THE EARLY ROOTS OF SOCIAL DISPARITIES IN HEALTH: EXPERIENTIAL CANALIZATION OF BRAIN AND BEHAVIOR

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Self-Regulation in Childhood Predicts Later Life Outcomes

Moffitt T E et al. PNAS 2011;108:2693-2698
Academic, economic, and social outcomes for the Perry Preschool and Abecedarian Programs.

Knudsen E I et al. PNAS 2006;103:10155-10162
Mean IQ scores as a function of age for intervention and control groups in the Perry Preschool and Abecedarian Programs.

Knudsen E I et al. PNAS 2006;103:10155-10162
Self-Regulation: What is It?

Self-Regulation –

- coordination of activity in multiple systems in response to stimulation (internal as well as external) that can be arrayed along a continuum from effortful to automatic
  - Physiological (stress response)
  - Emotional (reactivity and regulation)
  - Attentional (orienting, alerting, volitional)
  - Effortful (executive functions)
The Architecture of Self-Regulation

- Executive Functions
  - Working Memory, Inhibitory Control, Attention Flexibility

- Attention
  - Alerting, Orienting

- Emotional Reactivity and Regulation
  - Positive and Negative

- Stress Physiology
  - Sympathetic, Parasympathetic, HPA

- Genes
  - Neuromodulator Receptor Function
Poverty
Self-Regulation and Executive Function

- Placing self-regulation in context
- Executive Functions early in development are shaped by experiential influences acting through stress hormones... and later in development shape these responses in turn
- Leading to generally Reflective as opposed to Reactive responses to stimulation
- Both “top down” as well as “bottom up”
Complex learning, executive function

Simple learning, reactivity, fear conditioning
Experiential Canalization

- Outmoded separation of nature-nurture in which characteristics of the individual exist in isolation from context – statistical interaction

- Gottlieb (1991). How environment and biology combine to shape development in ways appropriate for the context in which development is occurring – biological interaction

- As applied to self-regulation (Blair & Raver, 2012), the question is one of the functional role of behavior and the extent of malleability
Family Life Project

- Longitudinal, population based sample followed from birth (n = 1,292), in predominantly non-urban, low-income communities
  - Data collection in the home at 7, 15, 24, 36, 48, and 60 months of age to assess aspects of parenting and family ecology
  - Child emotion, attention, stress physiology, and executive functions
  - Genetic SNPs relating to dopaminergic, adrenergic, glucocorticoid, cholinergic receptor sensitivity
Data collection
Data collection at 7, 15, and 24 months

- Cortisol and alpha amylase from saliva at baseline and 20min intervals in response to emotion challenge (mask and toy)
- Parenting: observed structured free play coded from video
  - sensitivity, detachment, positive regard, animation, stimulation for development, intrusiveness and negative regard
- Household Chaos: combined household density, hours of TV, preparation for home visits for data collection, cleanliness, neighborhood noise
- Cumulative Risk: combined partner, hrs worked, occ prestige, income to need, maternal education, density, safety
Blair et al. (2011) *Development and Psychopathology*
High quality parenting is associated with the cortisol response to emotional arousal at 7 and 15 months.

Blair et al. (2008) *Developmental Psychology*
Relation of parenting to the cortisol response at 24mos is dependent on level of child emotional arousal

Low emotional arousal: positive parenting associated with low cortisol

High emotional arousal: positive parenting associated with high cortisol (reactivity)
Executive Function
Executive Function

- Executive Functions assessed with a new longitudinal measure at 36, 48, 60 months

- Flipbook format, computer scoring

- Inhibitory control, working memory, attention shifting
  - Addition of Stroop-like sounds, go no-go, and self-ordered pointing tasks at 48 and 60 months
Executive Function at age 3 years

Parenting Positive 7, 15, 24 mos

\[ -0.32^{***} \]

Parenting Negative 7, 15, 24 mos

\[ -0.15^{**}, -0.26^{***}, -0.39^{***} \]

Cortisol Baseline 7, 15, 24, mos

\[ -0.42^{***} \]

Executive Functions 36 mos

\[ 0.15 \]

IQ 36 mos

\[ -0.26^{***} \]

\[ -0.27^{***} \]

\[ -0.26^{***} \]

\[ -0.19^{***} \]

\[ 0.26^{***} \]

\[ 0.14^{**}, 0.34^{***}, 0.27^{***} \]

Income-to-Need Ratio

Maternal Education

African American ethnicity

Blair et al. (2012) Child Development
# Executive Function Development

<table>
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<tr>
<th></th>
<th>Mean (SD)</th>
<th>EF 36</th>
<th>EF 48</th>
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<tr>
<td>EF 36 mos</td>
<td>.49 (.21)</td>
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<tr>
<td>EF 48 mos</td>
<td>.62 (.16)</td>
<td>.45**</td>
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<tr>
<td>EF 60 mos</td>
<td>.72 (.14)</td>
<td>.33**</td>
<td>.57**</td>
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Executive function accuracy

![Graph showing executive function accuracy over months](image-url)
Executive Function Change

[Graph showing changes in Executive Function over age]
## Predictors of Change in EF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>df</th>
<th>t</th>
<th>Sig.</th>
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<tbody>
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<td>Intercept</td>
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<td>.148</td>
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<tr>
<td>Age</td>
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<td>.004</td>
<td>1757.268</td>
<td>6.807</td>
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<tr>
<td>Age * Age</td>
<td>.000</td>
<td>.000</td>
<td>1650.927</td>
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<tr>
<td>Black</td>
<td>.029</td>
<td>.010</td>
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<tr>
<td>State</td>
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<td>.010</td>
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<tr>
<td>Maternal Ed</td>
<td>.004</td>
<td>.002</td>
<td>1010.078</td>
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<tr>
<td>Cortisol mean</td>
<td>-.088</td>
<td>.032</td>
<td>874.811</td>
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<td>Household chaos</td>
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<td>.006</td>
<td>634.954</td>
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<tr>
<td>Positive parenting</td>
<td>.093</td>
<td>.025</td>
<td>893.014</td>
<td>3.738</td>
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<td>Negative parenting</td>
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<td>.028</td>
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<td>-3.017</td>
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<td>Age * positive</td>
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<td>805.269</td>
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<td>Age * negative</td>
<td>.001</td>
<td>.001</td>
<td>770.764</td>
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<td>Age * cortisol</td>
<td>.001</td>
<td>.001</td>
<td>803.421</td>
<td>2.077</td>
<td>.038</td>
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Gene X Environment

- Variants of genes associated with ‘sensitivity’ to dopamine, norepinephrine, and cortisol will be differentially related to executive function ability depending on level of risk in the environment (GxE interaction)
- High sensitivity will be associated with low executive function in high risk contexts and high executive function in low risk (high support) contexts
- Interaction will take one of three forms
Genetics

- COMT rs4680 catechol-o-methyltransferase
  - Substitution of G for A resulting in valine to methionine substitution at position 158, val^{158}met, resulting in less efficient (1/3) breakdown (catabolism) of catecholamines in the synapse
  - Important in PFC where molecular transporters are less abundant
  - Codominant; met variant may be specific to humans
COMT
Genetics

- DRD2 rs6277 dopamine D2 receptor gene
  - SNPs expressed predominantly in striatum, presumed to be related to reinforcing properties of DA
  - Multiple variants studied; association of substitutions with DA availability and addiction behavior
  - DRD2 rs6277 in FLP sample, presence of A/T variant associated with higher dopamine availability than C/G variant
  - Other DRD2 gene variants reduced frequency in FLP sample
DRD2
DRD2 and EF growth

[Graph showing the growth of Executive Function accuracy across different DRD2 and CHAOS conditions.]
Analyzing Change

- Leveraging change to strengthen inference about the relation of the environment to an outcome.
- In the FLP data, incremental change in Home quality and Parenting quality between assessment time points is associated with incremental change in executive function.
- Among children equal in EF ability at age 36mos, change in home environment is associated with change in EF at age 60mos.
Mean HOME and Change in HOME from 7 to 36 months
Predicting Executive Function Change at age 5

<table>
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<th>b</th>
<th>se</th>
<th>β</th>
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<td>Executive Function age 3</td>
<td>.20</td>
<td>.02</td>
<td>.31</td>
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<tr>
<td>HOME score age 3</td>
<td>.13</td>
<td>.05</td>
<td>.17</td>
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<tr>
<td>HOME dif age 5 – age 3</td>
<td>.11</td>
<td>.05</td>
<td>.09</td>
</tr>
</tbody>
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Controlling for household income-to-need, maternal education, child race

Blair et al. (in press) Developmental Psychology
Latent change model

Blair et al. (in press) Developmental Psychology
Cortisol, Risk, and Hours in Child Care

Berry et al. (in press a) Developmental Psychology
Self-Regulation and Education Practice

- The experiential canalization approach provides a meaningful framework for education practice

  - Priorities include

    - Evaluation of curricula to support self-regulation development, both as an end in itself and as a means to academic ends
    - Development of measurement of self-regulation for evaluation and improvement
    - Partnership with schools to generate and utilize data for purposes of evaluation and decision-making
Self-Regulation and Education Practice

- Evaluation of the Tools of the Mind curriculum
- RCTs of Pre K and Kindergarten versions
  - Mature make-believe, socio-dramatic play
  - Planning play
  - Teacher scaffolding
  - Peer interactions; buddy reading, doing and checking
  - Use of mediators
  - Self-regulation games
Make-Believe Play

Mature Make Believe Play:
- Deep engagement
- Planned in advance
- Roles with rules
- Scenarios that change and adapt
- Symbolic props
- Language used to plan the play
Children Plan Their Play

I am going to take people's orders.
Cognitive Self-Regulation

- Children are asked to talk about how they “know things”
- Children act as a checker for another child, practicing a version of “reflection on action”
Effects of Tools K on CLASS organization
Effects of Tools K on CLASS emotional and instructional support
Implications for Early Intervention

- Administration for Children and Families Early Head Start Partnership: Buffering Stress
  - www.acf.hhs.gov/programs/opre/ehs/buffering_children/abstracts.html

- Six independent studies to examine
  - Validation of the role of stress in the link between poverty and child outcomes
  - Implementation of strategies with primary caregivers in EHS to promote positive child outcomes
  - Efficacy of these strategies in RCTs
Early Intervention: ACF Buffering Stress

- All projects focus on parent training
  - Attachment and Biobehavioral Catch-Up (ABC)
  - Parent-Child Interaction Therapy and Emotional Availability training
  - Incredible Years
  - Video based parent training – PALS and FIND
Conclusions and Implications

- A psychobiological model of self-regulation indicates a focus on the function of behavior in context; adaptation
- Prevention efforts can recognize the multilevel manifestation of risk (genes, physiology, emotion, cognition) in efforts to reduce or counteract it
- Conditions of poverty have been shown to be stressful physiologically for children, but we know relatively little about stress physiology and genetics of self-regulation
- Research and theory suggest the importance of the regulation of stress; not that stress is inherently harmful but is something to be managed – controllable vs. uncontrollable
Collaborators and Funders

**Penn State University**
- Mark Greenberg, PhD
- Doug Granger, PhD
- Cynthia Stifter, PhD
- Leah Hibel, PhD
- Katie Kivlighan, PhD
- Kristine Voegtline, PhD

**UNC Chapel Hill**
- Lynne Vernon-Feagans, PhD
- Martha Cox, PhD
- Margaret Burchinal, PhD
- Mike Willoughby, PhD
- Patricia Garrett-Peters, PhD
- Roger Mills-Koonce, PhD
- Eloise Neebe, MA
- Laura Kuhn, MA

**New York University**
- Cybele Raver, PhD,
- Daniel Berry, PhD
- Alexandra Ursache, MA

**Funding**
- National Institute of Child Health and Human Development
  - R03 HD39750 , P01 HD39667, R01 HD51502 (ARRA)
- Institute of Education Sciences R305A100058