Research Strategy
Household Income and Child Development in the First Three Years of Life
(Baby's First Years)
June 27, 2019
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[NOTE: The following is the Research Strategy submitted to NICHD on March 7, 2016 and approved and funded by NICHD. Some of the proposed measures in this document have been replaced by measures listed in the Analysis Plan Appendix Table I and Appendix Table II attached to this study registration. We have also edited some details in order to protect the anonymity of study participants.]

PROJECT SUMMARY

Recent advances in developmental neuroscience suggest that experiences early in life have profound and enduring influences on the developing brain. Family economic resources shape the nature of many of these experiences, yet the extent to which they affect children's development is unknown. Our team of neuroscientists, economists and developmental psychologists proposes to fill important gaps in scientific knowledge about the role of economic resources in early development by evaluating the first randomized controlled trial to determine whether unconditional cash gift payments have a causal effect on the cognitive, socio-emotional and brain development of infants and toddlers in low-income U.S. families. Specifically, 1,000 mothers of infants with incomes below the federal poverty line from four diverse U.S. communities will receive monthly cash gift payments by debit card for the first 40 months of the child's life. Parents in the experimental group will receive $333 per month ($4,000 per year), whereas parents in the control group will receive a nominal monthly payment of $20. In order to understand the impacts of the added income on children's cognitive and behavioral development, we will assess treatment/control group differences at age 3 (and, for a subset of measures, age 2) on measures of cognitive, language, memory, self-regulation and socio-emotional development. Brain circuitry may be sensitive to the effects of early experience even before early behavioral differences can be detected. In order to understand the impacts of added income on children's brain functioning at age 3, we will assess, during a lab visit, treatment/control group differences in measures of brain activity (electroencephalogram [EEG]). To understand how family economic behavior, parenting, and parent stress and well-being change in response to income enhancement, we will assess treatment/control differences in family expenditures, food insecurity, housing and neighborhood quality; family routines and time use; parent stress, mental health and cognition; parenting practices; and child care arrangements at child age 2 and, for a subset of these measures, child age 1. This study will thus provide the first definitive understanding of the extent to which income plays a causal role in determining early child cognitive, socio-emotional and brain development among low-income families.

SPECIFIC AIMS

Poor children often lag behind affluent children in language, memory, executive functioning and social-emotional development, with corresponding differences in neural structure and function in brain regions that support these skills.[1-4] As adults, poor children are likely to experience a range of unfavorable labor market and health outcomes.[5] Why this is the case is often debated, but not well understood.[6] Proponents of poverty-reduction policies point to the many ways in which economic hardship affects how parents provide for and interact with their children.[7,8] Critics argue that what matters most is not the money itself, but other factors correlated with poverty such as being raised by a single mother or low parental education.[9]

We propose to fill important gaps in scientific knowledge about the extent to which family poverty influences early-life development. We will conduct the first randomized controlled trial designed to evaluate the effects of unconditional income transfers on (1) the cognitive, socio-emotional and brain development of toddlers in low-income families; and (2) family economic behavior, parenting, and parent stress and well-being. The intervention, funded by non-federal sources, is a simple unconditional income transfer. Low-income families will be randomly assigned to a treatment group that receives cash payments of $333 per month—an amount roughly comparable to a variety of income assistance policies in the U.S. and shown to be associated with meaningful improvements for poor children in prior studies—or to a control condition that receives $20 per month. The payments will be made for the first 40 months of the child's life. The experiment will enable us to identify the causal effects of reliable and unconditional income payments on early child development in the U.S., informing not only our basic and applied scientific understanding of early development, but also shedding light on the role of anti-poverty policies in promoting the well-being of poor children.

Aim 1: To understand the impacts of cash payments on low-income children's cognitive and behavioral development by assessing treatment/control group differences at age 3 (and, for a subset of measures, age 2) in validated and reliable measures of cognitive, language, memory, self-regulation and socio-emotional functioning.

Aim 2: To understand the impacts of cash payments on low-income children's brain functioning at age 3 by assessing treatment/control group differences using electroencephalographic-based measures of brain circuitry, including resting brain activity as well as the neural signatures of vocabulary development and memory formation.

Based on prior research and theory, we hypothesize that cash supplements will affect young children's development by changing the nature of their family contexts in two important ways: increasing investments and decreasing family stress. In the case of investments, additional income may enable poor parents to improve their children's cognitive development by buying goods and services such as picture books and other sources of stimulation in the home; higher-quality non-parental child care; learning opportunities outside of the home; better housing and neighborhoods; and, by reducing or restructuring work hours, more parental time and interactions with children. Environmental enrichments such as these may improve children's cognitive functioning, in particular language skills and IQ, via direct effects on brain development.

Second, providing reliable cash payments may reduce low-income parents' psychological distress, fatigue, stress and cognitive resource demands, all of which are adversely affected by constant financial juggling to make ends meet. With improved mental health and more cognitive resources ("bandwidth"), parents may have less conflict with each other (or other partners) and warmer and more responsive interactions with their children. They may also be better able to implement consistent and positive family routines – including regular medical and well-child check-ups. These improvements in family life and routines may enable both parents and young children to better regulate their physiological stress responses, thereby improving neural development in children's brain areas that support executive functioning, memory, learning, socio-emotional development and health. Understanding the nature of these pathways constitutes our third aim:

Aim 3: To understand the ways in which family and child developmental contexts are affected by unconditional cash supplements, we will assess treatment/control differences in family expenditures, food insecurity, housing and neighborhood quality, routines and time use, parent stress, parent-child interactions, parenting practices and child care arrangements at child age 2 and, for a subset of measures, at child age 1.

Building basic scientific knowledge about the role that cash transfers, and resulting increases in income and reductions in poverty, play in the development of young children is crucial for improving the design of a range of anti-poverty policies and programs for families.

RESEARCH STRATEGY

Significance

Recent advances in developmental neuroscience suggest that experiences early in life have profound and enduring influences on the developing brain, at a time when heightened plasticity is observed relative to later developmental periods.[10] Family economic resources shape the nature of many of these experiences, yet the extent to which they affect early-life development is not fully understood. Our team of neuroscientists, economists and developmental psychologists proposes to fill important gaps in scientific knowledge about the role of economic resources in early development by conducting the first U.S. randomized controlled trial to test whether unconditional cash gift payments have a causal effect on the cognitive, socio-emotional and brain development of infants and toddlers in low-income families.

Social science studies provide evidence on the causal effects of family income on birth outcomes and older children, but not infants and toddlers. Many previous studies of income and poverty effects have used longitudinal data and natural variation in family income to assess how poverty relates to child development. These studies generally included demographic variables or other statistical adjustments to control for observable ways in which low-income families differed from more affluent families.[9,11,12] Not all studies draw the same conclusions, but the bulk of the evidence suggests that early childhood differences in family income at the low end of the income distribution are robust predictors of birth outcomes, children's later achievement, educational attainment and even adult earnings.[5,13,14] In contrast, studies that either fail to differentiate family income by child age or focus on the broader income distribution typically found fewer and smaller income effects.[9,15] In all of this work, despite efforts to account for observable differences in family characteristics, the potential for bias from unobservable characteristics looms large.

A smaller set of studies has sought to identify causal effects of low income by focusing on random-assignment or quasi-experimental sources of variation in family income. The Negative Income Tax (NIT) experiments of the 1970s offered guaranteed incomes in the form of cash gift payments, with the generosity of payments declining as other sources of family income increased.[6,16-18] The NIT evaluations were not designed to study infants and toddlers, but did gather limited data on children's school outcomes. Results were mixed, with positive impacts on achievement in middle childhood and completed schooling in adolescence in some sites, but null impacts in others.

More consistent quasi-experimental evidence of income effects comes from the welfare-to-work experiments of the 1990s, most of which increased employment and some of which also increased family income with earnings supplements. Although there were no comparable positive effects on achievement or high school completion among older children, in the case of low-income children making the transition into school, these studies indicated that income increases improved achievement and schooling outcomes, with a $4,000 increase in annual income (in current dollars) for 2-3 years increasing school achievement by .18 standard deviation units.[19,20] Our proposed experiment is powered to detect effects of this magnitude.

Recent quasi-experiments have taken advantage of other sources of plausibly exogenous changes in family income, suggestive of what an unconditional cash transfer might provide. Studies exploiting variations in the timing of state- and province-specific expansions of U.S. and Canadian tax benefits for low-income families show that receipt of these types of cash gift payments contribute to higher test scores among elementary school children.[21,22] In other work, casino disbursements to Native American families have been linked to increased educational attainment for adolescents.[23] Although the magnitude of income increases in these studies was only several thousand dollars, the increases account for a substantial share of a poor family's income—often 20% or higher—and the effects on children's outcomes were large enough to be meaningful.

Related evidence on income effects comes from recent evaluations of programs providing conditional or unconditional cash transfer payments to low-income families. First tested in developing countries as a way to incentivize children's continued schooling and medical care, conditional cash transfers (CCTs) often produced significant improvements in children's development, education and health. This is attributed to the structure of CCTs, which provide incentive payments that directly offset the specific and large opportunity cost of the desired behavior.[24] In the U.S., the evaluation of Opportunity New York City (ONYC), a CCT program targeting reduced family poverty and economic hardship, showed no impacts on children's school test scores after two years of participation.[25,26] Possible explanations for the null effects include the complexity of the payment schedule, the diversity and complexity of behaviors being targeted, implementation difficulties, the small amount of cash support relative to the high cost of living in New York, and the fact that children were older than those enrolled in many other income studies. Unconditional cash transfers (UCTs), sometimes bundled with other benefits, show some promise in improving economic well-being among participants in the developing world, but remain untested in the U.S. context.[27,28]

Although the findings from these social science studies are informative, none of the prior studies focused on infancy and toddlerhood, the time when the developing brain is most malleable to environmental context. Their focus on older children arose from logistical constraints, including the difficulty and cost of collecting valid developmental measures from young children, the exemption of mothers with very young children from welfare-to-work experiments, and the challenge of conditioning cash transfers on behavior relevant to infants and toddlers. Second, many U.S. policy studies were based on income increases that were conditioned on or bundled with employment, which complicated efforts to isolate causal impacts of the income transfers per se.

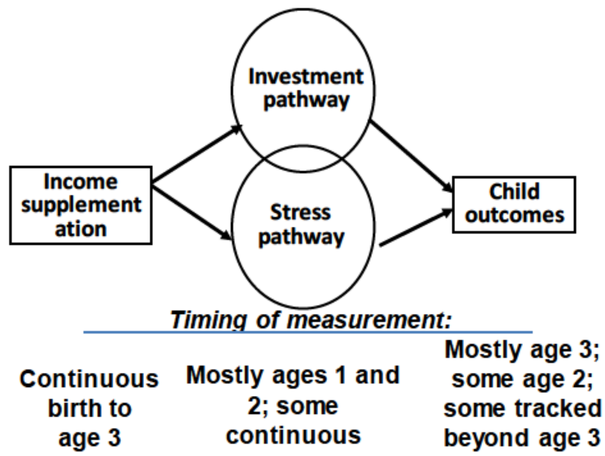
New neuroscience studies find family income correlates with brain function and structure, but lack causal evidence. An important advance in neuroscience has been the study of how early environments, especially adverse environments, shape brain development.[29] A subset of these studies has focused on family socioeconomic status (SES) generally or on income specifically as a key dimension of early contexts.[1-3] In contrast to the social science literature, these studies focus on specific cognitive skills and, increasingly, on direct measures of brain development. This innovation is critical because differences in neural circuitry are often evident well before general cognitive or behavioral differences can be detected,[10,30] and thus serve as an early indicator of the development of cognitive disparities. Moreover, neuroscience provides an explanatory framework for the physiological mechanisms that lead to lower cognitive skills and other observed behavioral differences. Distinct brain circuits support discrete cognitive skills, and differentiating between these underlying neural systems may point to different causal pathways and approaches for intervention.[2,31-33]

Neuroscience studies have documented SES differences in language, memory, executive function and socio-emotional processing.[2,31,33-35] For example, Noble and colleagues found that, by the start of school, socioeconomic factors were associated with language skills, memory and executive functions at substantial magnitude (effect sizes of .25-.50 standard deviations).[31] Similar socioeconomic disparities in neurocognitive skills have been reported from toddlerhood through adolescence.[32,34,36] SES-based differences have also been found in the structure and function of brain regions that support these skills in studies of older children and adolescents using MRI techniques.[1,37-45] For example, four independent labs have reported that family income is associated with the volume of the child's hippocampus, a part of the brain that is related to memory and learning,[39,41,45,46] One large study recently reported associations between family income and the size of the brain's surface, particularly in regions supporting children's language and executive functioning; this association was strongest among the most disadvantaged families.[1]

Several small-scale correlational studies have reported that income is related to differences in early childhood brain function as early as 6 months of age.[47,48,49] Studies by members of our team and others have shown that these early measures of brain function are correlated with better cognitive[50] and verbal[51,52] abilities in later childhood and adolescence. Similarly, poverty and economic deprivation have been correlated with neural patterns[48,49] that have been associated with later behavioral and attention problems.[53] Importantly, reducing adversity can partially normalize these patterns.[54]

Neuroscience studies suggest that the early experience of poverty may shape children's brain development, and that such mechanisms may underlie observed differences in subsequent cognitive skills, behavior, school completion and achievement. However, despite the specificity and rigor of brain measurement, these descriptive studies of small samples support neither causal inference nor population generalizability.

Generating additional evidence about the pathways by which income affects the development of low-income children will advance scientific knowledge. A large social science literature has documented that poverty is associated with lower quality caregiving environments,[55-60] but these studies are largely correlational, precluding strong conclusions about the causal nature of the associations. Our study will estimate causal impacts of increased income, as generated by unconditional cash supplements, on key dimensions of family life, which we conceptualize in two main pathways. First, economic models view families with greater income as better able to purchase or produce important inputs into their young children's development. This ***investment pathway*** results in children experiencing more materially enriching early environments. Second, psychologists and sociologists point to the ways in which economic disadvantage impairs children's development through a ***stress pathway.*** This pathway includes income effects on the quality of family relationships[59,61,62] as well as on biological indices of chronic stress.[63-66] These pathways have shown distinct associations with developmental outcomes, with generally stronger impacts of investment on early cognitive skills and stronger impacts of the stress constructs on early socio-emotional skills.



Investment Pathway. Low-income parents face steep challenges in meeting basic financial needs and ensuring that resources are available so that they can adapt to fluctuations in income and expenses.[67,68] Many poor families are not only cash-constrained, but they also have few savings and lack access to low-cost sources of credit.[69-74] As a result, when faced with income shortfalls, they are often forced to cut back on expenditures, even for essential goods such as food and housing, and to pay high interest rates on small but accessible loans.[75] A predictable monthly cash income supplement in the first 40 months of life may support children's cognitive development by enabling poor parents to meet basic needs and further invest in goods and services for their families, such as cognitively stimulating items in the home; higher quality non-parental child care; learning opportunities outside of the home; and, by reducing or restructuring work hours, more parental time and interactions with their child.[76-78] Early maternal employment has null to negative effects on cognitive development, suggesting that reductions in employment induced by our payments may be beneficial for some children. Higher monthly income may also contribute to better housing or moves to better neighborhoods. Evidence from studies of poverty reduction and income supports has shown that these programs reduce material hardship and improve aspects of children's learning environments as well as their participation in enriching child care and activities.[79,80] Studies of near-cash benefits and patterns of family expenditures provide related empirical support to these pathways.[58,81-84] Moreover, analysis of observational data finds that cognitive stimulation and learning resources partially explain the effects of poverty on children's achievement.[55,57] Finally, evaluations of the Negative Income Tax, casino disbursements and a Kenyan UCT did not find offsetting or harmful behavior, such as alcohol or cigarette expenditure or consumption.[23,85,86] All of these family processes will be measured in our study, with questionnaires and videotaped parent-child interactions.

Investments and enrichments may improve children's cognitive functioning, in particular language skills, IQ and other pre-academic skills, through direct effects on brain development.[39,87] For example, children's experience of cognitively stimulating activities is related to the development of language-supporting brain regions, as measured by ERP.[88-97] Direct studies of associations between family income and neural development are scarce, and are largely limited to school-aged children and adolescents.[39,98,99]

Stress Pathway. Income may also affect other aspects of family functioning among low-income families. Seminal work in this area focused on parents as the primary conduits of stress in households – that is, economic hardship increases parental psychological distress and decreases emotional well-being, which in turn creates conflict and withdrawal in family relationships and results in parent-child interactions that are more negative and harsh as well as less nurturing and supportive.[60-62] Recent work has broadened the focus on parents' psychological well-being to include other dimensions of children's experiences, and has recognized that many aspects of poor children's environments challenge their adaptive systems, including instability in family structure, chaotic routines and violence. The co-occurrence of these environmental threats accumulates in children's lives and creates emotional and physiological stress, including alterations in cortisol.[59,100-102]

Reducing parents' psychological strain and the stress that children themselves experience may improve children's cognitive functioning, in particular memory, executive functioning and socioemotional skills, through direct effects on brain development. Reductions in family stress are likely to benefit the regulation of children's stress physiology,[103-105] thereby improving neural development in the areas of the brain that are particularly sensitive to the effects of chronic stress. Among infants, lower cortisol levels during a learning task are linked with better learning and memory skills,[106] suggesting that early-life stress may impede memory development in early childhood. Similarly, early adversity has been associated with differences in the neural responses underlying memory formation.[107] However, direct studies of associations between family income and the neural basis of learning and memory development have been limited largely to older children and adolescents,[39,41,44-46] and do not yet support causal inference.

The hypothesized investment and stress pathways differ in their developmental mechanisms, but are overlapping and reinforcing. For example, both increased economic resources and improved mental health and family routines may result in higher quality child care, more cognitively enriching out-of-home activities, and more visits for preventive medical or dental care. Moreover, downstream effects may be bidirectional; for example, more verbal children may trigger more speech and book reading from their parents. In addition, the particular pathways might be different for different families but still contribute to similar magnitudes of income effects on children's developmental outcomes.[108]

The investment and stress pathways are complemented by behavioral science studies of cognitive resources and decision making. Enhanced family income may create more enriching and less stressful family environments by reducing the cognitive load that parents face.[109-112] Studies show that conditions of scarcity place demands on limited cognitive resources, directing attention to some problems at the expense of others.[110,111] Thus, low income may interfere with parents' efforts to take care of their children's basic needs by rendering them less able to plan for and engage in activities that may enrich their children's lives. Ours will be the first RCT study to test impacts of income supplementation on maternal "bandwidth."

Informing policy debates on the consequences and benefits of conditional and unconditional income support policies. Beyond its core contributions to science, this study will provide important evidence about the likely effects of tax and transfer policies on young children in the U.S. The benefit levels and coverage of such programs (e.g., earned income and child tax credits, food assistance) are debated fiercely in today's state and federal budget battles.[113] Absent from these debates is causal U.S. evidence on the consequences of proposed changes to these programs for the development of very young children in low-income families. The $333 monthly cash gift payments comprising the intervention in this study are consistent with the size of income increments associated with changes in children's cognitive and socio-emotional development, and are well within the financial range of benefits of existing programs that are active in ongoing debates.

Innovation

Our proposed study fills large gaps in the social and behavioral sciences and in developmental neuroscience. It will be **the first large-scale U.S. experiment involving unconditional cash transfers to poor families with infants.** As such, it will improve on prior experimental and quasi-experimental studies of child wellbeing that increased family income with in-kind supports or by conditioning income increases on employment or other behaviors. Furthermore, it complements studies offering similar types of unconditional cash to the very poor in low- and middle-income countries.[27] Our study tests the idea that regular, reliable cash gift income transfers improve child development and improve family environments among poor families. Second, **by specifically transferring income to families during their children's earliest developmental years**, this study will provide important evidence on income effects during a period when children's development is particularly sensitive to family economic circumstances, and when children's brains are most plastic and responsive. Third, we are among the first to **employ neuroscience methods for measuring brain function in the context of a large social science experiment,** which will provide the strongest causal evidence to date on the neural mediators linking income to child outcomes. These neural mechanisms may serve as an early indicator of income's effects, and our findings may shed light on the mechanisms responsible for behavioral change. Fourth, **ours will be the single largest longitudinal study of early childhood development that combines socioeconomic, parental well-being, and family functioning social science measures and methods with biological stress and neuroscience-based assessments of children's development**. Our comprehensive data collection and measurement plan – at baseline and at child ages 1, 2, and 3 – will allow us to assess a host of cognitive and socio-emotional skills that play a major role in the cognitive neuroscience literature, including language, memory, executive functions and socio-emotional development, as well as a broad range of pathways by which increased income is hypothesized to impact children's developmental outcomes. Despite the huge potential advantages of cross-fertilization, neuroscience research on SES and cognitive development and related research in the social and behavioral sciences have moved forward quite independently of one another. The synergistic combination that we have developed in our collaborative planning for this study over the past 3.5 years is unprecedented: random assignment, rigorous sampling and survey methods, state-of-the-art measurement of parenting and other family processes, coupled with laboratory methods from neuroscience including centralized analysis of electrophysiological and stress physiology data. Finally, this study will **leverage private philanthropic funding of $5.81 million in cash supplements to undertake the intervention, using governmental funding to evaluate the impacts of this increased income**.

Approach

This project will be led by four Principal Investigators: Greg Duncan, PhD in economics; Kimberly Noble, MD, PhD in neuroscience; Katherine Magnuson, PhD in human development and social policy; and economist Lisa Gennetian, PhD. Psychologist Hirokazu Yoshikawa, PhD and neuroscientist Nathan Fox, PhD form the rest of our core team of project investigators. Our collective experience includes direction of large longitudinal data collection projects (e.g., Panel Study of Income Dynamics), design of and participation in birth cohort studies using hospital recruitment, and experimental studies (e.g., Bucharest Early Intervention Project; Moving to Opportunity housing mobility experiment; welfare-to-work experiments conducted by MDRC; *Un Buen Comienzo* preschool experiment in Chile). Several of us have written widely-cited studies of the neuroscience (Noble) and social science linkages between poverty and child development (Duncan and Magnuson). Each of us has collaborated closely with one or more of the other members of the team on major federally-funded research projects.

We have partnered with neuroscientist co-Is in each proposed study site to oversee the collection of neuroscientific data collection at age 3: Michael Georgieff, MD (pediatrics) at the University of Minnesota, an expert in infant brain development and neurocognitive function; Connie Lamm, PhD in Psychology at the University of New Orleans, an expert in the electrophysiological correlates of self-regulation; Dennis Molfese, PhD, Timothy Nelson, PhD and Jennifer Nelson, PhD, all in Psychology at the University of Nebraska and experts in using brain recording techniques to study brain development and cognition; and William Fifer, PhD in Psychology at Columbia, an expert on infant experience, electrophysiology, and learning, and who will oversee the electrophysiological data collection in New York as well as the pooled data processing and analysis of all EEG/ERP data collected across the sites.

Charles Nelson, PhD, and Charles Zeanah, MD will serve as consultants to the project, providing their extensive expertise in measuring brain function and stress physiology in randomized experiments involving children facing extreme early adversity. A multidisciplinary advisory board consisting of neuroscientists and social scientists will provide feedback over the duration of the project: W. Thomas Boyce, a pediatrician with expertise in neurobiological and psychosocial processes; Flavio Cunha, an economist who studies parenting strategies in low-income families; Kathryn Edin, a mixed-method sociologist whose studies how low-income families "make ends meet"; Bridget Goosby, a health demographer who studies how stratification and discrimination affect biological processes among racial and ethnic minority families; Bruce McEwen, a neuroscientist with expertise on the effects of stress on neuroplasticity; Eldar Shafir, a psychologist with expertise on cognitive decision making in the context of poverty; and Michael Lopez, a child psychologist who has worked closely with policymakers on early childhood interventions for Hispanic children.

Pilot Study. With separate funding, 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 (see Appendix 1). Greenphire (greenphire.com/home) was selected from several companies to administer the payments and provide toll-free customer service. Their 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 Greenphire share information about their 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 $20/month for 12 months. Twenty-nine of the 30 mothers consented to our tracking of administrative records data and debit card transactions. Baseline differences in background characteristics favored neither group, suggesting successful randomization. Debit cards were given out immediately following the baseline interview; all mothers used their cards within 6 weeks and regularly thereafter. Very few reported substantial issues with the card, such as a loss or theft, fraudulent charges, or needing help resetting PINS. At 12 months, 27 mothers completed a survey interview closely resembling our proposed age-2 home visit, with an in-home assessment of family expenditures, routines and time use, parent stress and parenting practices, and child care arrangements. (In the pilot, we did not contact the 3 mothers who moved out of state, though this effort would be made for the proposed larger study.) Despite the small sample size (13 treatment and 14 control mothers), differences of over .5 standard deviations were found favoring the treatment group for reduced household chaos as well as increased mother-child learning activities and child-care expenditures; the latter was statistically significant ($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.

Research Design. The proposed study will enroll a total of 1,000 mothers of newborn infants with household cash incomes in the prior calendar year below the official poverty line for households of their size (including the infant as a household member). Enrollment will be evenly distributed across four sites: New York City; the greater New Orleans metropolitan area; the greater Omaha metropolitan area; and the Twin Cities. A total of 12 hospitals will participate, but we do not list them in order to preserve participant confidentiality.

The four sites were selected because they are diverse in terms of racial and ethnic composition of low-income residents, cost of living, urbanicity, and the generosity of state safety net programs such as Temporary Assistance to Needy Families (TANF) and state Earned Income Tax Credits (EITC); see Appendix 2. Recruitment (and our three subsequent annual data collections) will be spread evenly over the course of 12 months to avoid possible impacts of seasonal variation and to keep interviewer workload manageable. The Survey Research Center (SRC) at the University of Michigan will enroll participants and conduct baseline and age 1 survey interviews, survey interviews and home observation assessments at age 2, and survey interviews in the lab at age 3. SRC is especially skilled in fielding national studies that replicate protocols across multiple sites with high fidelity and provide data for the ongoing monitoring of the quality of recruitment efforts and data integrity. Extra quality assurance of these elements, as well as all age-3 cognitive and EEG data collection, will be conducted by our research team. The research team will also collect administrative data to obtain ongoing measurement of earned income and public benefits, possibly including health and Medicaid records and child protective services involvement. Conditional on early-wave findings, we will seek additional funding for follow-up assessments and analyses beyond the children's third birthdays, including obtaining additional administrative data such as school records for the target children and their siblings.

Intervention. The intervention in this project is a simple income manipulation in the form of cash gift payments to families, funded by philanthropy. Mothers in the treatment group will receive monthly cash gift payments of $333 ($4,000 per year) for the first 40 months of the child's life, paid on the day of the month of the child's birthday by automatic loading on an electronic debit card. To put the magnitude of the payments in context, the proposed annual income supplement of $4,000 would increase income in the average poor family in our pilot study by about 20%. Monthly text messages will announce the payment to recipients. We propose to pay families for 40 months to ensure that the age-3 lab-based data collection occurs well before the end of our cash gift payments. In order to eliminate any payment-mode effect, the control group will receive a nominal payment -- $20 per month, delivered in the same way as for the experimental group. Debit cards are a superior mode of cash transfer for practical reasons (e.g., few low-income individuals have bank accounts) as well as for conceptual reasons: We wanted to preserve the unconditional cash transfer nature of the transaction and enable point-of-sale or ATM cash transactions. As in the pilot study, Greenphire will administer the debit cards to the mothers. Our pilot study experience suggests that all mothers will use their debit cards regardless of experimental condition, thus leading us to expect that take up will be near-universal.

We have secured the appropriate exemptions or approvals in all of our sites to ensure that the mothers will not lose eligibility for virtually all public benefits as a result of our cash gift transfer. Specifically, our cash gift payments will be exempted from countable income in the determination of benefits from relevant programs, including TANF, SNAP, WIC, Medicaid, Housing Choice Vouchers, child care subsidies, and Head Start.

Enrollment Procedures. Mothers will be recruited in maternity wards of participating hospitals shortly after giving birth (see Appendix 1; 98.6% of all births in the US in 2012 occurred in hospitals, with a higher percentage among births to low-income, Black and Hispanic women).[114] Eligibility criteria include: (1) mother 18 years or older; (2) household income below the federal poverty threshold in the calendar year prior to the interview, counting the newborn; (3) infant admitted to the newborn nursery and not requiring admittance to the intensive care unit; (4) residence in the state of recruitment; (5) mother not "highly likely" to move to a different state or country in the next 12 months; (6) infant to be discharged in the custody of the mother; and (7) English or Spanish speaking (necessary for the child outcome measures). Census data for our hospitals' catchment areas suggest our sample will be roughly 35% African American, 45% White (including Hispanics), 7% Asian, 14% other; 20% are expected to also identify as being Latino. Births will be stratified by parity and differentially sampled if necessary to ensure an adequate representation (35% or more) of first births and a small number (10% or fewer) of births that were preceded by 3 or more births to the same mother. In 2013 national fertility data, 40% of all births (and 37% of non-Hispanic Black and 33% of Hispanic births) were first births, while 12.% of all births (and 16%of both non-Hispanic Black and Hispanic births) were fourth or higher parity.

Month	*Primary Activity*
1-6	Project planning
7-18	Hospital-based recruitment and baseline interviews
19-30	Age-1 telephone interviews
31-42	Age-2 in home interviews
43-54	Age-3 lab assessments
19-54	Gather and process data from administrative records
45-54	Impact analysis of family process
55-60	Impact analysis of child outcomes
57-60	Prepare data for release

Sample recruitment strategies and exclusion criteria are designed to balance external validity of the sample with respect to all poor families with newborns, optimize the target population for whom this intervention might be most powerful, and minimize difficulty and expense of recruitment and follow-up. We include all families living in poverty for several reasons. First, prior quasi-experimental studies have found positive income effects for all poor families, regardless of depth of poverty. Second, although our payments represent a larger proportional transfer to families in deep poverty, conceptually, it is not clear that the poorest families are uniquely able to use the money to improve child outcomes. In keeping with our goal of informing policy debates on the consequences and benefits of income support policies, use of the poverty-line threshold matches best with the population commonly targeted by U.S. means-tested social policies.

Sampling mothers from a hospital rather than a community-based organization or social service agency increases the likelihood that families are representative of low-income communities served by the hospital. There is no comparable cost-effective gateway to recruit prenatally and achieve similar generalizability. Because first-time parent(s) tend to be earlier in their earnings profile, the economic conditions of first-birth children are, on average, worse than for higher-parity children. Further, the proportion of money available to the target child will be larger for small families, motivating a special interest in first births. On the other hand, the generally younger mothers of first births may be less effective in managing their income supplements than the older mothers of higher-parity births. These competing considerations lead us to opt for representation of children of all parities, but to stratify our sample by parity as described above.

At the time of hospital-based screening and recruitment, SRC will conduct a baseline survey and obtain informed consent for study participation (including consent for survey, observational, physiological, and administrative data). We plan to identify 1,200 eligible mothers, with 1,000 participants expected to take up the lottery offer. Mothers will be told that study participation involves three subsequent data collection points (although they will be free to withdraw from the study at any time without penalty). At the child's first birthday, a phone interview will be conducted with the child's caregiver, who will be the mother in most cases. At the child's second birthday, an in-home interview and observational assessment will be conducted. At the child's third birthday, caregivers and children will participate in a laboratory assessment. Following standard research procedures, all participating families will receive a cash incentive ($50) for participating in each of the baseline, age 1 and age 2 interviews, and a larger incentive ($200, plus transportation costs) for the age 3 laboratory assessments.

To address ethical concerns about large gift payments coercing mothers to participate in research, mothers will consent to participate in the research study, complete the baseline survey, and be compensated for completing this survey *prior* to learning about the possibility of monthly cash gift payments. Following questionnaire completion, the mother will be offered the opportunity to enter a lottery, in which 40% will be randomly assigned to receive a $333 monthly cash gift payment and 60% will receive a $20 monthly cash gift payment. Mothers will not be told of the amounts of the two payments prior to providing consent. Mother who agree to participate in the lottery will then learn whether they will receive $333 or $20 months cash gifts, be handed their debit card, and be given instructions on its use with the opportunity to ask any questions. These baseline procedures worked well in our pilot study.

To avoid coercion, we will explain to the mother that her participation in the lottery is completely independent of her subsequent research participation. That is, cash gift payments will be not conditioned on subsequent participation in the research. Although a small number of women may then choose to take the cash gift payments and decline to participate in the future research, we think this is quite unlikely as (1) participants will have already indicated a willingness to participate in future data collection efforts, (2) SRC has an outstanding track record of recruitment and retention and (3) the research activities will be separately compensated. None of the 30 pilot study mothers has refused our interview requests.

Child Outcome Measures. We will collect a host of age-appropriate measures of children's cognitive, behavioral and brain functioning (see also Appendix 4 for details). A subset of these measures are proposed for preregistration in clinicaltrials.gov.

Child language and cognitive measures at age 3 (lab visit). We will administer tasks to assess language, memory, and self-regulation, all of which are normed from age 3 through adulthood and validated for both low-SES children and children whose primary language is English or Spanish. This will enable us to continue to follow up children on the very same tasks at older ages through future funding proposals. We will assess IQ using the Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI).

Child social and emotional measures at age 3 (lab visit). We will employ the Preschool Self-Regulation Assessment, an experimenter-report measure of the child's regulation during the testing session. Additionally, the BITSEA, a standardized questionnaire measure that assesses social and emotional competence in young children, will be administered to mothers, providing subscales of internalizing and externalizing broadband problems validated with low-income populations.[117]

Brain activity at age 3 (lab visit). Nearly all studies of brain development in early childhood rely on electrophysiological techniques such as electroencephalography (EEG).[118] These techniques measure the electrical activity of the human brain (or "brainwaves") by placing electrodes on the scalp and amplifying the signal. Changes in voltage are then plotted over a period of time. While EEG is measured while the child is "at rest," ERP assesses the child's neural response to a particular set of stimuli, such as words or pictures, to better understand how children's brains are functioning during particular cognitive tasks. Both techniques measure brain function with precise temporal resolution (on the order of milliseconds) and modest spatial resolution. Most importantly, these approaches allow the young child to sit comfortably next to a caretaker or on the caretaker's lap, thereby facilitating the collection of high-quality data with a population that may not easily sit still. Although MRI provides higher spatial resolution, participants must lie perfectly still in a dark and noisy tube, and while very young infants may fall asleep in the scanner, many older infants and toddlers will not. Thus, while studies have on occasion been successful in obtaining MRIs in very young children,[42,119,120] most large-scale studies of structural brain development do not take this approach because of the threat of significant amounts of missing data.[119,120] Functional MRI (fMRI) – obtained while a child is engaged in a cognitive task, thereby providing information on brain function as opposed to structure – poses even more logistical challenges for very young children, and is rarely if ever attempted with infants and toddlers.

The brain signals recorded with resting EEG are commonly quantified using *power*, an index of cortical activation reflecting synchronous currents within a local neuronal population.[121] This signal is decomposed into oscillations that occur in different frequency bands. Researchers can examine how the power of the signal varies by frequency band across the scalp, representing differences in activity in different regions of the brain.

To avoid undue participant burden, we focus on the effects of income supplementation on the neural development of language and learning/memory, two neurocognitive systems that show marked individual differences and malleability to early environmental context, and which we expect will be differentially affected by our hypothesized investment and stress pathways, respectively. We will collect all electrophysiological data on 128-lead, high-density Electrical Geodesics Inc. (EGI) systems using identical procedures across the four sites, as have been described in numerous experiments in the co-investigators' labs.[122-133] Each lab has prior experience collecting these measures with low-income families and toddlers. All raw EEG and ERP data will be transmitted via secure electronic transfer to Co-I Fifer's lab at Columbia for central processing and analysis.

Data from resting EEG will include spectral power and coherence. Several small-scale correlational studies have reported that income is related to differences in early childhood resting EEG power as early as 6 months of age.[47,48,49] Specifically, family income has been correlated with power in the frontal region in the gamma frequency band.[47] We therefore hypothesize that children in the intervention group will show greater frontal gamma power relative to children in the control group, a pattern which has been associated with the development of better cognitive[50] and verbal[51,52] abilities. Poverty and economic deprivation have also been correlated with an excess of theta EEG power and a deficit in alpha power,[48,49] which in turn have been correlated with later behavioral and attention problems. [48,49,53] We therefore hypothesize that the intervention group will show reduced theta power and greater alpha power than children in the control group.

We will also obtain ERP measures of children's language[88,134] processing. To assess language development, we will measure children's neural response to known vs. unknown words (as categorized by the mother). Audio presentation of the words results in a series of positive and negative deflections of voltages on the scalp. By convention, ERP signals are typically named according to whether the amplitudes of these deflections are positive ("P") or negative ("N"), and the number of milliseconds following the stimulus at which they occur. In toddlers, the amplitudes of the N200, N350 and N600-900 ERP components are larger to known words relative to unknown words. This contrast between known and unknown words becomes progressively more lateralized to the left side of the brain with age.[134] It is hypothesized that children in the intervention group will show greater left-lateralization of these components for known words relative to children in the control group, indicating a more advanced neural signature of vocabulary development.

Child cognitive measures at age 2 (home visit). Although our primary cognitive, social-emotional and brain outcome measures will be administered at age 3, we will obtain brief measures of children's cognitive development at the age 2 home visit (noting that many of the age 3 measures are not appropriate for children this young). Specifically, we will administer the Mullen Scale of Infant Development. In addition, we will videotape a 15-minute free play and clean-up mother-child interaction using a consistent set of small toys and code it for child language output (mean length of utterance, types and tokens) using approaches our team has experience using with diverse low-income families.[139]

Family Process Measures. We will obtain multiple measures of family processes that are hypothesized to explain the poverty-brain connections and represent our secondary outcomes of interest (see also Appendices 5 and 6). Data will be obtained through surveys and interviewer observations. All survey measures described below have been validated in prior large-scale studies of low-income families conducted by our team. A subset of these measures are proposed for preregistration in clinicaltrials.gov.

Economic resources and investment at ages 1, 2, and 3. Survey measures of the nature and use of economic resources will include families' total income and earnings, debt and savings as well as indicators of economic hardship, food insufficiency, and household expenditures. Our measure of total income will enable us to measure the *net* family income increased by the cash supplements, while details on income flow to and from family members living outside the household, combined with household rosters, will enable us to assess how much of the increased income is shared across extended families. We also will request administrative data from state and county programs to measure income using Unemployment Insurance (UI)-based quarterly earnings and state records of TANF, SSI, CCDBG child care subsidies, and SNAP (food stamp) payments. These administrative data will provide us with a second source of information on income and benefit use. Given potential family mobility across states and counties, within reason we will attempt to obtain data from as many state and county programs as possible. In the Moving to Opportunity (MTO) study, we were able to collect data for over 90% of a comparable low-income sample.

Information about the quality and characteristics of housing and residential histories will be collected by observation (at age 2), and from parent surveys and GPS-address data matching, which will enable us to test whether income supplements are used to pay for moves to better housing units and/or neighborhoods. Information about parental employment and non-parental child care, including the type, amount and cost of care, will be collected from parent surveys. Details on hours worked, scheduling of those hours, total number of hours, and predictability of work schedules will enable us to test for differences in the timing of the mother's return to part- or full-time work following the baby's birth and for differences in the longer-run division of maternal work hours between none, part time, full time and more than full time (e.g., from overtime or second jobs). Data on type and cost of child care will enable us to assess whether income supplements are used to access center-based and/or more expensive care. Surveys also will gather information about cognitively stimulating activities, learning materials, and parental time spent with children. We will ask about child enrichment expenditures as well as spending that might crowd out additional spending on children in negative ways, such as on cigarettes and alcohol. Finally, the age 2 videotaped mother-child interaction will be coded for maternal linguistic input, including number of words spoken to the child, mean length of utterance, and types/tokens.[139]

Maternal and child stress physiology at age 2. To obtain direct physiologic indices of stress dysregulation, hair cortisol (capturing cumulative stress) and salivary cortisol (capturing stress reactivity) will be measured in children and mothers at the age 2 home visit. Because hair follicles accumulate cortisol continuously, hair cortisol acts as a biomarker for chronic stress of the type experienced by low-income populations.[65,140-142] Additionally, hair assays provide a very stable measure of cortisol that can be obtained noninvasively in a single sample, free of many of the methodological challenges associated with collecting diurnal salivary cortisol, including susceptibility to minor perturbations due to food intake, time of acquisition, or acute stressors.[143,144] Despite the relative recency of this technological advance, low SES has been associated with higher hair cortisol in both adulthood[143] and early childhood,[145,146] and preliminary data suggest that associations with income are strongest among low-income families.[147] To assess stress reactivity, we will collect salivary cortisol at baseline, prior to, and following presentation of a mildly stressful stimulus (a scary mask).This technique has been successfully implemented in disadvantaged families with young children.[103,148-151] We will assess treatment group differences in baseline cortisol, reactivity and recovery, with attention to heightened and/or blunted reactivity, both of which are considered signs of dysregulation. Finally, we will videotape these interactions for later coding of treatment effects on behavioral/emotional reactivity and regulation.

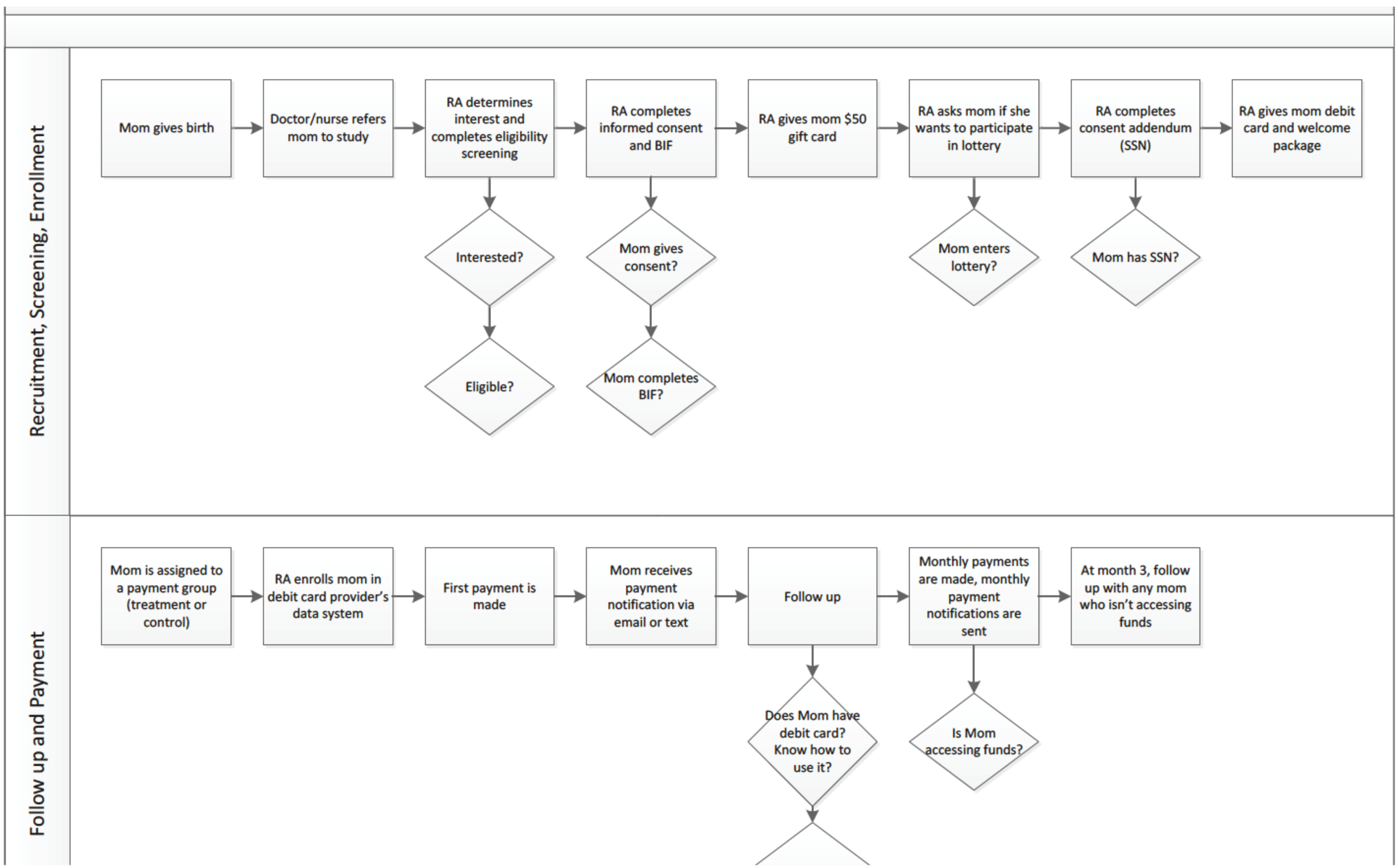
Stress-related processes, parenting quality, and maternal cognitive resources at ages 1, 2, and 3. To further assess the family stress pathway, information on maternal stress, mental health and interactions with children will be collected at child ages 1 and 2. Survey measures will assess family stress, chaos in the home, parenting beliefs and maternal symptoms of depression and anxiety. The videotaped free play and clean-up task at child age 2 will be coded for parental warmth and harshness. As a measure of maternal sensitivity, we will analyze mother and child synchrony in baseline cortisol levels, as well as in stress reactivity/recovery during the scary mask presentation described above (as the mother will observe her child's distress during the task). Higher mother-child synchrony is linked to better attachment, language, and socioemotional competence,[152] and lower SES dyads tend to have reduced synchrony relative to higher SES counterparts.[153] The NIH Toolbox Flanker test will be administered to mothers at child ages 2 and 3 to measure maternal cognitive resources (executive functioning, or "bandwidth"). Administrative data will enable us to track child welfare reports. Finally, data on preventive health care visits, including well-child and dental visits, will be collected via parent interview.

Demographic characteristics. Baseline demographic measures, listed in Appendix 5, will be used to improve the precision of our experimental impact estimates and, in some cases, enable us to examine whether and how impacts vary by some of these key baseline characteristics.

Long-term Follow-up. Although our 5-year window of research will enable us to collect data through age 3 and run basic impact and some moderation analyses, we will continue to engage in project activities beyond the end of our grant period. Since subject consent forms cover administrative data generated after age 3, we plan to secure additional funding for subsequent collection and analyses of administrative data, including school records of target children and their siblings. The large number of family- and child-based measures collected in our age 2 home visits will be available for analysis 18 months prior to the end of our grant period, and will inform subsequent data collection strategies including the possibility of MRI-based measures of regional brain structure and function when the children are old enough to be assessed with this technique.

Summary. Our team of neuroscientists, economists and developmental psychologists proposes the first experimental test of unconditional income transfers in the first years of life in the United States. Results will provide definitive evidence about the nature and magnitude of causal connections between family income and early neural, cognitive, and socio-emotional development. Beyond core contributions to both neuroscience and social science research, the proposed project will provide an unparalleled scientific foundation for the design of numerous tax and transfer policies aimed at low-income families with young children.

Appendix 1: Flowchart Based on Pilot Study (launched July 2014) – Recruitment and Debit Cards



Appendix 2: Demographics and Benefits Generosity by Site

	New York, NY		New Orleans, LA		Twin Cities, MN		Omaha, NE	
DEMOGRAPHICS	20-mile radius	50-mile radius	20-mile radius	50-mile radius	20-mile radius	50-mile radius	20-mile radius	50-mile radius
Poverty (percentages show total population below the Federal Poverty Line)								
	15.67%	13.30%	19.68%	17.24%	10.65%	10.27%	11.91%	12.35%
Ethnic Distribution (percentages based on population below the Federal Poverty Line)								
Hispanic or Latino	40.28%	38.53%	8.87%	7.09%	12.86%	12.18%	18.33%	16.28%
Not Hispanic or Latino	59.72%	61.47%	91.13%	92.91%	87.14%	87.82%	81.67%	83.72%
Racial Distribution (percentages based on population below the Federal Poverty Line)								
White	37.00%	41.07%	28.83%	42.02%	52.01%	57.58%	61.89%	69.33%
African American	28.10%	26.29%	62.97%	51.25%	26.08%	22.54%	20.71%	15.70%
Asian	9.85%	9.47%	3.19%	2.10%	10.50%	9.00%	2.72%	2.97%
American Indian or Alaska Native	0.82%	0.77%	0.70%	0.80%	1.85%	1.95%	1.90%	1.70%
Native Hawaiian or Pacific Islander	0.04%	0.04%	0.13%	0.08%	0.04%	0.04%	0.08%	0.13%
Other race	20.86%	19.03%	2.68%	1.95%	4.07%	3.71%	7.30%	4.99%
Two or more races	3.32%	3.32%	1.50%	1.80%	5.36%	5.18%	5.41%	5.19%
POLICY								
Number of Medicaid Waivers Offered								
	12		8		4		7	
Average TANF Benefit Level (2015 annual maximum benefits for family of 3)								
	$9,468		$2,880		$6,384		$4,368	
COST OF LIVING								
Indices (percentage above or below the national COL of 100%)								
	+116.7%		-1.00%		+11.0%		-11.7%	

Demographics information from the American Community Survey
Medicaid information from http://medicaidwaiver.org/
TANF information from http://www.cbpp.org/research/tanf-cash-benefits-have-fallen-by-more-than-20-percent-in-most-states-and-continue-to-erode
Cost of Living information from https://www.census.gov/compendia/statab/2012/tables/12s0728.pdf

[Appendix 3 Omitted]

Appendix 4: Child Outcome Measures (Note: not all of these outcomes are preregistered)

Measure description	Measure source [a]	Administration time	Psychometrics	Wave [b]
Language Development				
Mean Length of Utterance	Free-play interactions[139]	20 minutes	Very wide range across studies and ages (temporal reliability .61-.90+)	2
Types and Tokens	Free-play interactions[139]	Varies (often self-paced by child)	n/a	2
Receptive Vocabulary: Picture Vocabulary	NIH Toolbox[168]	About 5 minutes	Test-retest reliability .84 Convergent validity .74	3
Memory				
Declarative Memory: Picture Sequence Memory	NIH Toolbox[168]	About 5 minutes	Test-retest reliability .76 Convergent validity .59	3
Executive Function and Self-Regulation				
Flanker Inhibitory Control and Attention Test	NIH Toolbox[168]	About 5 minutes	Test-retest reliability .95 Convergent validity .70	3
Dimensional Change Card Sort Test	NIH Toolbox[168]	About 5 minutes	Test-retest reliability .92 Convergent validity .74	3
Working Memory: List Sort Working Memory	NIH Toolbox[168]	About 5 minutes	Test-retest reliability .87 Convergent validity .64	3
Preschool Self-Regulation Assessment	PSRA[169]	About 30 minutes	Internal consistency of assessor report (not full assessment) .82-.93	3
Socioemotional Processing				
Behavioral coding of mother-toddler interaction	Degnan et al.[170,171]	10 minutes	n/a	2
Social and emotional responsivity including fear, distress, anger/frustration, exuberance, persistence, activity level, inhibitory control	LAB-TAB Preschool version[115]	10 minutes	Internal consistency .50-.95	3
Externalizing/internalizing behavior	Brief Infant–Toddler Social and Emotional Assessment (BITSEA)[117]	7-10 minutes	Test-retest reliability .87 Internal consistency .65-.79	3

Pre-Academic Skills				
Brief Literacy	Woodcock-Johnson[172]	About 5 minutes	Reliability .80-.90+	3
Brief Math	Woodcock-Johnson[172]	About 5 minutes	Reliability .80-.90+	3
IQ				
Mental Development Index	Bayley Scales of Infant and Toddler Development[173]	About 30 minutes	Reliability .86-.93 Specificity .77-1.00	2
WPPSI-IV	WPPSI-IV[174]	30-45 minutes	Internal consistency .95 Test-retest reliability .86-.92	3
Brain Function and Connectivity				
EEG: resting brain function (*power*, an index of cortical activation reflecting synchronous post-synaptic currents *within* a local neuronal population, and *coherence*, a measure reflecting synchronization of oscillatory EEG activity *between* electrode sites, serving as a putative measure of functional connectivity)	Marshall et al 2002[132]	About 10 minutes	n/a	3
ERP: language (comparison of brain activity to known words vs. unknown words)	Zangl & Mills (2007)[175]	About 5 minutes	n/a	3
ERP: memory (comparison of brain activity to previously-seen vs. novel faces)	Nelson & Collins (1991)[135]	About 5 minutes	n/a	3
Health and Development				
Well-baby visits, illness, diagnoses and medications, injuries	MetroBaby[176]	About 5 minutes	n/a	1, 2, 3
Developmental milestones	Ages and Stages Questionnaire (ASQ)[177]	10-15 minutes	Sensitivity .86 Specificity .85	1,2,3
Body Mass Index (BMI)	CDC	About 2 minutes	n/a	3
School Achievement				
School test scores for target children and siblings	Administrative data			ages 5+

[a] Source of item indicates a recent survey or study with comparable samples that administered the item. When not available, source indicates the primary authors of the scale or item. MetroBaby=NYU Center for Research on Culture, Development, and Education Birth Cohort Study, see www.steinhardt.nyu.edu/crcde/projects/childhood; NIH Toolbox= Northwestern University and NIH, see www.nihtoolbox.org; NCS=National Children's Study, see http://www.nationalchildrensstudy.gov/research/workshops/Pages/U-Minnesota-formative-ncs-research-day-2011.pdf

[b] 1 = age 1 phone interview, 2 = age 2 home visit, 3 = age 3 lab visit; administrative data are gathered continuously and will be accessed shortly before they will be analyzed.

Appendix 5: Measures of Maternal and Family Processes and Characteristics (Note: not all of these measures are preregistered)

Measure description	Item source [a]	Wave [b]
Household Economic Behavior		
Household income: total earnings, total from social assistance and related programs	MTO[178] and admin data	H, 1,2,3
Household size: roster of every person residing in the household, relationship to the infant, age, sex	MTO[178]	H, 1,2,3
Indicators of economic stress: utility cutoffs, eviction, missed payments, untreated health conditions	MTO[178]	H, 1, 2, 3
Food insufficiency: less than desired amount of food, type of food, skipped meals	MTO[178]	H, 1, 2, 3
Household expenditures: rent/mortgage, utilities, transportation costs, alcohol, drugs, cigarettes	MetroBaby[176]	H, 1, 2, 3
Net worth: formal and informal debt, any assets/savings	MTO[178]	H, 3
Housing and Neighborhoods		
Perceptions of neighborhood safety: safety, victimization	MTO[178]	H, 1, 2
Neighborhood poverty: Census data on percent poor in the neighborhood	Census	H, 1, 2, 3
Housing quality: crowding/number of rooms, type of housing, housing problems	MTO[178]	1, 2, 3
Residential mobility: number of moves in recent past, whether voluntary/involuntary	MTO[178]	1, 2, 3
Parental Employment		
Parental work histories and schedules: total hours (full or part time), number of jobs, days worked, regularity of work schedule	MetroBaby,[176] MTO,[178] admin data	H, 1, 2, 3
Nonparental Care		
Nonparental care experiences: number and type of providers, hours in care, regularity of care, qualities of care	NSECE	1, 2, 3
Maternal Relationships		
Mother's romantic relationships: marital status, relationship quality with biological father and/or other romantic partner, presence of domestic violence	MetroBaby,[176] CDC	H, 1, 2, 3
Home Environment		
Child-related enrichment expenditures: children's books and toys, out-of-pocket nonparental care	MetroBaby[176]	1,2, 3
Parent-child interaction and environment: Infant/Toddler HOME Inventory (stimulating toys and activities, home organization)	Caldwell & Bradley[179]	2
Parent-child language: mean length of utterance, types and tokens from videotaped interaction (free play and clean-up task)	Matas et al.[180]	2
Chaos in the home: Home Environment Chaos Scale	Evans[181]	H, 1, 2, 3

Parental Stress		
Family stress: parenting-related stressors	Fragile Families[182]	1, 2, 3
General stress: Perceived Daily Stress Scale	Cohen & Williamson[183]	1, 2, 3
Maternal hair cortisol: index of chronic stress	1 measure[138,65,141,142]	2
Maternal salivary cortisol: index of acute stress	3 measures[100,133-136,184-193]	2
Maternal cognitive resources ("bandwidth"): Flanker Inhibitory Control and Attention Test	NIH Toolbox[168]	2, 3
Child protective services: maltreatment investigations and substantiations	Admin data	H, 1, 2, 3
Maternal Health		
Physical health: general health, pregnancy, contraception	MetroBaby[176]	H, 1, 2, 3
Mental health: depression, anxiety	PHQ-9[194], Beck[195]	H, 1, 2 ,3
Child Stress		
Child hair cortisol: index of chronic stress	1 measure[66,140,141]	2
Child salivary cortisol: index of acute stress	3 measures[100,133-136,184-193]	2
Demographic Characteristics		
Maternal and paternal education		H, 1, 2, 3
Race		H
Ethnicity		H
Country of origin		H
Language(s) spoken in the home		H, 1, 2, 3
Birth weight		H
Parity		H

[a] Source of item indicates a recent survey or study with comparable samples that administered the item. When not available, source indicates the primary authors of the scale or item. MTO=Moving to Opportunity study, see www.mtoresearch.org; MetroBaby=NYU Center for Research on Culture, Development, and Education Birth Cohort Study, see www.steinhardt.nyu.edu/crcde/projects/childhood; NSECE=National Survey of Early Education and Care, see http://www.acf.hhs.gov/programs/opre/research/project/national-survey-of-early-care-and-education-nsece-2010-2014

[b] H = hospital at birth, 1 = age 1 phone interview, 2 = age 2 home visit, 3 = age 3 lab visit; administrative data are gathered continuously and will be accessed shortly before they will be analyzed.

Appendix 6: Conceptually-Related Family Processes

FAMILY INVESTMENT PATHWAY MEASURES

Economic wellbeing
- Household income
- Indicators of economic hardship
- Food insufficiency
- Assets and debt
- Total household expenditures

Neighborhood quality
- Neighborhood poverty
- Perceptions of neighborhood safety (safety, victimization)

Housing quality
- Crowding/number of rooms
- Type of housing
- Housing problems

Child-related enrichment expenditures
- Children's books and toys
- Out-of-pocket nonparental care

Parent-child interaction and environment
- Infant/Toddler HOME Inventory (stimulating toys and activities, home organization)

Parent-child language
- Mean length of utterance
- Types and tokens from videotaped interaction (free play and clean-up task)

FAMILY STRESS PATHWAY MEASURES

Family stress
- Chaos in the home
- Parental stress index
- Family stress index
- Maternal hair cortisol
- Maternal salivary cortisol

Mother's health and resources
- Maternal physical health
- Maternal mental health
- Maternal cognitive resources ("bandwidth")

Sensitivity of parenting
- Parental warmth as indexed on the Infant/Toddler HOME Inventory
- Child protective services
- Synchronicity of maternal and child cortisol reactivity

Child stress measures
- Child hair cortisol
- Child salivary cortisol

RELATED FAMILY PROCESSES

Parental work histories and schedules: total hours (full or part time), number of jobs, days worked, regularity of work schedule
Nonparental care experiences: number and type of providers, hours in care, regularity of care, qualities of care
Maternal romantic relationships: marital status, relationship quality with biological father and/or other romantic partner, presence of domestic violence

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