SES and Neural Function in Childhood

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Socioeconomic Status in Childhood

- Predicts adult health and health behavior
  - Insulin resistance, Heart Disease, Smoking, Alcohol Abuse, Obesity, Mental Health (Goodman, Daniels, Dolan, 2007; Fujiwara & Kawachi, 2009; Poulton, et al., 2002; Pollitt, Rose, & Kaufman, 2005)
- Predicts achievement in school (Stipek & Ryan, 1997)
Previous Studies

Parental SES

- Working memory (Evans & Schamberg, 2009)
- Long term memory (Farah, et al., 2006)
- Language use (Nobel, et al., 2005)
- Stress reactivity (Boyce, et al., 1999)

Neural correlates related to prefrontal function
(Kishiyama, et al., 2009; Stevens, et al., 2009)

Neural correlates of language function
(Razza, et al., 2008; Noble, et al., 2006)
What is the Mediator?

Language?

Language could directly (or indirectly) affect brain development (Heart & Risley, 1995)

Differences in language (during childhood) are large, replicable and consistent

Stress Exposure?

Direct action of stress hormones (cortisol) on the structure & function of our brains (Schonkoff, et al., 2009)

Increased exposure to stressful experiences

Other: Traumatic Events, Risk Factors, Structural Barriers, Schooling experiences.
The Prefrontal Cortex
• Regulates behavior
• Required for working memory, inhibition, switching
• Predicts academic success
• Associated with health behaviors

The Hippocampus
• Regulates stress reactivity
• Required for long term memory
Questions

• Is there an association between neural function and SES in childhood?
  • Prefrontal Cortex?
  • Hippocampus?

• Will language exposure mediate these findings?
• Will stress exposure mediate these findings?
Study 1: Participants

18 children (17 F, 1 M)
8-12 years M= 9.9yrs

9 low SES families /9 high SES families

Income/needs (.22-6.58)

Parent education (Middle School [1] – Graduate Degree[6])

MacAuthur Ladder
Methods

Task

Low Language demands
Stimulus Response Learning Task
Rule learning requires PFC (Bottiger & D’Esposito, 2005)
Rule learning develops across childhood (Zelazo, et al., 2006)

Larger Study

Dinner time conversations
Coded for language complexity, words per minute
Study Time Line

Behavioral Testing
- Learn Familiar

FMRI scanning
- Practice Familiar
- Learn Novel

Day 1

Day 2

At least 1, no more than 3 days
Income correlates with performance

Income to Needs x Familiar (age, time of day): $r = .30$, $p = .32$

Income to Needs x Novel (age, time of day): $r = .71$, $p = .006$
SES by Rule Interaction

Low (9) > High (9) for Novel>Familiar

Areas associated with learning are more active for low Compared to high SES subjects

Sheridan, Sarsour, Jutte, D’Esposito, Boyce (in prep)
SES by Rule Interaction

Middle Frontal Gyrus (MFG)
MFG by Percent Correct

Novel: *$r = -.511, p = .03$  
Familiar:  
$r = -.404, p = .096$
MFG by Family Language Complexity

Language Complexity

Systematic Analysis of Language Transcripts (SALT9) software
  Child and Family Separately

Complexity: Sum of Word Roots, Bound Morphemes, Conjunctions

*\( r = -0.75, p = 0.001 \)
Mediation: Accuracy

Family Language Complexity

Income to Needs Ratio

\[ b = 0.58, p = 0.009 \] (\[ b = 0.55, p = 0.13 \])

Novel Rule Accuracy

\[ b = 0.81, p = 0.002 \]

\[ b = 0.58, p = 0.03 \]

Family Language Complexity

All regressions controlling for: Age and Time of Day
Mediation: MFG

Family Language Complexity

Income to Needs Ratio

Learning in RDLPFC

\[ b = -0.69, p = 0.01 \]

\[ b = -0.45, p = 0.26 \]

\[ b = 0.81, p = 0.002 \]

\[ b = -0.68, p = 0.02 \]

All regressions controlling for: Age and Time of Day
Study Questions

Are there differences in prefrontal function in childhood related to family SES? **YES**

Which experiences during childhood account for these differences?

Language exposure? **YES**
Study 2: Demographics

fMRI N = 20 (11 male, 9 female)

Age M=9.74 (8 - 12 years)
Income to Needs Ratio M= 2.71 (.23 - 4.54)
Mom Years Ed M=16  (10 - 20)
IQ M= 111  (86 - 142)
Mom IQ M=118   (96 - 130)

Adults (typical fMRI study group) N = 20
Study Design

Day 1 (Stress Reactivity Study) N = 40
Child version of Trier Social Stress Test
6 cortisol samples before, during, after Trier
No increase in Cortisol during TSST

Day 2 (fMRI) N = 20
Previous studies in adults revealed Right hippocampal activation to pairs of stimuli.

Subject instructed to remember.
Task related activation (pair - item)

Adults
$p < .001$

Children
$p < .005$
Hippocampus by Cortisol

\[ r = 0.610, \ p = 0.006 \]

\[ r = 0.603, \ p = 0.006 \]
Hippocampus by SES

$r = .361, p = .14$
DLPFC by SES

r = .527, p = .025
Mediation: Hippocampal Function

SES (composite) $b = .30, p = .11$

Pair Encoding in the Right Hippocampus $b = .70, p = .007$

Average Cortisol (EKG/EEG) $b = .35, p = .22$

All regressions controlling for: Age and IQ
Mediation: Prefrontal Function

All regressions controlling for: Age and IQ
Questions

- Is there an association between the function of the hippocampus and SES in childhood?
  - Little evidence
  - But also the prefrontal cortex

- Does stress exposure mediate these findings? NO
Discussion

- How surprising is the finding that SES is associated with the prefrontal cortex?

- Prefrontal cortex is much closer link to differences in health *behaviors* & *achievement*:
  - Associated with smoking & addiction
  - Associated with academic achievement

- Prefrontal cortex has a long developmental trajectory (longer than the hippocampus)
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Mentors: Ichiro Kiawachi, W. Thomas Boyce, Charles Nelson, John Gabrieli, Stephen Hinshaw, Mark D’Esposito
Right DLPFC (items) $r = .63$, $p = .004$
Right Hippocampus (items) $r = .54, p = .02$
Right Hippocampus (items) $r = .54$, $p = .02$
**SES by Task Performance**

- $r = .42, p = .07$
- $t \text{ (Low, Middle)} = -2.82, p = .017$
- $t \text{ (Middle, High)} = \text{n.s.}$
- $t \text{ (Low, High)} = \text{n.s}$
Effect of Age (dprime)

Adults and Children: Behavioral Performance on Memory Test

Dprime = Norm (Hit) - Norm (FA)