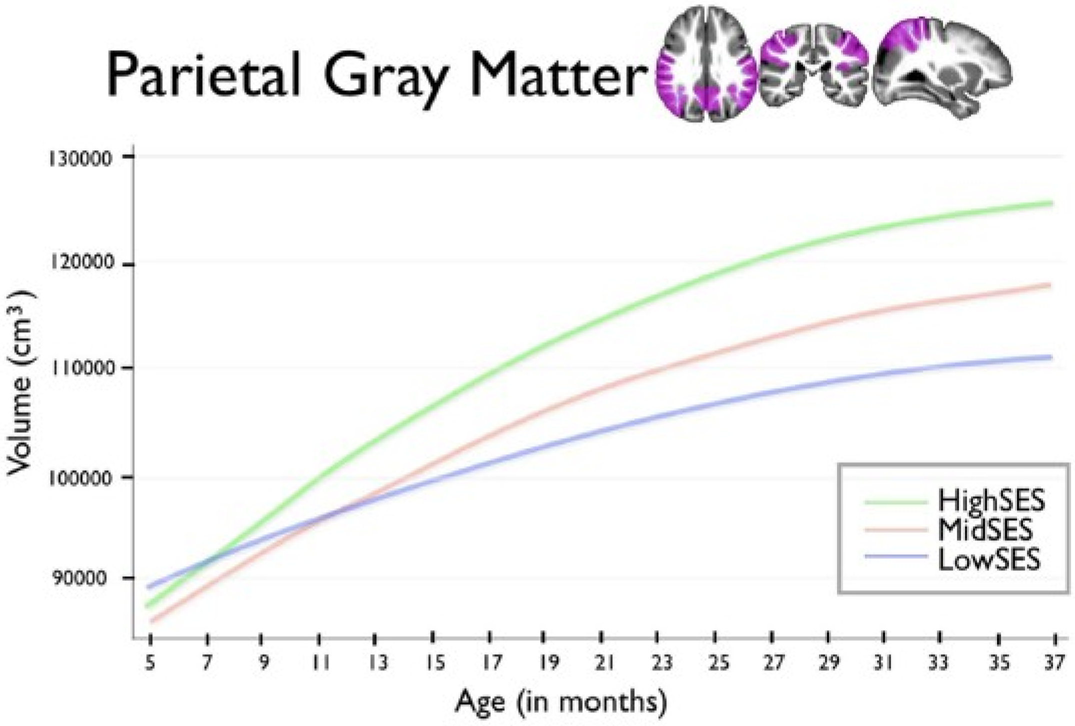


Figure 4. This figure shows parietal lobe gray matter volumes for group by age. Age in months is shown on the horizontal axis, spanning from 5 to 37 months. Total gray matter volume is shown on the vertical axis. The blue line shows children from Low SES households; children from Mid SES households are shown in red. The green line shows children from High SES households.
doi:10.1371/journal.pone.0080954.g004

Hanson et al (2013) PLoS One.

Summary of Hanson et al findings

- Infants from low income families had lower volumes of gray matter, in frontal and parietal regions
- No differences in white matter, temporal or occipital loves.
- Differences in brain growth were found to vary with SES, with children from lower-income households having slower trajectories of growth during infancy and early childhood.

The Influence of Socioeconomic Status on Children's Brain Structure

Katarzyna Jednoróg[1,2*¶], Irene Altarelli[1*¶], Karla Monzalvo[3,4,5], Joel Fluss[5,6,7], Jessica Dubois[3,4,5], Catherine Billard[5,6], Ghislaine Dehaene-Lambertz[3,4,5], Franck Ramus[1]

- Study of 23 healthy 10-year-old children
- Wide range of parental SES
- Behavioral study as well as MRI
- Behaviorally language is most affected by SES

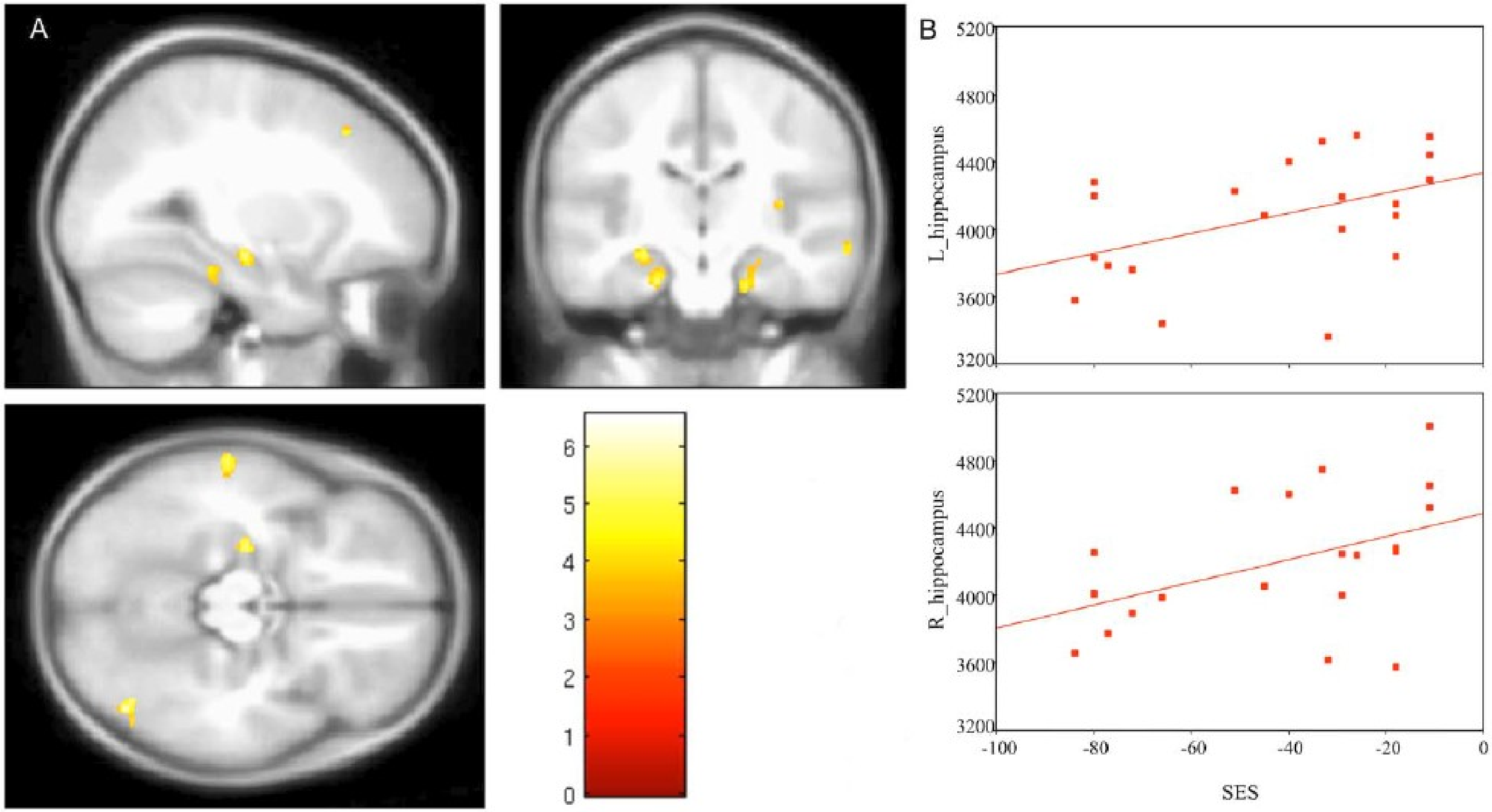


Figure 2. Gray matter volumes correlated with SES. A) VBM results displayed on a customized pediatric brain template; the color scale represents T-values; B) left and right hippocampus volume changes as a function of SES (from SBM).
doi:10.1371/journal.pone.0042486.g002

Jednorog et al (2012) PLoS One

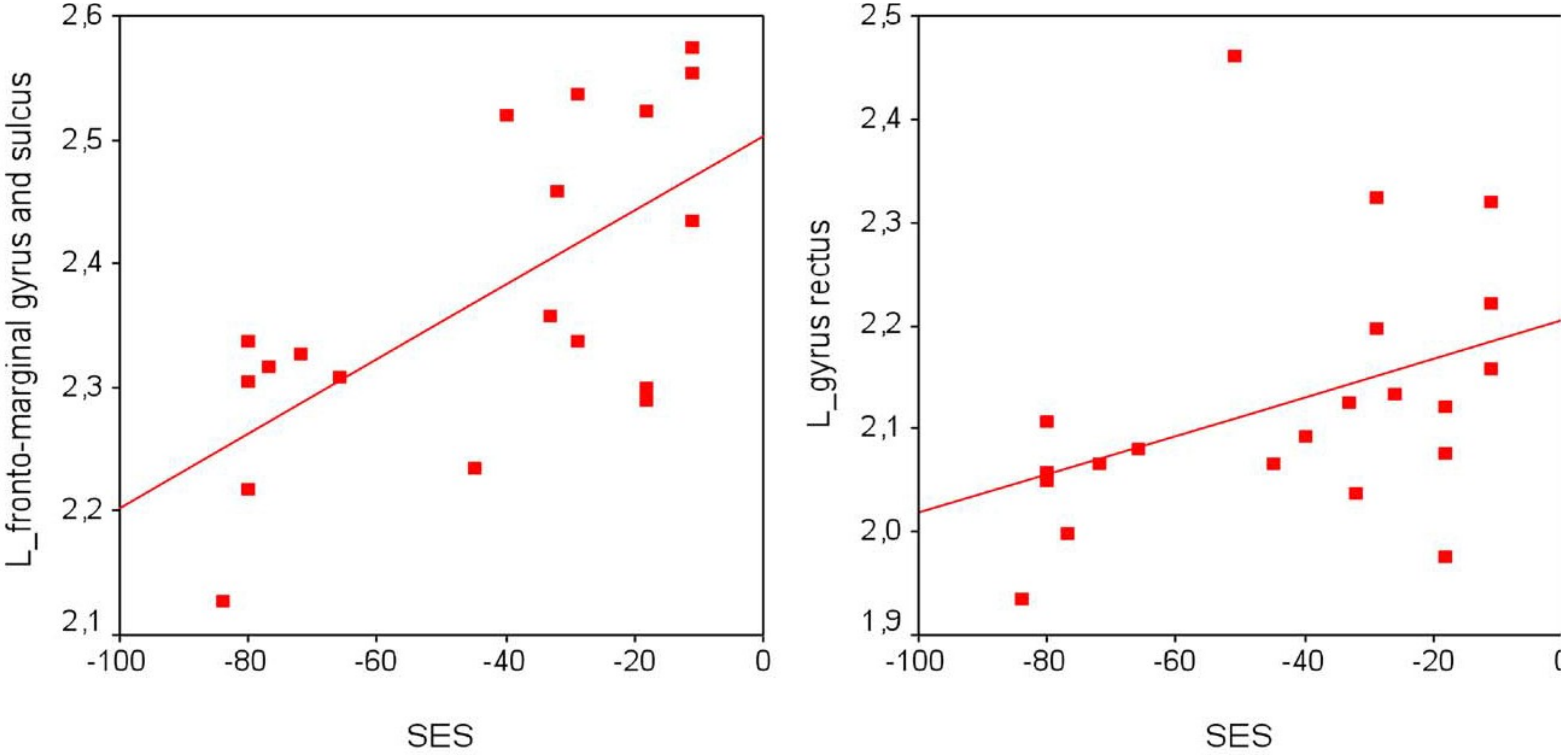


Figure 3. Left hemispheric anterior frontal regions showing a positive correlation between gyrification index and SES.
doi:10.1371/journal.pone.0042486.g003

Jednorog et al (2012) PLoS One

Summary of Jednorog et al findings

- Low SES was associated with smaller volume of gray matter in bilateral hippocampi, temproal gyri
- Local gyrification effects in frontal lobes supportive of a potential developmental lag in low SES children

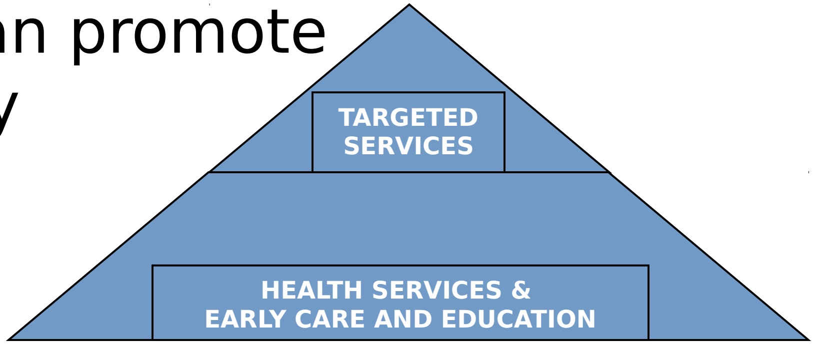
There Are No Magic Bullets

Positive relationships and quality learning experiences can be promoted both at home and through a range of **evidence-based** parent education, family support, early care and education, and intervention services.

A balanced approach to emotional, social, cognitive, and language development will best prepare children for success in school and later in the workplace.

Science Points Toward a Two-Tiered Approach to Reducing Disparities

Basic health services and good quality **early care and education** can promote healthy development and early detection of problems in all children.



Targeted services for children experiencing tolerable or toxic stress can reduce disruptions of the developing nervous and immune systems that lead to later problems in learning, behavior, and health.

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NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD

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