STRESS, POVERTY, AND THE DEVELOPMENT OF EXECUTIVE FUNCTIONS IN CHILDREN: AN EDUCATIONAL CRISIS IN THE MAKING

Clancy Blair, PhD
Department of Applied Psychology
NYU Neuroscience and Education Lab
New York University

Birth to Five Policy Alliance and Peer Advocate Roundtable
October 11, 2012 New Orleans, LA
Income inequality is increasing

Reardon, S. (2011). The widening academic achievement gap between the rich and the poor. In Whither Opportunity? Rising Inequality, Schools, and Children’s Life Chances
Disparity in educational outcomes associated with income inequality is growing

Reardon, S. (2011). The widening academic achievement gap between the rich and the poor. In Whither Opportunity? Rising Inequality, Schools, and Children’s Life Chances
Disparity associated with income now rivals that of parental education

Inequality, economically and educationally, is bad for health and well being

Crisis in Education

- The growing disparity in educational outcomes between the rich and the poor is a problem.
  - Inequality, economically and educationally, is a threat to stability and vitality of democracy in the United States.
  - Limited advances in pedagogical theory and practice.
  - Is a focus on self-regulation, specifically on executive functions, part of the solution?
Addressing the Crisis in Education

- Early education programs
  - Lifelong beneficial effects from early intensive programs
    - Perry Preschool, Abecedarian, Chicago Parent-Child
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 in Childhood Predicts Later Life Outcomes

Moffitt T E et al. PNAS 2011;108:2693-2698
Executive functions and educational disparities

- Executive function abilities predict academic and social readiness for school and early academic ability in children in poverty over and above other child characteristics, such as intelligence and prior academic knowledge.
What are executive functions?

- Working Memory
- Inhibitory Control
- Attention Shifting

General cognitive skills associated with planning, reasoning, problem solving; connecting current and past information and actions in a future-oriented goal directed perspective
Luria’s peg tapping task

When I tap one time, you tap two times …

…and when I tap two times, you tap one time.

okay…

peg

alright …
Item selection task

from Jacques and Zelazo (2001), Developmental Neuropsychology
Relation between executive function and teacher report of self-regulation
## Prediction of Math in Kindergarten

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<td>EF in K</td>
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from Blair & Razza (2007). *Child Development*  

*p < .05, **p < .01*
## WJ-III Applied Problems in Kindergarten

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From Welsh et al. (2010). *Journal of Educational Psychology*
Word Reading in Kindergarten

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from Welsh et al. (2010). *Journal of Educational Psychology*
Executive Functions and Early Ability

- Is executive function more (or less) important for later achievement than early academic ability?
  - Duncan et al. (2007) found that math entry skills were a better predictor of later math and reading skills than any other predictor.
- Not an “either-or” question but a question of process (and also of measurement!)
  - Early and later self-regulation/executive function contribute to early and later skill.
Relation between EF and Early Skill

**Figure 1.** Path model for kindergarten reading achievement.

**Figure 2.** Path model for kindergarten math achievement.
Executive functions partially *mediate* the effects of poverty (*family characteristics and home environment*) on school readiness and early academic ability.

In part, the effect of poverty on executive functions reflects that idea that poverty is physiologically stressful for children.

Children in poverty tend to present resting levels of stress hormones (cortisol) that are higher or lower than children from middle and upper income homes.
Self-Regulation Components

- Multiple components that can be arrayed on a continuum from automatic to effortful
  - Physiological (stress response)
  - Emotional (reactivity and regulation)
  - Attention (orienting, alerting)
  - Effortful (executive functions)
Self-Regulation Definition

- **Self-Regulation**: Management of emotion, attention, and stress physiology for the purposes of goal-directed action through cognitive processes and strategies
Self-Regulation Model

- Model of self-regulation
  - Engagement of attention, emotion, stress response systems in ways that benefit executive cognitive control and self-directed behavior... and vice versa
  - Self-regulation is both *effortful* and *automatic* and both *top-down* as well as *bottom-up*
Neuroscience

- **Bottom-up signaling occurs through**
  - rapid activity in limbic and brainstem structures signaling via neuroendocrine hormones (cort, DA, NE) that act as neuromodulators and that are potentiated by activity in the hypothalamic pituitary-adrenal (HPA) axis and autonomic sympathetic and parasympathetic systems

- **Top-down influence through**
  - Engaging executive functions and feedback associated with slower, more effortful processing occurring in prefrontal cortical networks
Figure 2. Dopamine has a powerful influence on PFC function, especially through its actions at DA D1 receptors. Either too little or too much DA D1 receptor stimulation impairs PFC function. A representative dose/response curve for the D1 agonist A77636 is shown. Low doses of a D1 agonist such as A77636 can improve working memory performance in monkeys, while higher doses impair performance below control levels (indicated by horizontal line). DA, dopamine; PFC, prefrontal cortex. (Adapted from Cai and Arnsten 1997.)
Model of Self-Regulation

- At moderate levels of stress hormone increase, synaptic activity in PFC is increased and complex learning and reflective ability is enhanced.

- At very high levels of stress hormone increase, activity in PFC is reduced and activity in brain areas associated with more reactive responses to stimulation is increased.

- Experience will shape brain networks that underlie this phenomenon.
Experiential Canalization

- Shaping of development by the environment through effects on malleable systems in ways that promote adaptive functioning in that environment
- In terms of self-regulation, experiential shaping of development toward a more reactive or more reflective phenotype
- The emergence of sets of beliefs about the efficacy of specific behaviors in specific contexts
Experiential Canalization: Evidence

- Shaping of executive functions and self-regulation development through hormones associated with stress response systems?
Family Life Project

- Longitudinal, population based sample followed from birth ($n = 1,292$) in predominantly rural, low-income communities in the U.S.A.

- Data collection in the home 7, 15, 24, 36, 48, 60 mos
  - parenting and home quality
  - emotion, attention, and executive functions
  - saliva samples – stress hormones cortisol and alpha amylase
    - Collected around emotion challenge tasks
  - direct assessments of academic abilities
Self-Regulation Development

- EARLY ENVIRONMENT
- EARLY CAREGIVING
- CHILD STRESS RESPONSE
- EXECUTIVE FUNCTIONS
High quality parenting is associated with the cortisol response to emotional arousal at 7 months.
High quality early parenting is associated with a lower overall level of cortisol at 15 months

Blair et al. (2008) *Developmental Psychology*
Executive Function Development

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

- Inhibitory control, working memory, attention shifting
  - Addition of Stroop-like sounds, go no-go, and self-ordered pointing tasks at 48 and 60 months
“Here are two pictures. Something’s the same. They are both flowers.”
“Here’s another picture. Which of these... is the same as this one?”
Canalization of Executive Function Ability

- In our longitudinal data, we found that effects of poverty and parenting quality on executive functions were mediated in part through cortisol
Executive Function at age 3 years

Blair et al. (2011) Child Development
Malleability of Executive Functions

- What about the malleability of executive functions?
- Experimental data
  - Chicago School Readiness Project
  - Head Start REDI Project
- Tools of the Mind
  - Diamond et al. (2007) Science
  - Trials currently in TN/NC, NYC/Tampa FL, and MA
Chicago School Readiness Project

- Teacher training and coaching by a mental health consultant to improve the emotional climate of the classroom, lower children’s level of conflict with peers, and lower teacher stress

- Changing the climate should reduce self-regulation challenges for children and teachers, increase attention focus and executive function, and increase learning outcomes
CSRP: Impacts on Children’s Self-Regulation and Pre-Academic Skills

SOURCE: Raver, Jones, Li-Grining, Zhai, Bub, & Pressler, 2008
NOTES: Significance levels are indicated as * p < 0.10; ** p < 0.05; *** p < 0.01.
CSRP Mediation

Figure 1. A mediating model of Chicago School Readiness Project’s (CSRP) impact on low-income children’s preacademic skills

Note. $T_k =$ CSRP treatment; $Y_{ijk} =$ preacademic outcomes; $M_{ijk} =$ mediators (i.e., self-regulation measures); $\gamma_c =$ effects of treatment on preacademic outcomes; $\gamma_a =$ effects of treatment on mediators; $\pi_b =$ effects of mediators on preacademic outcomes.

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Note. Mediated effect is unstandardized.

† $p < .10$. * $p < .05$. ** $p < .01$. 
Tools of the Mind

- Program based on the work of Lev Vygotsky developed by Deborah Leong and Elena Bodrova
- Designed to impact both self-regulation and to teach content skills in literacy and mathematics
- An approach to teaching children that changes the way children learn
Tools of the Mind

- Systematic—activities are designed to provide initial teaching and introduction by the teacher followed by gradual release of practice to children, ending in a fluid performance.
- Sequential—content rolls-out follows a developmental learning sequence.
- Individualized—activities are designed so all children participate at their own level and teachers provide individualized support for each child based on that child’s needs.
Development of Self-Regulation

Physical self-regulation
- control body position and movements

Social-emotional self-regulation
- Control temper, anxiety, feelings

Cognitive self-regulation
- Attention, memory, executive function
Cognitive Self-Regulation

- Children play games where they have to remember.
- Children follow a learning plan, complete a work product, and set learning goals.
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”
Preschool Program Improves Cognitive Control

Adele Diamond, W. Steven Barnett, Jessica Thomas, Sarah Munro

Cognitive control skills important for success in school and life are amenable to improvement in at-risk preschoolers without costly interventions.
## Tools of the Mind, EF, and academic ability

from Diamond et al. (2007). *Science*

<table>
<thead>
<tr>
<th>Measure</th>
<th>WCJ applied problems raw score</th>
<th>Get Ready To Read raw score</th>
<th>PPVT standard score</th>
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THE EARLY YEARS

Evaluating Montessori Education

Angeline Lillard* and Nicole Else-Quest

An analysis of students’ academic and social scores compares a Montessori school with other elementary school education programs.

Results for 5-year-olds. Montessori students achieved higher scores [converted to average z scores (18)] for both academic and behavioral tests.

Results for 12-year-olds. Students in the Montessori program wrote more sophisticated and creative stories and showed a more developed sense of community and social skills. Scores were converted to average z scores (18).
Conclusions and Implications

- Data provide support for an arousal based model of executive function development.
- Data also indicate that executive functions are malleable and influenced by multiple aspects of experience in early childhood.
- Data also suggest that effect of experience on stress physiology and executive functions is one mechanism through which poverty gets under the skin to affect children’s development.
- Experimental data are needed to address both the short and long term malleability of executive functions and associated aspects of self-regulation.
Collaborators and Funders

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