

Income and the Developing Brain During the First Three Years of Life

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A growing body of small-scale studies documents that the cognitive and brain development of low-income children differs from that of children reared in higher-income families. Differences favoring more affluent children are found for young children's language, memory, executive function, and socioemotional processing, with corresponding differences in neural structure and function in brain regions that support these skills.¹ At the same time, a large body of social science research documents income disparities in more general measures of children's achievement, school performance, and learning-related behaviors such as attention and self-regulation.² Developmental scientists agree that poverty is especially likely to shape children's early development because of the high plasticity and rapid growth of the brain during the first three years of life. Yet, there has not been a rigorous study of how income supports for families affect the brain function and development of infants and toddlers.

We propose the first randomized experiment testing causal connections between poverty reduction and brain development among very young children. We will randomly assign some 1,000 low-income mothers and their newborns in several ethnically and geographically diverse communities to either (1) an experimental group that receives \$333 in cash payments each month (\$4,000 each year) for each of the first 40 months of the children's lives, with the first payments occurring shortly after the baby's birth, or (2) a control group that receives much smaller payments (\$20 per month). Based on our and others' prior work, the \$3,760 annual difference will be large enough to produce and detect meaningful differences in children's cognitive development.

Moreover, to understand how poverty reduction improves brain functioning, at ages one and two we will measure family context that we expect links poverty to development: parent stress, family expenditures, routines and time use and parenting practices, and child care arrangements. Rigorous laboratory measures of children's cognitive and brain development, as well as measures of health, stress and behavior, will be gathered at age three.

Results would provide strong and clear evidence about the magnitude and pathways of causal connections between enhanced income and early cognitive and brain development. Beyond its core contributions to science, the proposed project will provide important evidence about the likely effects of tax and income-enhancement policies for young children, such as the Child and Earned Income Tax Credits, incentive-based employment programs, and related social policies designed to enhance family economic well-being.

A one-year pilot study launched in July, 2014 established the feasibility of our proposed approach. Grants from W.K. Kellogg, Annie E. Casey, Jacobs, Smith-Richardson, and the Sherwood foundations, plus likely funding from the National Institutes of Health and the JBP Foundation would cover all but about \$4 million of the project's \$15.8 million cost. We seek funding to close this gap.

For additional information about this project please contact Greg Duncan (gduncan@uci.edu), Katherine Magnuson (kmagnuson@wisc.edu) or Kimberly Noble (kgn2106@tc.columbia.edu)

SOME DETAILS

Who we are

Neuroscientist: Kimberly Noble, MD, PhD (with Nathan Fox, PhD)

Social scientists: Greg Duncan, PhD; Lisa Gennetian, PhD; Katherine Magnuson, PhD; Hirokazu Yoshikawa, PhD

Collectively, our expertise spans neuroscience, economics, and developmental psychology. Four of us hold chaired and/or distinguished professorships at leading research universities. All but one of us has extensive experience with experimental studies (e.g., Moving to Opportunity; the welfare-to-work experiments conducted by MDRC in the 1990s; the *Un Buen Comienzo* preschool experiment in Chile). Several of us have directed large longitudinal data collection projects (e.g., the Panel Study of Income Dynamics). Several of us have written widely-cited studies of the neuroscience (Noble) and social science linkages between poverty and child development (Duncan and Magnuson). All of us have collaborated closely with one or more of the rest on major research projects.

What we would do

Some 1,000 infants born to mothers with low socioeconomic status (income no greater than the federal poverty thresholds) in 4 sites (250 infants in each site) in the United States will be distributed at random to experimental or control groups. Experimental group parents would receive unconditioned cash payments of \$333 per month (\$4,000 per year) for 40 months. The comparison group would receive a nominal payment-- \$20 per month, delivered in the same ways. Following standard research procedures, all participating families would receive a \$100 respondent incentive for participating in three of our four planned interviews and a \$200 payment for our proposed age-3 laboratory assessments. The prospective sites are: New York City (two hospitals within the Columbia University Medical Center system); New Orleans (Tulane-Lakeside Hospital); the Omaha area (Bryan Medical Center and University of Nebraska Medical Center); and St. Paul (University of Minnesota Children's Hospital). The study investigators and local partners have successfully completed studies and recruited mothers in these hospital settings.

Mothers will be recruited in maternity wards of participating hospitals shortly after giving birth and, after consenting, will be administered a 20-minute baseline interview. The three follow-up waves of data collection will provide information about family functioning as well as developmentally appropriate measures of children's cognitive and behavioral development. We will collect information from the mother on the phone when the infant is 12 months old and in the home from the mother and child at the children's second birthday. At age 3, mothers and children will be assessed and interviewed in research laboratories at each site. We will seek consent from mothers to collect state and local administrative data that will shed light on several relevant domains of child and family wellbeing, including parental employment, utilization of public benefits such as Medicaid and Supplemental Nutrition Assistance Programs (SNAP), and any involvement in child protective services. Such consent will also include the option to obtain relevant administrative data to measure long-term outcomes including student-level school records when children become of school age.

The compensation difference between families in the experimental and control groups would boost family incomes by \$3,760 per year, an amount shown in economics and developmental psychology to be associated with socially significant and policy relevant improvements in

children's school achievement. After accounting for likely attrition, our total sample size of 800 at age 3 years, evenly divided between experimental and control groups, provides ample statistical power to detect meaningful (.20 sd – the equivalent of 3 IQ points) differences in cognitive functioning, and key dimensions of family context.

Cognitive measures at age 3

To date, convincing causal studies of the effects of poverty on brain development are scarce. However, recent studies by our team and others have reported correlations between poverty and brain structure/function in several neural regions that support language, memory, executive function and socioemotional skills.^{3,4} In this experimental study, we will build on these prior correlational studies to test whether such associations are causal.

At the age-three lab visit we will administer validated, reliable and developmentally sensitive measures of language, memory, executive functioning and socioemotional skills selected from the NIH Toolbox. We will also collect direct measures of young children's brain development. A core feature of brain development, reflected in brain function, is the development of brain circuitry. Our ability to use language, for example, depends critically on communication between select regions of the brain. Electroencephalography (EEG) is particularly well-suited to studying the emergence of these connections in early childhood. Our team and others have used EEG to show that this developing circuitry is associated with cognitive and verbal abilities in young children. We hypothesize that enhanced income will contribute to more optimal development of this circuitry, and that this process will explain a substantial portion of the link between income and language ability.

Similarly, the development of brain architecture in the first years of life is crucial for later learning and adaptive social behavior. Our team and others have shown that children reared in adverse conditions show atypical levels of brain activity. Importantly, reducing adversity can partially normalize these patterns. Early adversity has particularly important effects on the neural circuits that support memory, executive function and socioemotional processing. We therefore hypothesize that poverty reduction will lead to more optimal brain activity patterns, and that these EEG variables will explain the links between income and these cognitive skills.

Family processes that facilitate brain development

If family poverty reduction shapes early brain development and cognitive functioning, it is important to identify the family processes that help pave the way. Social scientists have studied two complementary pathways by which low family incomes shape the context of child rearing. First, additional resources enable parents to buy goods and services for their families and children that support cognitive development (see Figure 1). These include higher quality housing, nutrition and non-parental child care; more cognitively stimulating home environments and learning opportunities outside of the home; and, by reducing or restructuring work hours, more parental time spent with children. These environmental enrichments may improve children's cognitive functioning, in particular language skills and IQ, by increasing the connectivity and coherence of neural networks. Measures of these features of the child's environment will be collected during the in-home interview when the child is 2 years old.

A second pathway is that additional economic resources may reduce parents' own stress and improve their mental health (see Figure 2). This may allow parents to devote more positive attention to their children, thus providing a more predictable family life, less conflicted relationships, and warmer and more responsive interactions. Research suggests that warm and

responsive caregivers are able to help children regulate their stress responses, thereby reducing the likelihood that children experience the kind of prolonged activation of their stress response systems that has been linked to compromised neural development in the areas of the brain that support memory, executive functioning, and socioemotional processing. Measures of maternal stress and mental health will be collected at ages 1 and 2.

A Pilot Study

In June 2014 we launched an IRB- approved pilot study of 30 poor mothers of newborns from New York Presbyterian Hospital/Columbia University Medical Center to assess baseline procedures, implementation of the debit card and cash transfer, and pilot data collection to inform the development of final survey data instruments and home assessments. The pre-paid debit card does not require a bank account, and can be used to make purchases directly at stores (“point-of-service”) or to withdraw cash at ATMs or banks. Mothers consented to have the debit card company share data about debit card transactions with the research team. Cell-phone texts alerted each mother about monthly payments. Thirty mothers participated in the baseline survey, indicated a willingness to be contacted for future data collection, and agreed to participate in randomization to one of two cash receipt conditions. The pilot sample was largely African American (67%) and Hispanic (70%, mostly Dominican; 37% completed surveys in Spanish). Average maternal age was 25.9; average reported income was \$22,311; and average household size was 4.6. Half of the infants were first-born.

After completing a baseline interview, 15 of the 30 mothers were randomly assigned to receive \$100/month for 12 months (smaller payments than in the proposed study), and 15 were assigned to receive \$20/month for 12 months. Twenty-nine of the 30 mothers consented to our tracking of administrative records data and debit card transactions. Baseline differences in background characteristics favored neither group, suggesting successful randomization. Debit cards were given out immediately following the baseline interview; all mothers used their cards within 6 weeks and regularly thereafter. Very few reported substantial issues with the card, such as a loss or theft, fraudulent charges, or needing help resetting PINS. At 12 months, 27 mothers completed a survey interview closely resembling our proposed age-2 home visit, with an in-home assessment of family expenditures, routines and time use, parent stress and parenting practices, and child care arrangements. Despite the small sample size (13 treatment and 14 control mothers), differences of over .5 standard deviations were found favoring the treatment group for reduced household chaos as well as increased mother-child learning activities and child-care expenditures; the latter was statistically significant ($p < .05$). The pilot study suggests that study implementation, methods of income transfer and research strategy are feasible with low-income mothers with infants, in ways that can support the research at scale.

Connections to policy

As an unconditional cash transfer, our income support “treatment” most resembles European-style child allowances and the U.S. child tax credit. But findings from our project will help inform policy proposals across a host of federal and state programs. The Earned Income Tax Credit conditions its payment on earnings, but can transfer as much as \$6,000 per year to low-income families. SNAP requires that its payment be used for food purchases, but effectively boosts family income by as much as \$8,000. TANF benefits are conditioned on various state-

directed rules and amount to about \$5,000 in a typical state. Housing Choice Vouchers are directed toward rent payments, and typically provide the equivalent of \$7,500 per year. The benefit levels and coverage of almost all of these programs are fiercely debated in today's budget battles. Virtually absent from these debates is evidence on the consequences of proposed changes for the healthy development of young children, because the needed studies have not been done. Advocates who claim that poverty hurts children are countered by other advocates who say "it's not poverty, it's 'single-parent families,' or 'character'" or any number of other alternative explanations. Our study's \$4,000 annual payment is within the range of benefit and coverage changes being debated for these kinds of programs and also consistent with the income changes that research studies suggest would produce changes in children's cognitive development and health. Thus, our study will be the first to provide definitive evidence on the extent to which young children's cognitive development and health is affected by income reductions or enhanced by income increases—or whether income itself does not matter at all.

Timeline

We propose a five-year plan of work for the main study, beginning July 1, 2017. The first six months of the main multi-site study will involve planning for data collection. The 1,000 mothers and infants will be recruited between months 7 and 18 of the main project period. Between months 19 and 31, recruited infants would be celebrating their first birthdays, at which time we will conduct telephone interviews with their mothers. In-home interviews timed to children's second birthdays will take place over months 32 to 43 of the project. Third-birthday lab visits would take place between months 44 and 55. Analyses would begin with partial data from the lab assessments during months 49 to 55 and would be completed by the end of the 60th month. We are eager to follow the sample beyond the children's third birthdays, providing we collect meaningful impacts on child and family functioning. We anticipate that administrative data, including information on school achievement, will be especially useful in any follow-up initiative. Finally, we are also interested in the public good that may result from this project – accordingly, we plan to issue a public-use data file 12 to 15 months following the completion of our third-birthday laboratory-based data collection.

Budget

Our ambitious project is costly. Respondent payments alone will approach \$7 million. Direct costs for the survey work sum to roughly \$4 million. We estimate that the direct costs of lab visits, time of PIs and staff, travel and other project-related expenses will sum to an additional roughly \$4 million over the course of the five project years.

We have submitted an unusually large grant to NICHD to fund a majority of the research costs. This received an excellent score, and a continuing resolution from the current Congress through March or April of 2017 should enable NICHD to fund its share of the project. We should find out about that in early 2017. Philanthropists in Omaha have pledged resources to support work in the Omaha site. Planning resources and commitments to support the income payments or research costs have also been secured from The Annie E. Casey Foundation, Ford Foundation, JPB Foundation, Jacobs Foundation, W.K. Kellogg Foundation, Sherwood Foundation and Smith Richardson Foundation. As of October, 2016, we welcome additional partners to fill the funding gap of approximately \$800,000 per year for each of the five years (\$4 million in all) and ensure successful launch of the study.

Figure 1: Enrichment pathways model

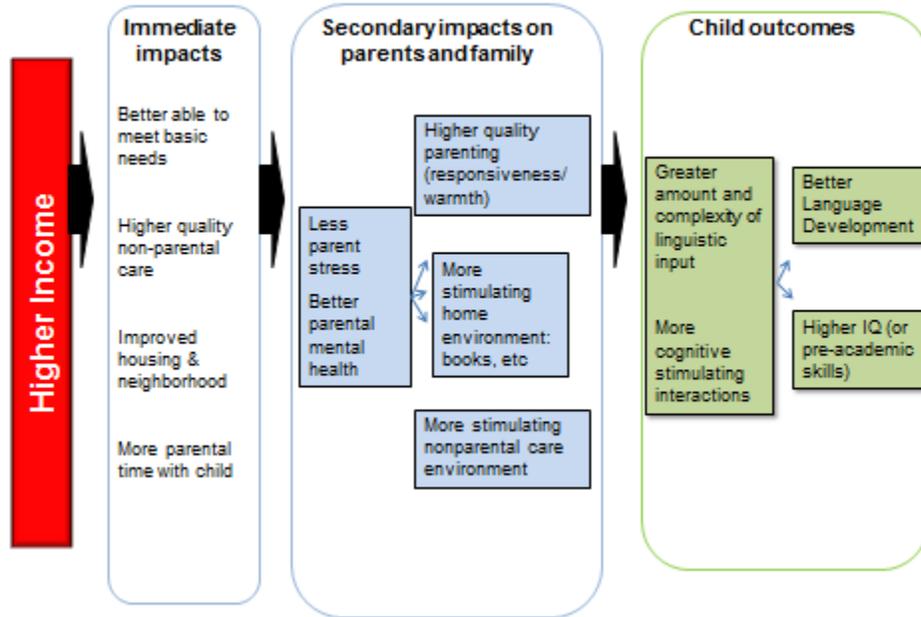
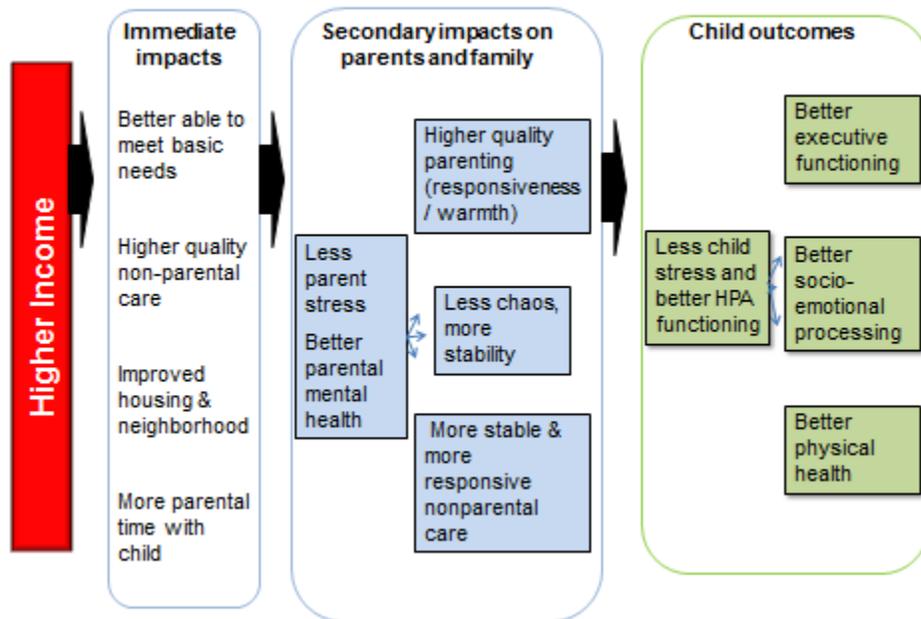


Figure 2: Stress pathways model



ENDNOTES

¹ Duncan G and Magnuson K, (2012) "Socioeconomic status and cognitive functioning: Moving from correlation to causation" *Wiley Interdisciplinary Reviews: Cognitive Science*, 3:377–386.

²Akee R, Copeland W, Keeler G, Angold A, and Costello J (2010). "Parents' incomes and children's outcomes: A quasi-experiment." *American Economic Journal: Applied Economics* 2010, 2(1):86–115; Dahl, G. B. & Lochner, L. (2012). "The impact of family income on child achievement: Evidence from the Earned Income Tax Credit," *American Economic Review*, 102(5): 1927-56; Duncan GJ, Morris PA, Rodrigues C. (2011). "Does money really matter? Estimating impacts of family income on young children's achievement with data from random-assignment experiments." *Developmental Psychology*, 47(5):1263–1279.

³ Noble, K. G., et al. (2012). "Neural correlates of socioeconomic status in the developing human brain." *Developmental Science*, 15(4): 516-527; Stevens, C., et al. (2009). "Differences in the neural mechanisms of selective attention in children from different socioeconomic backgrounds: an event-related brain potential study." *Developmental Science*, 12(4): 634-646., Hanson, J. L., et al. (2011). "Association between income and the hippocampus." *PLoS ONE*, 6(5): e18712., Jednoróg, K., et al. (2012). "The influence of socioeconomic status on children's brain structure." *PLoS ONE* 7(8): e42486.

⁴Structural or functional magnetic resonance imaging (s/fMRI) has far greater spatial resolution than EEG. However, EEG measures are particularly well suited to studying neural processes in toddlers, as, unlike MRI, they do not require the young child to sit perfectly still in a dark and noisy tube, but rather, allow for the child to sit comfortably on the parent's lap. Further, the far greater expense of MRI compared to EEG would render the former unfeasible in a large study. If the poverty reduction intervention proposed here suggests meaningful impacts on child development, a natural future follow-up study will include assessing MRI on a subset of participants as children get older.