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A LEARNUS mediated workshop

eld Weston
FOUNDATION

THE COGNITIVE NEUROSCIENCE OF SOCIOECONOMIC STATUS (SES)

Michael Thomas

Professor of Cognitive Neuroscience,
Birkbeck College, University of London
Director Centre for Educational Neuroscience

In this talk, I will discuss recent cognitive neuroscience evidence on how SES influences cognitive and brain development. SES has been identified as a key environ-mental measure that influences health, cognition, and educational outcomes in child development.

However, it is proxy measure that does not identify the actual causal processes influencing development. I will discuss how recent evidence from behavioural and brain imaging studies may help us isolate the relevant mechanistic pathways and point to interventions to allevi-ate the effects of deprivation on cognitive development.

Entrance by Invitation only

Places at the workshop are limited so an early response is advised.

To receive your free invitation contact:
Caroline Shott at communications@learnus.co.uk

Wednesday 19th October 2016
6.00 – 8.30pm

Robert Runcie Room
Church House
Westminster

Deans Yard
Westminster
London SW1P 3NZ

Workshop Mediator:

Derek Bell

Director of Learnus
Professor of Education,
College of Teachers

Centre for Educational Neuroscience

Learnus

The cognitive neuroscience of socioeconomic status (SES)

Professor Michael Thomas

LEARNUS MEDIATED WORKSHOP

19 October 2016

developmental neurocognition lab

Professor Michael Thomas
Birkbeck
University of London

Centre for Educational Neuroscience

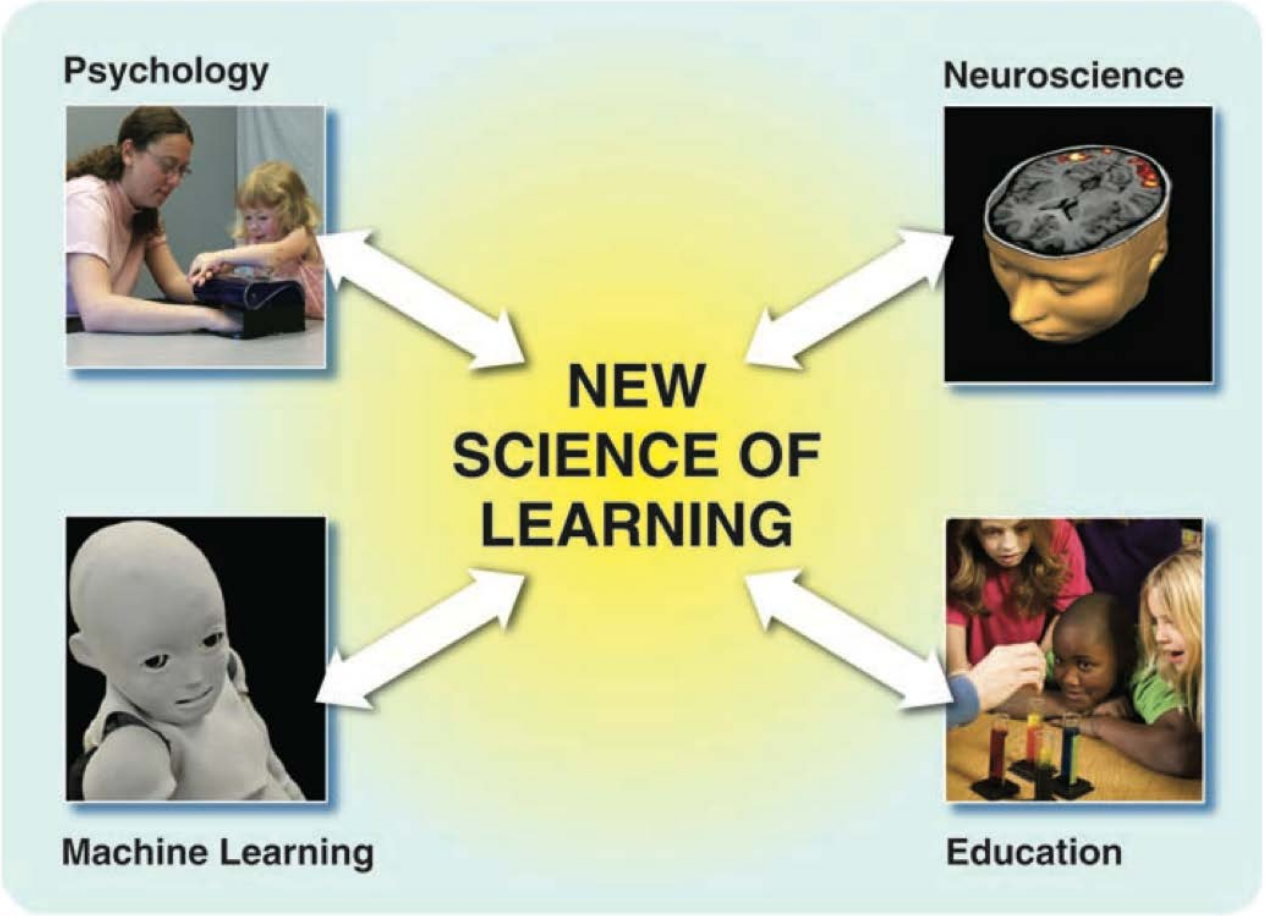
An inter-institutional transdisciplinary project

Neuroscience

Education

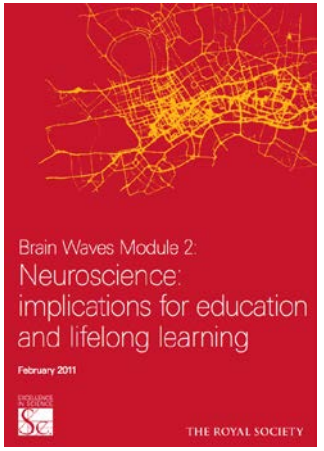
Child development

The new field of educational neuroscience



(Meltzoff, Kuhl, Movelland & Sejnowski, 2009)

The Vision



"There is common ground between neuroscience and education that suggests a future in which educational practice can be transformed by science, just as medical practice was transformed by science about a century ago"

– Royal Society Report 'Neuroscience: implications for education and lifelong learning' (2011).

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Educational neuroscience focuses on mechanisms of learning

Learning

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Teacher training, skills, competence

Teacher recruitment

Professional development

Education law

Education policy

Syllabus

Overarching curricula

Links to truancy, crime

Assessment

Links to employment labour markets

Learning

Organisation of classroom

Social influences

Parents, families

Leadership, School effectiveness

Pedagogy

Organisation of schools

Health

Childcare

Resources (staffing, buildings, technology)

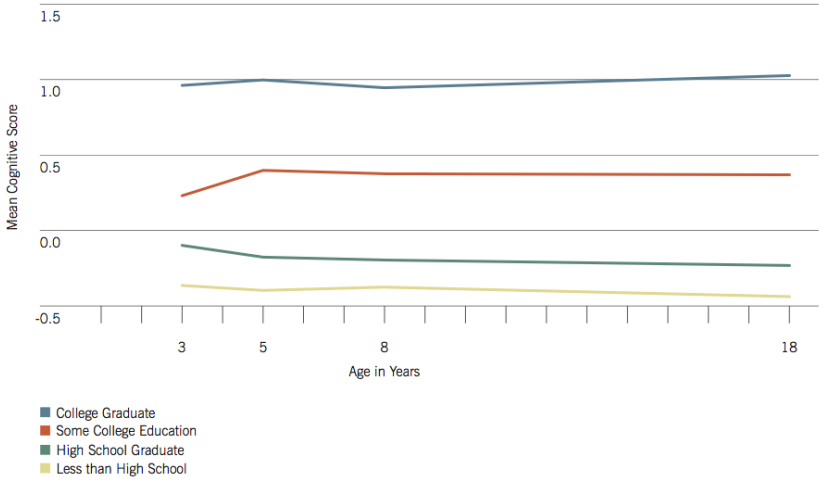
Organisation of provision (primary secondary, tertiary)

Socioeconomic Status

- The challenge
- What is SES?
- Confounded factors
- SES and behaviour
- SES and the brain
- Causal factors
- Interventions
- Genetics
- The need for mechanistic accounts
- Key unanswered questions

The challenge

Trend in Mean Cognitive Score by Maternal Education



Each score standardized within observed sample. Using all observations and assuming data missing at random.

Figure D1a. Average Percentile Rank on PIAT-Math Score, by Income Quartile

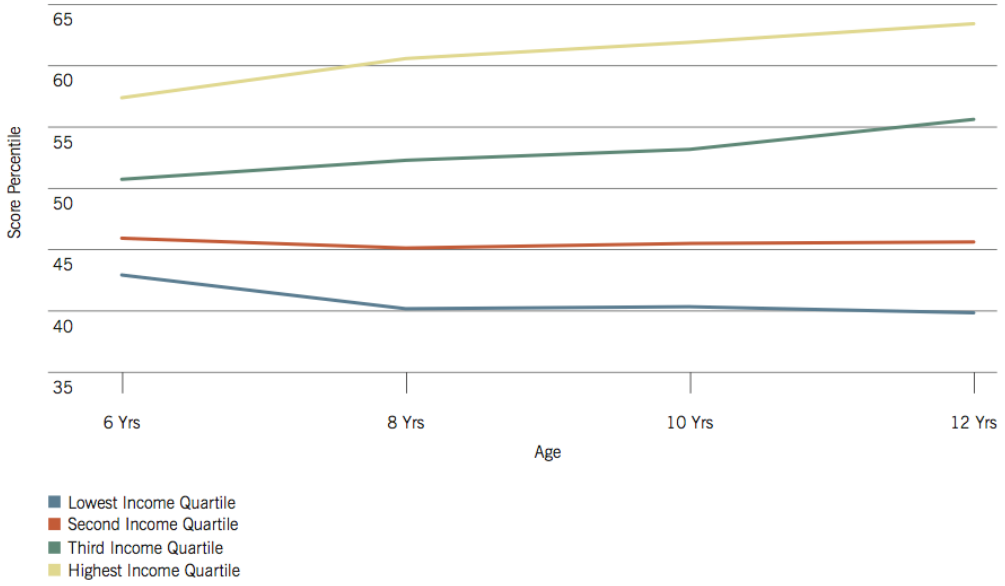
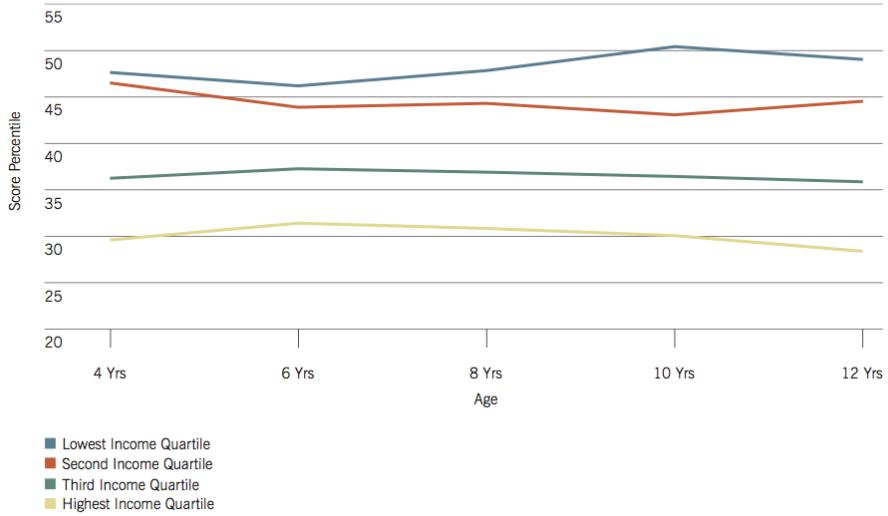


Figure D3a. Average Percentile Rank on Anti-Social Behavior Score, by Income Quartile



Lower SES associated with poorer outcomes in health, cognition, educational achievement

The Heckman Graph

Nobel-prize winning Economist

Earlier work: Job retraining for adults isn't economic

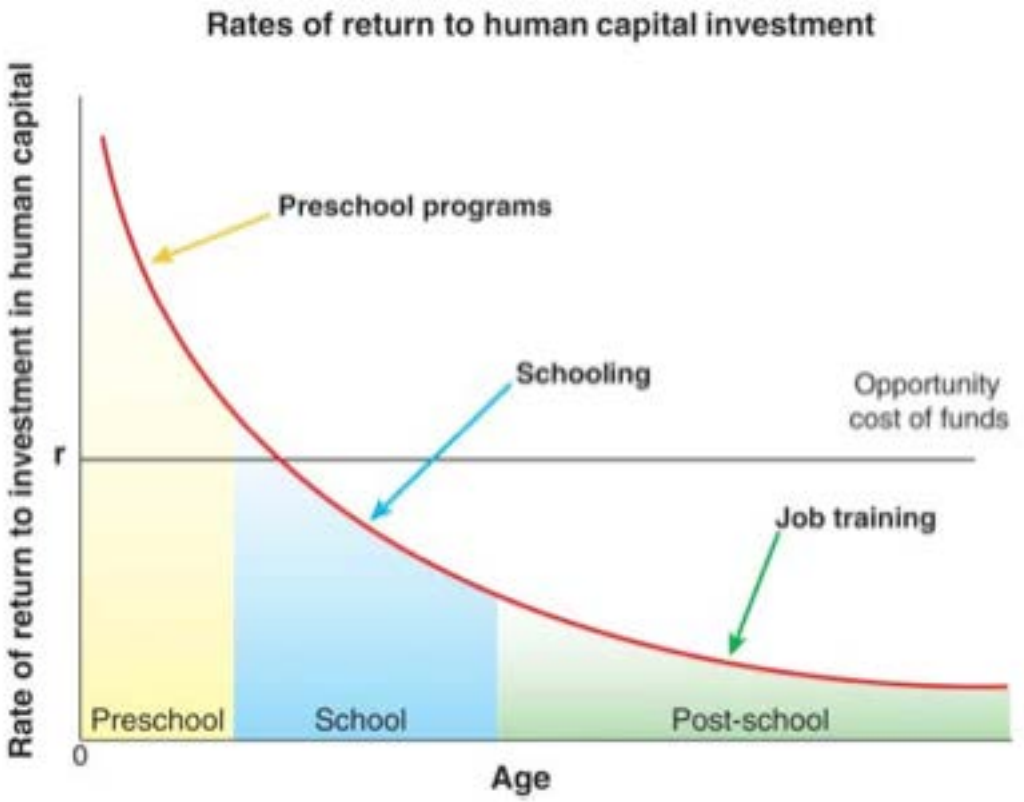
PERSPECTIVE

Skill Formation and the Economics of Investing in Disadvantaged Children

James J. Heckman

This paper summarizes evidence on the effects of early environments on child, adolescent, and adult achievement. Life cycle skill formation is a dynamic process in which early inputs strongly affect the productivity of later inputs.

We over-invest in most schooling and post-schooling programs and under-invest in preschool programs for disadvantaged persons

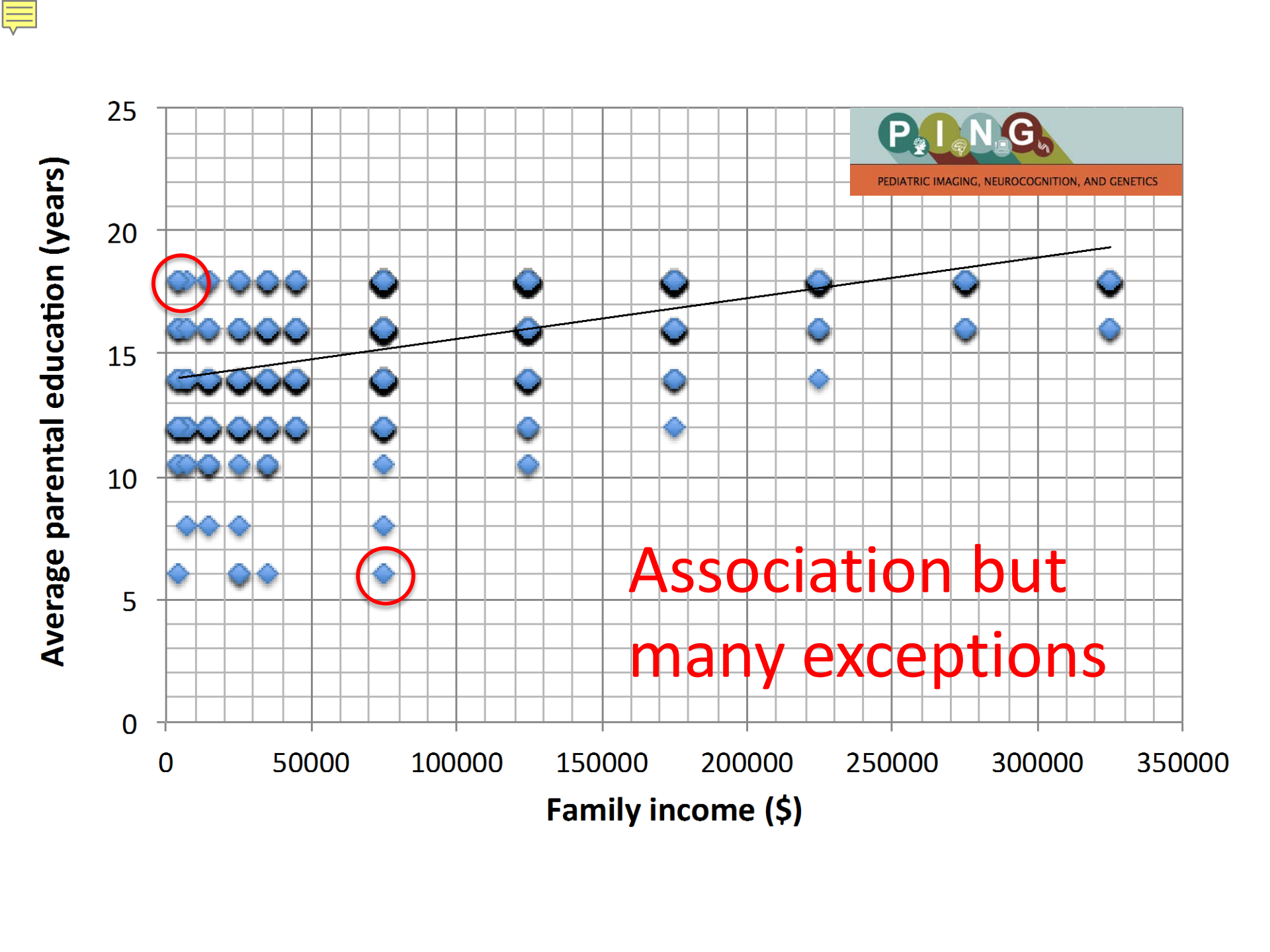


What is SES?

What is SES?

- Hackman & Farah (2009): “SES is a multidimensional construct that includes measures of economic resources in addition to social factors such as power, prestige and hierarchical social status”

- A basket of environmental factors that seem to hang together
  - Income-to-needs ratio (family income)
  - Maternal education
  - Home environment (resources, order/chaos)
  - Health
  - Characteristics of parents
  - Neighbourhoods
  - Physical environment (pollution)


PEDIATRIC IMAGING, NEUROCOGNITION, AND GENETICS
Average parental education (years)
25
20
15
10
5
0
0
50000
100000
150000
200000
250000
300000
350000
Family income ($)
Association but
many exceptions

Anything similar in other species?

- Analogous to dominance hierarchies in other social primates?
- Stress in baboons in the wild
- Lower ranked individuals
  - more stressed
  - less resources
  - more getting beaten up
  - less food
  - fewer mating opportunities
  - poorer health
  - die younger

Robert Sapolsky
Neuroendocrinologist
(Sapolsky, 2005)

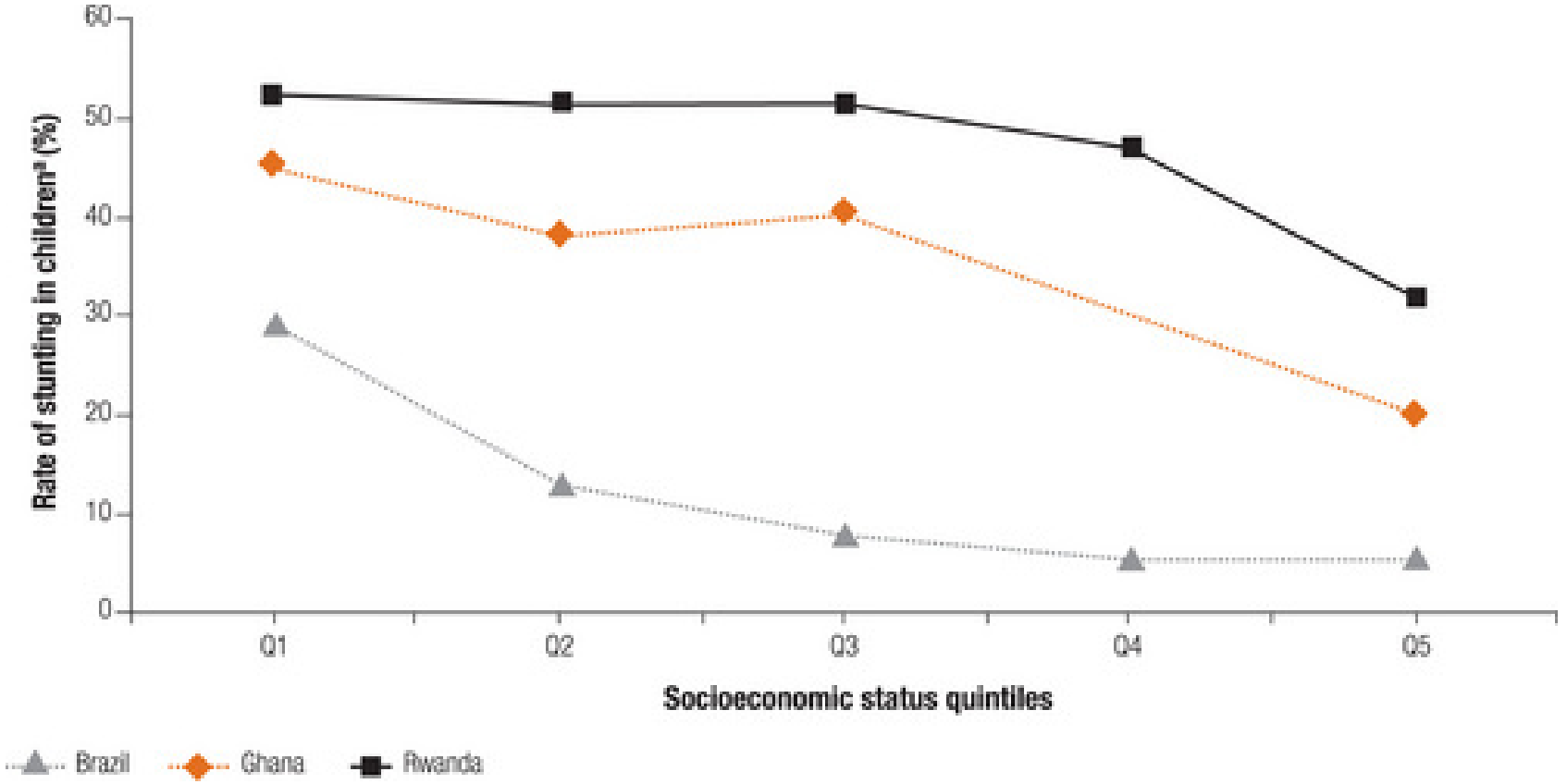
Anything similar in other species?

- BUT
  - Human psychosocial stress of poverty is subjective and relative
  - Humans have multiple hierarchies
  - Animal models not good for language, higher level cognition

Robert Sapolsky
Neuroendocrinologist
(Sapolsky, 2005)

Relative vs absolute?

Relative vs absolute?



Data from World Health Organisation

Confounded factors

Confounded factors

Table 3 *Intercorrelation among potential mediators and measures of socioeconomic status (n = 1009)*

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Birthweight	–										
2. Gestational age	.47***	–									
3. Maternal depression	−.02	.03	–								
4. Negative life events	.07*	.07*	.18***	–							
5. Parent stress	−.01	.07*	.50***	.10**	–						
6. Enrichment: Infant / Toddler	.10**	.01	−.23***	.02	−.10**	–					
7. Enrichment:Early Childhood	.05	−.02	−.24***	−.01	−.11**	.57***	–				
8. Maternal sensitivity: Infant / Toddler	.12***	−.02	−.24***	.01	−.12***	.48***	.46***	–			
9. Maternal sensitivity: Early childhood	.09**	−.05	−.21***	−.01	−.12***	.40***	.44***	.59***	–		
10. Early income-to-needs	.03	−.08*	−.24***	−.05	−.09**	.46***	.49***	.48***	.42***	–	
11. Maternal education	.07*	−.04	−.23***	−.03	−.06	.40***	.49***	.46***	.42***	.58***	–

* $p < .05$; ** $p < .01$; *** $p < .001$.

NICHD Study of Early Childcare. N = 1009 children in US followed from birth to 8 years

Hackman et al. (2015)
Developmental Science

SES and behaviour

Differential across cognitive domains

significant effects; gray
bars represent effect sizes for nonsignificant effects.

Farah et al. (2006)

Differential across cognitive domains

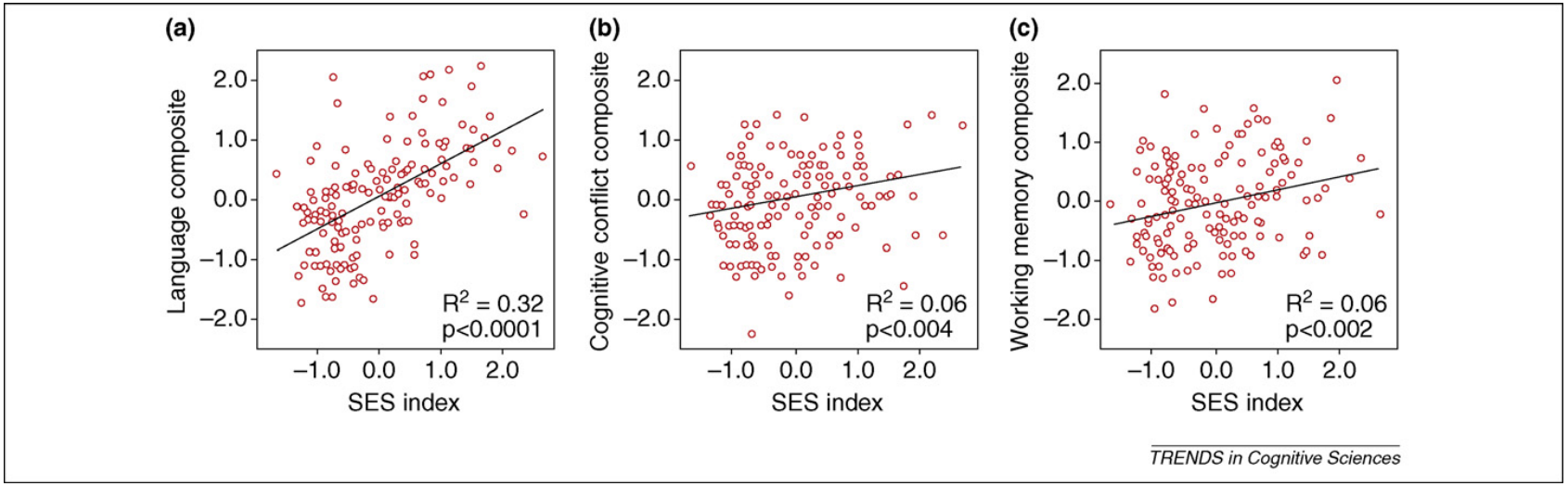


Figure 2. In first-graders, SES accounts for variance in neurocognitive composite measures of **(a)** 'language' performance on vocabulary and phonological processing tasks; **(b)** 'cognitive control' measures of the ability to inhibit a prepotent response and **(c)** 'working memory', based on tasks assessing working memory of spatial location and figural stimuli. SES accounts for statistically more variance in the language composite than in all other composites, which do not statistically differ from each other. Figure adapted, with permission, from Ref. [18].

Hackman & Farah (2009)

SES and the brain

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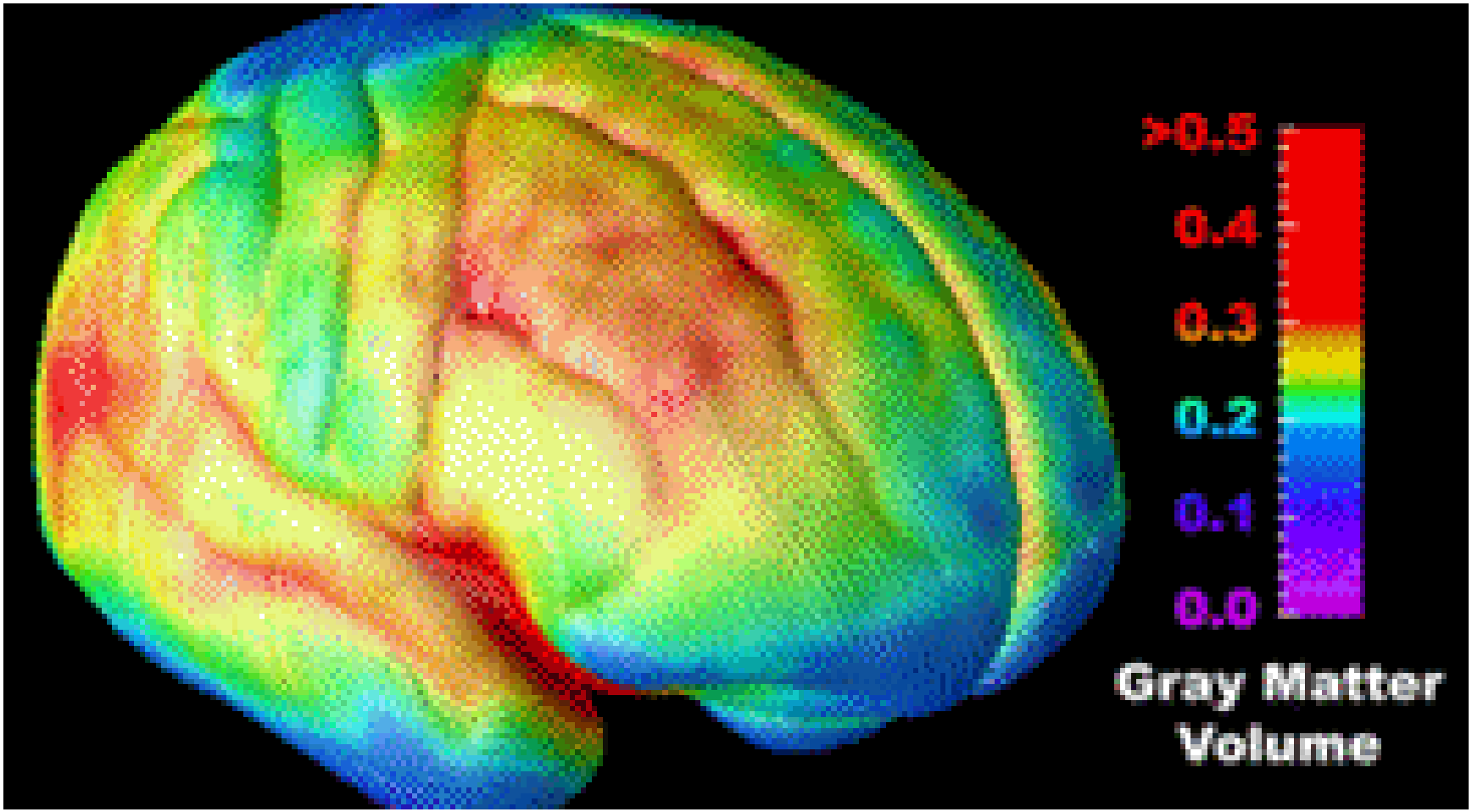
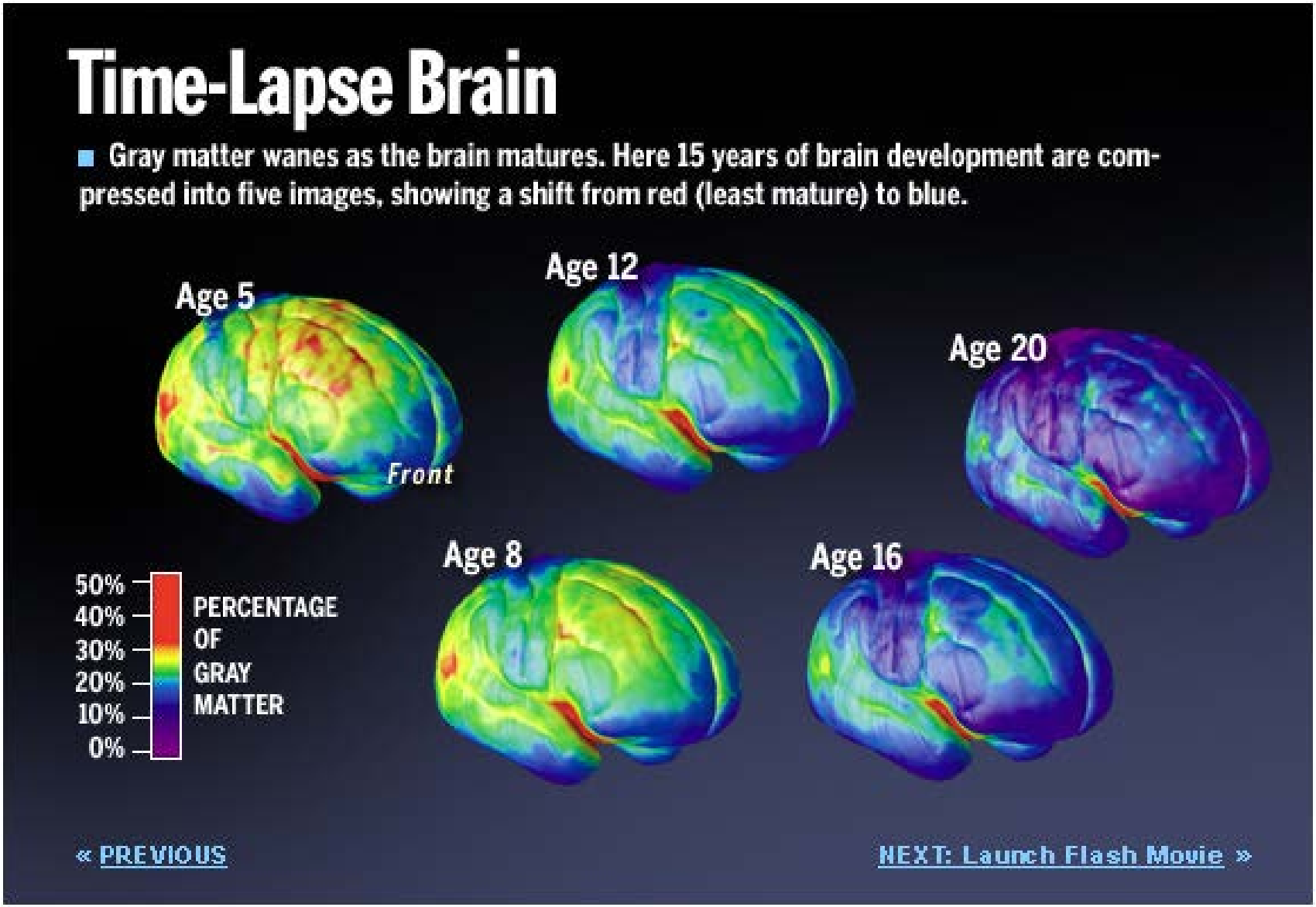
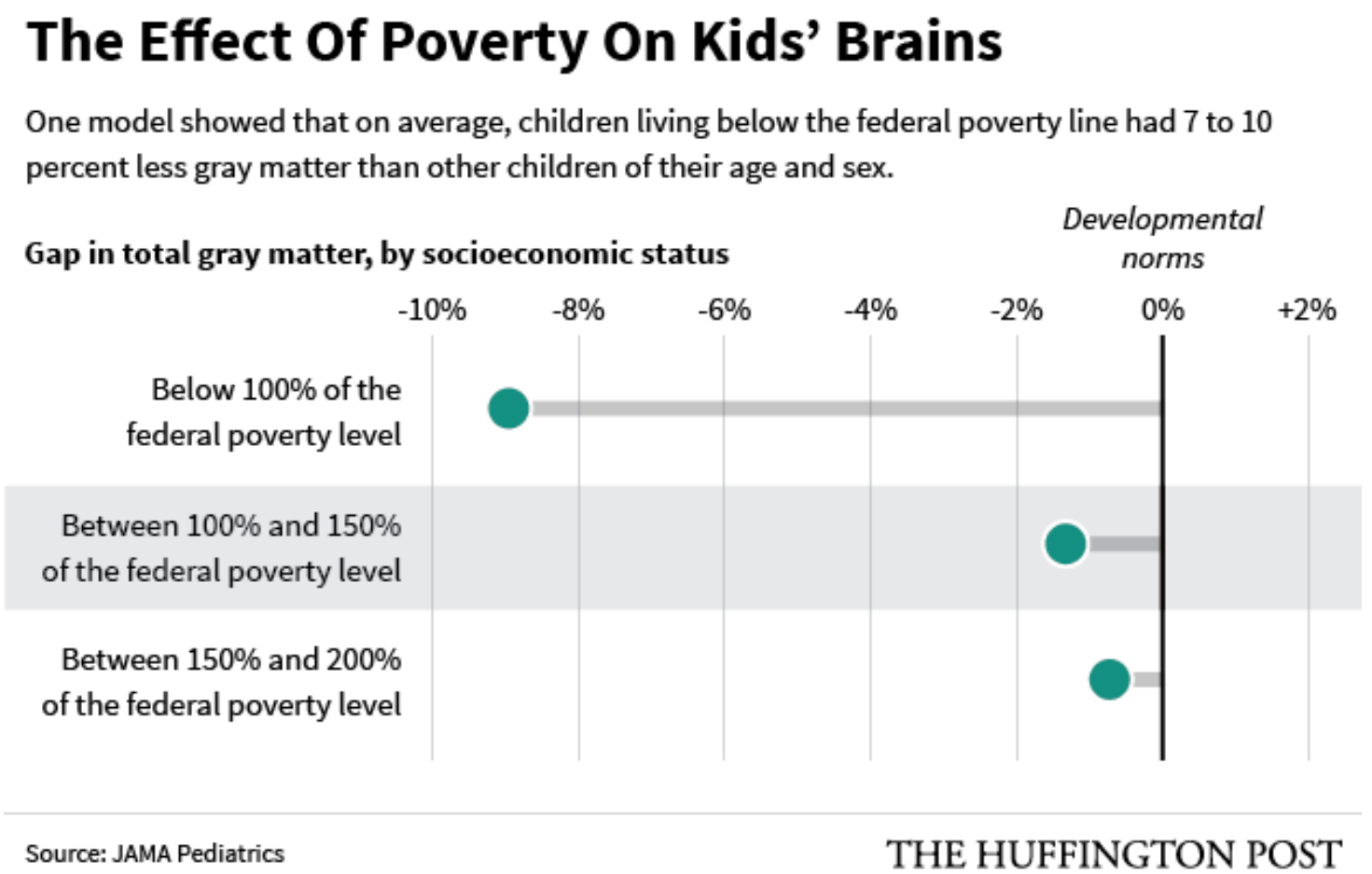
Gotgay et al. (2004): 5 to 20 year olds





Jay Giedd & colleagues, N=300 ish

SES and the brain

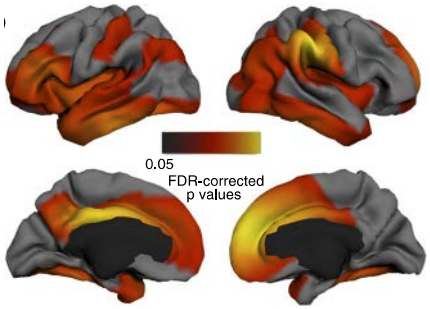


Family income, parental education and brain structure in children and adolescents

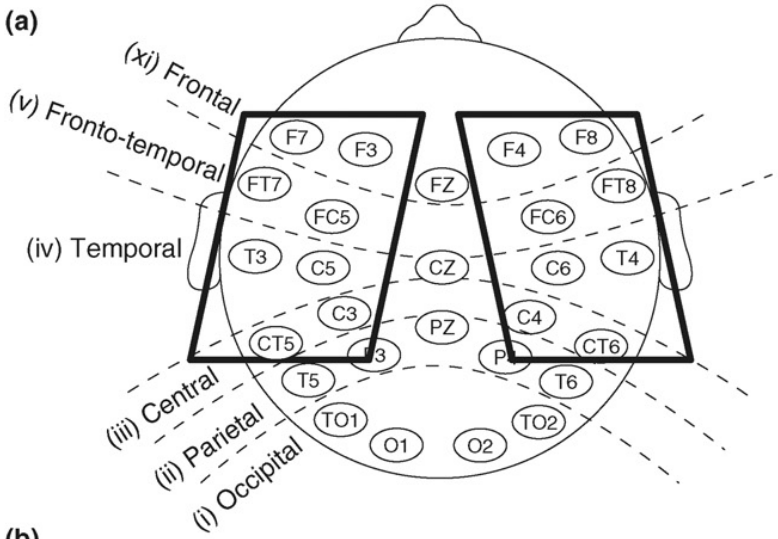
Kimberly G Noble[1,2,32], Suzanne M Houston[3–5,32], Natalie H Brito[6], Hauke Bartsch[7], Eric Kan[4,5], Joshua M Kuperman[8–10], Natacha Akshoomoff[10–12], David G Amaral[10,13], Cinnamon S Bloss[10,14], Ondrej Libiger[15], Nicholas J Schork[16], Sarah S Murray[10,17], B J Casey[10,18], Linda Chang[10,19], Thomas M Ernst[10,19], Jean A Frazier[10,20], Jeffrey R Gruen[10,21–23], David N Kennedy[10,20], Peter Van Zijl[10,24,25], Stewart Mostofsky[10,25], Walter E Kaufmann[10,26,27], Tal Kenet[10,27,28], Anders M Dale[8–10,29–31], Terry L Jernigan[10,11,12,29] & Elizabeth R Sowell[4,5,10]

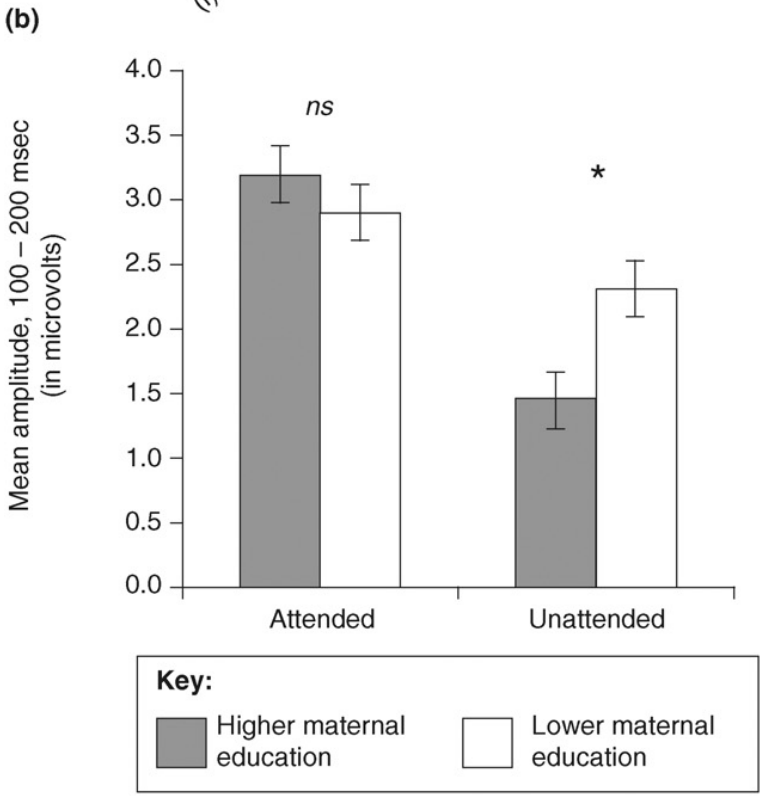
Socioeconomic disparities are associated with differences in cognitive development. The extent to which this translates to disparities in brain structure is unclear. We investigated relationships between socioeconomic factors and brain morphometry, independently of genetic ancestry, among a cohort of 1,099 typically developing individuals between 3 and 20 years of age.

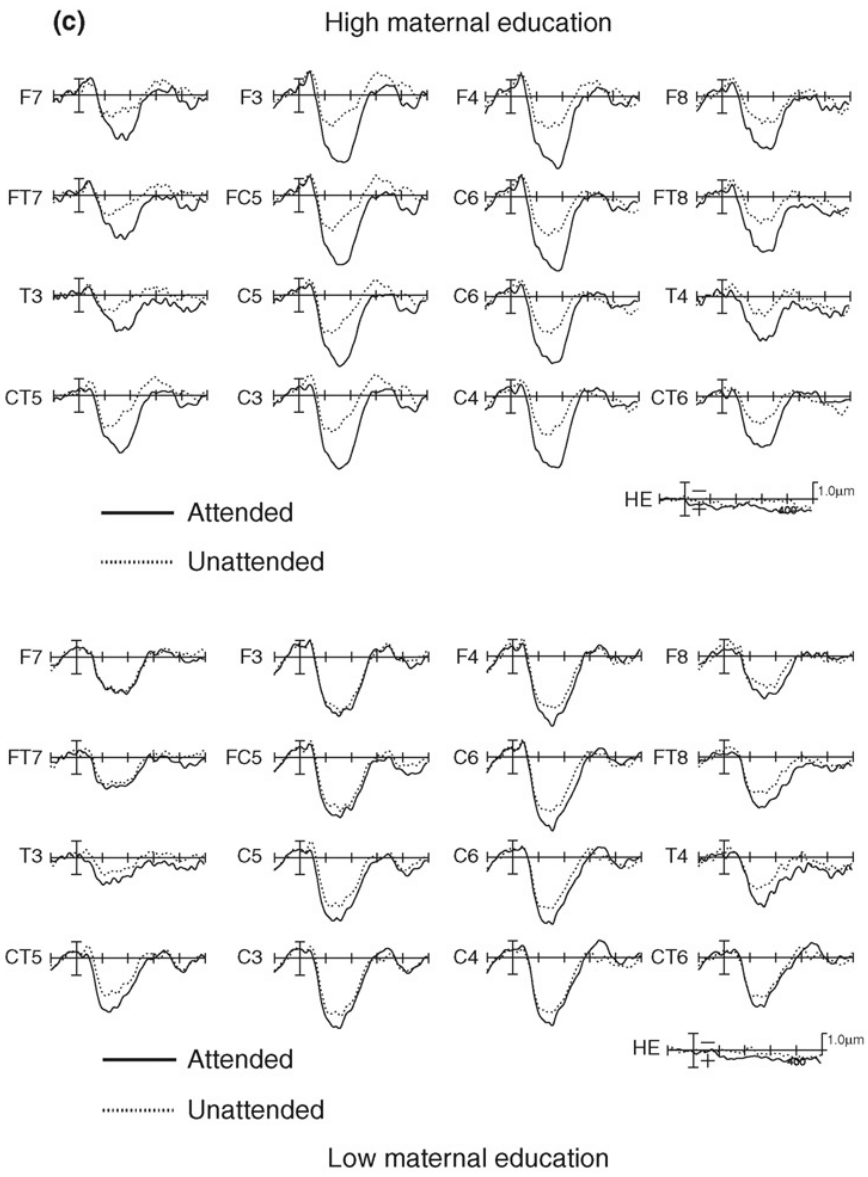
1-2% of variability



N=1099







Stevens et al. (2007) Developmental Science

Developmental Science

Paper

Effect of socioeconomic status (SES) disparity on neural development in female African-American infants at age 1 month

Laura M. Betancourt[1,*], Brian Avants[2], Martha J. Farah[3], Nancy L. Brodsky[1], Jue Wu[2], Manzar Ashtari[4] and Hallam Hurt[1,5]

Article first published online: 21 OCT 2015

DOI: 10.1111/desc.12344

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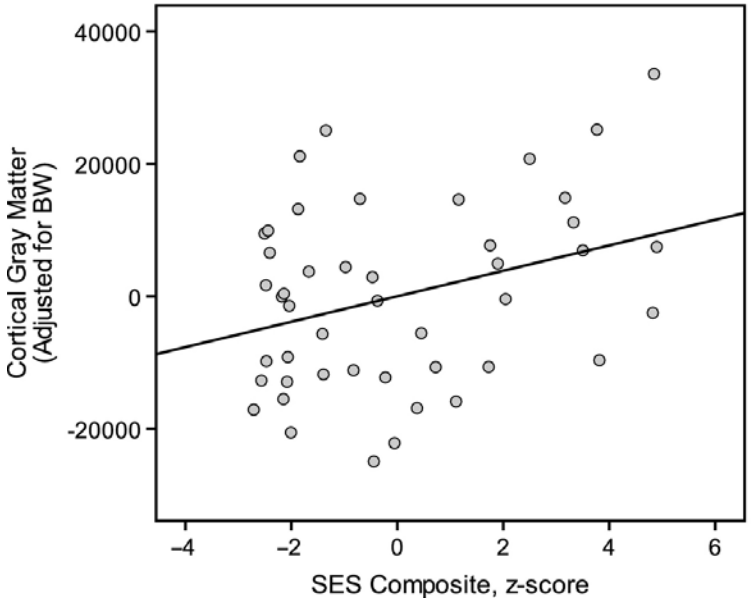
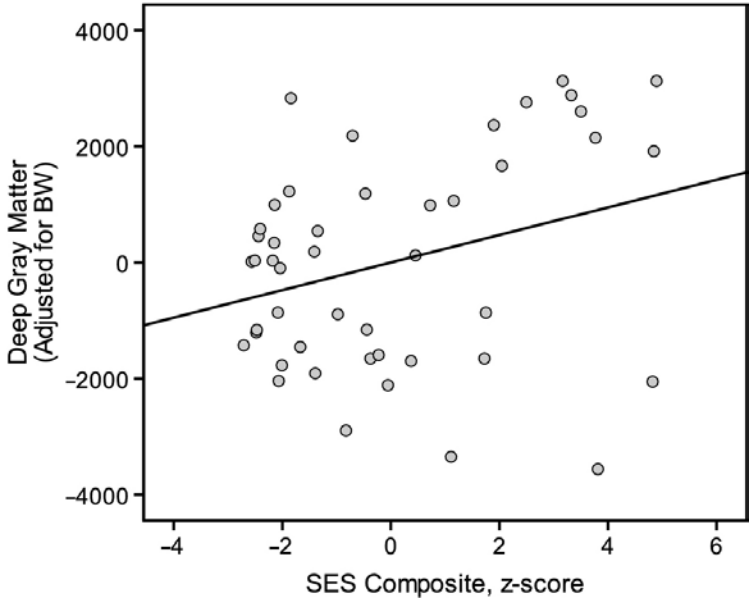
Issue

Developmental Science

Early View (Online Version of Record published before inclusion in an issue)





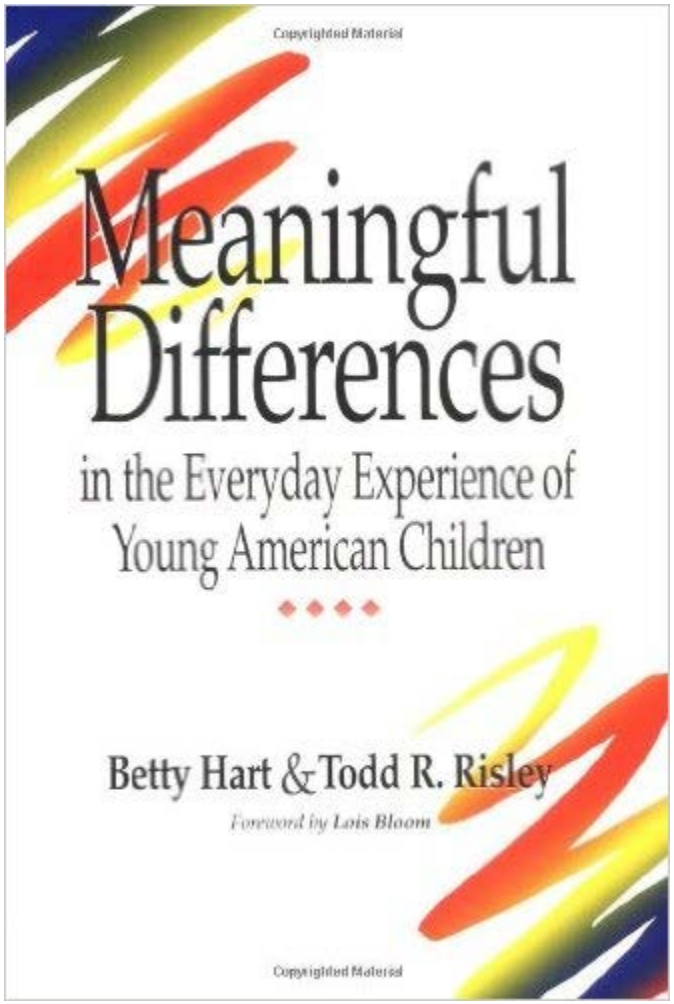
Deficit or adaptation?

- Poor selective attention = greater vigilance for more challenging environment?
- Poor long-term planning = ‘scarcity mindset’?

- Less brain matter at 1 month = prenatal effects?

Causal factors?

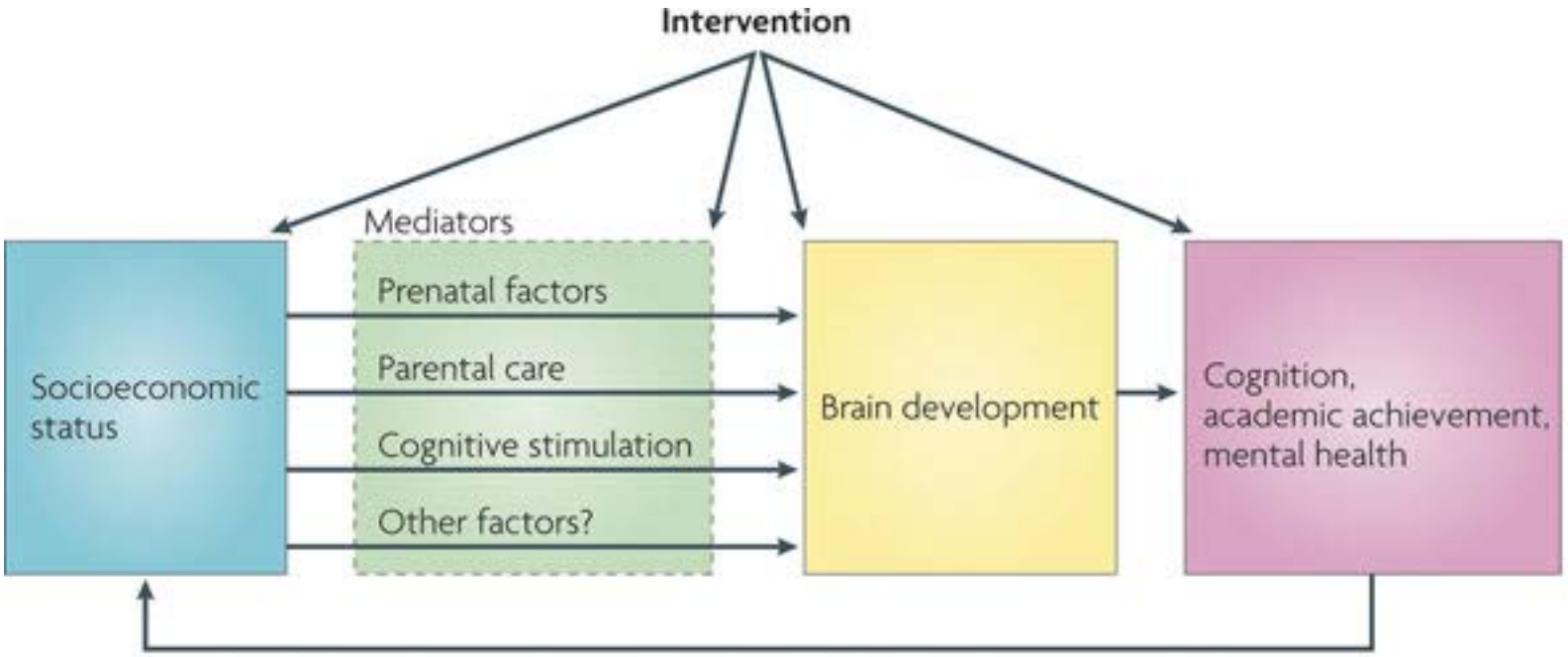
Causal factors?



By 4 years of age, children in families on welfare may have heard 30 million fewer words than children in professional families

Causal factors

- Family resource model
- Family stress model



Hackman, Farah, Meaney (2010)

Nature Reviews | Neuroscience

Developmental Science

Developmental Science (2015), pp 1–17

= planning, controlling, regulating behaviour

PAPER "SES"

Socioeconomic status and executive function: developmental trajectories and mediation

Daniel A. Hackman,[1] Robert Gallop,[2] [illegible] Martha J. Farah[1]

1. Center for Cognitive Neuroscience, Center for Neu[illegible]ence and Society, Department of Psychology, University of Pennsylvania
2. Department of Mathematics and Applied Statistics, We[illegible] University, USA
3. Departments of Design and Environmental Analysis and Huma[illegible] Bronfenbrenner Center for Translational Research, Cornell University, USA

If schooling partly compensates for the effects of earlier deprivation, lower-SES children should 'catch up'

Early relation between SES and executive function persisted without narrowing or widening across early and middle childhood

Table 3 *Intercorrelation among potential mediators and measures of socioeconom[illegible]*

Measure	1	2	3	4	5	6	7			
1. Birthweight	–									
2. Gestational age	.47***	–								
3. Maternal depression	−.02	.03	–							
4. Negative life events	.07*	.07*	.18***	–						
5. Parent stress	−.01	.07*	.50***	.10**	–					
6. Enrichment: Infant / Toddler	.10**	.01	−.23***	.02	−.10**	–				
7. Enrichment:Early Childhood	.05	−.02	−.24***	−.01	−.11**	.57***	–			
8. Maternal sensitivity: Infant / Toddler	.12***	−.02	−.24***	.01	−.12***	.48***	.46***	–		
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10. Early income-to-needs	.03	−.08*	−.24***	−.05	−.09**	.46***	.49***	.48***	.42***	–
11. Maternal education	.07*	−.04	−.23***	−.03	−.06	.40***	.49***	.46***	.42***	.58***

* $p < .05$; ** $p < .01$; *** $p < .001$.

NICHD Study of Early Childcare. N = 1009 children in US followed from birth to 8 years

Genetics

Research Article

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
1–12
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DOI: 10.1177/0956797
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SAGE

Large Cross-National Differences in Gene × Socioeconomic Status Interaction on Intelligence

Elliot M. Tucker-Drob[1,2] and Timothy C. Bates[3]

[1]Department of Psychology, University of Texas at Austin; [2]Population Research Center, University of Texas at Austin; and [3]Department of Psychology, University of Edinburgh

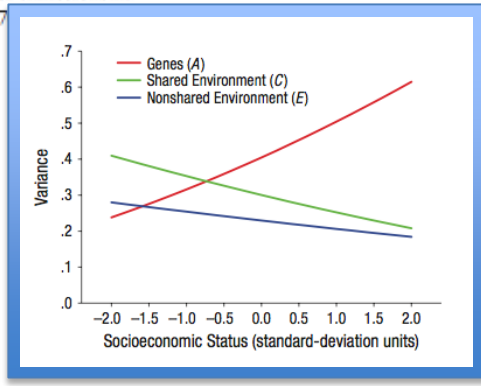


Table 2. Meta-Analytic Results: Estimates From Meta-Regression Models for all Structural Equation Model Parameters

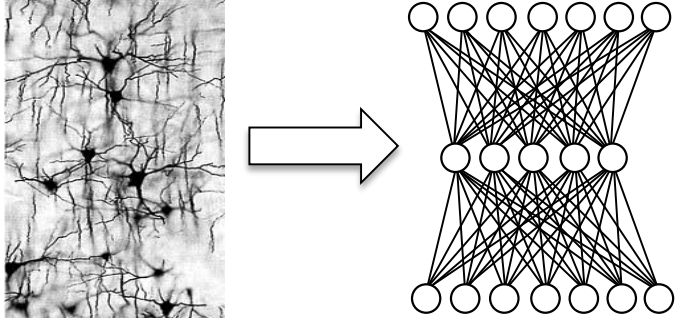
Meta-regression parameter	*s*	*a*	*a′*	*c*	*c′*	*e*	*e′*
United States	.300 (.027)	.636 (.044)	.074 (.020)	.548 (.070	−.046 (.032	.479 (.033)	−.025 (.016)
Europe	.280 (.022)	.672 (.045)	−.027 (.022)	.507 (.052	−.029 (.012	.471 (.034)	.063 (.065)
Difference	.020 (.033)	−.036 (.065)	.101 (.032)	.042 (.086)	−.017 (.028)	.008 (.047)	−.088 (.068)
τ	.073 (.016)	.097 (.013)	.029 (.012)	.158 (.018)	.007 (.195)	.115 (.018)	.137 (.069)

Note: The bottom row (τ) shows the standard deviations of the random effects, which represent residual heterogeneity in effect sizes. Standard errors are given in parentheses.

- A core hypothesis in developmental theory predicts that genetic influences on intelligence and academic achievement are suppressed under conditions of socioeconomic privation and more fully realized under conditions of socioeconomic advantage: a Gene × Childhood Socioeconomic Status (SES) interaction. Tests of this hypothesis have produced apparently inconsistent results. We performed a meta-analysis of tests of Gene × SES interaction on intelligence and academic-achievement test scores, allowing for stratification by nation (United States vs. non–United States), and we conducted rigorous tests for publication bias and between-studies heterogeneity. **In U.S. studies, we found clear support for moderately sized Gene × SES effects. In studies from Western Europe and Australia, where social policies ensure more uniform access to high-quality education and health care, Gene × SES effects were zero or reversed.**

A need for mechanistic accounts

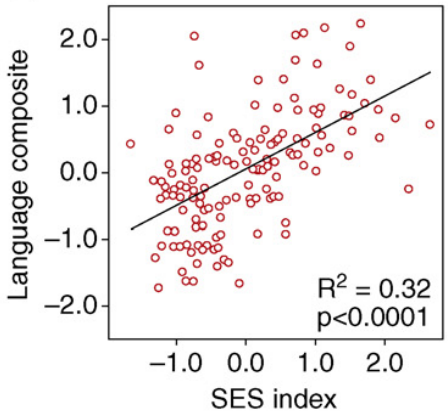
Neurocomputational models of development

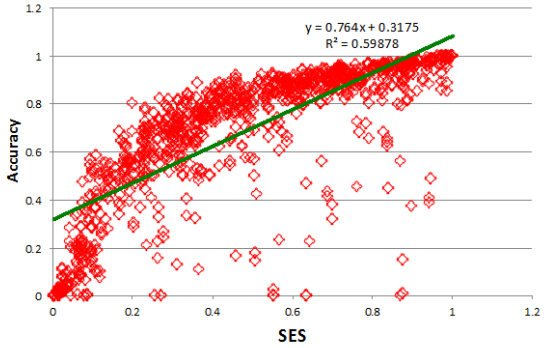


DATA

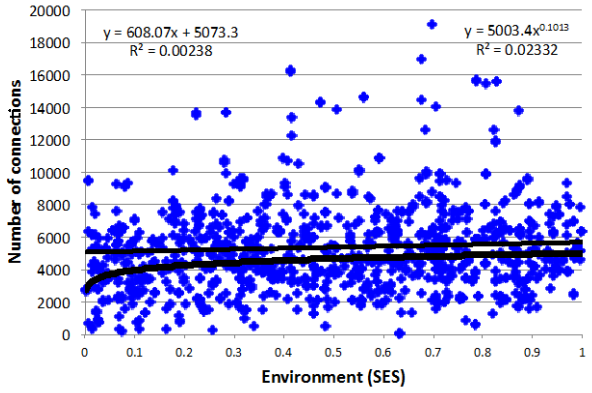
MODEL

Behaviour





Brain



Intervention

More time in day nursery before age two is associated with higher cognitive scores at age four

Many working parents experience guilt about sending their young children off to day nursery, especially in light of research published in the 2000s that suggested that too much early childcare is associated with later behavioural problems. However, a new study in the *International Journal of Behavioural Development* paints a more positive picture – the more time children spent in day nursery before the age of two (defined as group-based childcare outside the home), the better their cognitive performance when they were tested at 51 months. Based on their findings, the researchers – Jacqueline Barnes and Edward Melhuish at Birkbeck, University of London – suggest that the UK Government should consider rolling out free childcare provision at an earlier age (in the UK at present, limited free childcare doesn't begin until age three).

- N=978 0-51 months
- Controlling for other factors, higher cognitive development and particularly non-verbal ability was associated with more hours per week in group care from 0 to 51 months
- The majority of variance was explained by other predictors:
  - sex (girl), higher cognitive development at 18 months, older mother, first language English, mother of white ethnic background, with more qualifications, higher family social class, more maternal responsivity at 10 months and a more stimulating home learning environment (HLE) at 36 months
- Most variance was explained by 18 month cognitive development, maternal education, and family social class

Barnes, J. & Melhuish, E. C. (2016). Amount and timing of group-based childcare from birth and cognitive development at 51 months: A UK study. International Journal of Behavioural Development.

Intervention

- The essence of cognitive neuroscience research on SES is to point towards interventions to reduce the impact of family differences in SES on child development

- Three types of implication
  - Hackman, Farah, & Meaney (2010), Raizada & Kishiyama (2010) Sheridan & McLaughlin (2016)

Intervention

1. "Measurable in the brain" **DOES NOT EQUAL** "can't be changed"
   - Beyond severe neglect, effective interventions targeting executive functions + engaging with parents

Interventions

- Targeting the family rather than the school

> Current Issue > vol. 110 no. 29 > Helen J. Neville, 12138–12143, doi: 10.1073/pnas.1304437110

CrossMark click for updates

Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers

Helen J. Neville[a,1], Courtney Stevens[b], Eric Pakulak[a], Theodore A. Bell[a], Jessica Fanning[a], Scott Klein[a], and Elif Isbell[a]

N=lower SES preschoolers. Head Start + selection attention training vs. Head Start vs. active control. Measure selective attention, cognition, parent-reported child behaviours

Interventions

- Perry preschool
- Abecedarian
- Chicago schools

Long-term benefits for training executive functions

- EF training: Tools of the Mind
  - full preschool curriculum consisting of 60 (Vygotsky-inspired) activities, many requiring use of executive functions through play
- Language enrichment: 30 Million Words Initiative
  - parent-directed program to alter language interactions with children

Intervention

2. Mechanistic perspective highlights multiple points of possible intervention
   - directly on SES
   - indirectly on experiences or biological processes that mediate SES effects (e.g., prenatal diet)
   - indirectly on brain development by training specific neurocognitive functions,
   - on outcomes educationally or therapeutically
   - fostering factors of resilience (e.g., caregiver-child relationship)

Intervention

3. Measures of brain function may help distinguish separate causes of same behaviour
   - E.g. childhood emotional regulation difficulties caused by
     - adverse childhood events – intervene via therapy
     - lack of cognitive stimulation – intervene with more learning opportunities

Open questions

- Contribution of different SES causal factors to different behaviours? At different ages?
- Dependence on absolute levels?
- Age of intervention? (earlier always better? cheaper?) Importance of teenage years, too?
- Explanation of unevenness across cognitive profile?
- Separation of adaptation effects from deficits?
- How can we target pre-natal differences?
- How can we best enrich family environment?
- How can we increase the power of the school environment?

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http://www.psyc.bbk.ac.uk/research/DNL/
http://www.educationalneuroscience.org.uk

Thanks for your attention!

Questions?