New York State Joint Public Hearing on 2022 Executive Budget,
Session on Taxes, February 16, 2022
Written testimony of Kimberly Noble, MD PhD
Professor of Neuroscience & Education
Director, Developmental Psychology program
Teachers College, Columbia University

My name is Dr. Kimberly Noble, and I am a Professor of Neuroscience & Education and Director of the Developmental Psychology program at Teachers College, Columbia University. I am a neuroscientist and board-certified pediatrician, and for the past twenty years, I have studied the role of socioeconomic inequality in shaping children's cognitive, emotional, and brain development, particularly in early childhood.

Poverty is linked to children's brain development

Decades of research suggest that young children living in economically disadvantaged families and financially oppressed communities tend to be at risk for a host of negative outcomes, including lower school achievement, lower likelihood of employment, reduced earnings, and poorer health.[i] These patterns emerge early, compound over time, and persist into adulthood.[ii]

More recently, childhood poverty has been associated with differences in children's brain development. For example, higher family income has been associated with a larger brain surface in children, particularly in parts of the brain that support higher-order thinking.[iii] Furthermore, dollar for dollar, small differences in family income tend to be disproportionately associated with brain structure among children from the most disadvantaged families.[iv]

Early childhood is a period of heightened sensitivity to the environment

Brain science teaches us that **the developing brain is particularly sensitive to experience early in childhood**. In the first few years of life, children's brains develop increasingly complex connections between cells.[v] This ever-increasing web of connections is sensitive to – and a reflection of – children's experiences. The "superhighways" of connections between brain cells are routinely updated and honed based on use: Connections that are used infrequently are dropped (or "*pruned*"), whereas connections that are used frequently are maintained and strengthened.[vi] In this way, the developing brain demonstrates a remarkable "*plasticity,*" or sensitivity to early experience. In short, children's earliest experiences play a key role in shaping neurodevelopment.[vii] It is perhaps unsurprising, then, that social and economic disadvantage have been associated with differences in child development as early as infancy and toddlerhood.[viii]

Taken together, **neuroscience research suggests that supporting the lowest-income families very early in childhood may have the greatest impact** on children's development. And yet, nearly all interventions to promote child development occur much later, most commonly beginning with formal schooling.

Would reducing poverty in the earliest years of childhood support children's developmental trajectories? Although family income has been *correlated* with early childhood brain development, it is unclear whether growing up in poverty *causes* developmental differences for children early in life.[ix]

Establishing whether poverty reduction has a causal impact on early child development is of crucial importance for policy and practice: **Should interventions and policies target poverty reduction in early childhood directly, or should policies focus on other aspects of family life experienced by children living in poverty?** A careful randomized control trial is ideal for answering this question.

Baby's First Years: A Randomized Control Trial of Poverty Reduction in Early Childhood

Certainly, it would be unethical to randomly assign some families to reside in poverty and others not, in order to measure the impact of poverty on young children. However, it is possible to recruit a group of families who are already living with low income, and randomly assign them to different levels of monthly economic support. That is the basis for the Baby's First Years randomized control trial (BFY; www.babysfirstyears.com), of which I am one of the principal investigators. BFY is a multi-disciplinary effort led by a team of economists, policy experts, psychologists and neuroscientists from six universities across the United States. The study is funded by the National Institutes of Health, the City of New York, and more than two dozen private foundations.

The Baby's First Years study is the **first U.S. clinical trial of poverty reduction in early childhood**, and was designed to address whether a poverty reduction intervention causes changes in early childhood cognitive, emotional, and brain development, as well as in mothers' health and well-being.[x]

In the spring of 2018, we began recruiting 1,000 mothers living with low income in four metropolitan areas around the United States: New York City, Minneapolis-St. Paul, New Orleans and Omaha, NE. Mothers were recruited from hospital postpartum wards, shortly after giving birth. Upon enrolling in the study, all mothers were offered a monthly unconditional cash gift for the first several years of their children's lives, which they have been free to spend however they have wished, with no strings attached. Critically, the mothers were randomly assigned to receive one of two monthly cash gift amounts. The "high-cash gift group" is receiving **$333 per month ($4,000 per year**) and the "low-cash gift group" is receiving $20 per month ($240 per year). Both groups are receiving this money **for the first four years of their children's lives.**

To put the magnitude of these gifts in context, an extra $4,000 per year in cash support would increase the annual income of a family of three residing in poverty by approximately 20%.

This amount of cash support was chosen deliberately. Research suggests that a $3,000-$4,000 difference in annual income early in childhood tends to be associated with higher school achievement and better health as children get older.[xi] Additionally, this amount is similar in magnitude to other social services and benefits that mothers living with low income may qualify for. The research team therefore expected that this level of unconditional cash support would both be likely to affect early childhood development, and would lead to relevant knowledge for policymakers.

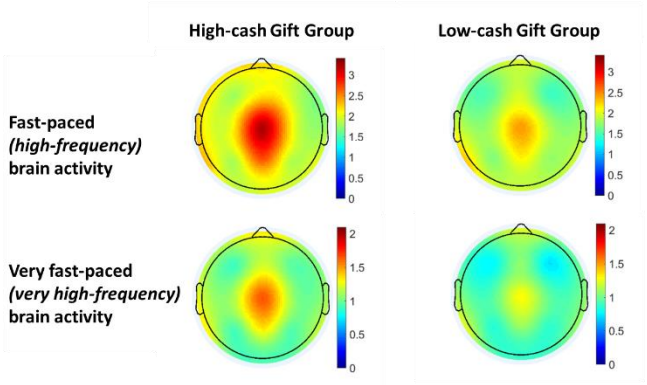
In the several years since the mothers enrolled in the study, the research team has been following up with them and their children annually. In these follow-up waves of data collection, we have been collecting many types of data – information to help us understand the impacts of the cash support on early childhood development, as well as family life, expenditures, relationships, economic circumstances, employment, and parenting choices.

The initial findings from the first wave of follow-up, which occurred around the children's first birthdays, were recently published in the *Proceedings of the National Academy of Sciences*.[xii] This first report centered on the impact of on year of cash support on infants' brain activity. Please note that other results from the study are still under peer review and have not yet been published, and will not be discussed today.

The impact of one year of unconditional cash support on infant brain activity

Infant brain activity was measured using a technology called electroencephalography, or EEG.[xiii] EEG measures the speed (or *frequency*) of the electrical signals between brain cells. All humans have some slow-paced *(low-frequency)* brain activity as well as some fast-paced *(high-frequency)* brain activity. Neuroscience research has shown that, as children get older, they tend to have more fast-paced brain activity.[xiv] In addition, past research suggests that, on average, children with more fast-paced brain activity early in childhood tend to be more likely to score higher on tests of cognition and other skills that are important for school.[xv] Finally, past research has suggested that children growing up in poverty or facing other forms of early adversity sometimes have less fast-paced brain activity early in childhood than do their peers.[xvi]

We reasoned that monthly cash support would potentially mitigate that pattern. Specifically, we hypothesized that the infants of the mothers in the high-cash gift group would show more fast-paced brain activity and less slow-paced brain activity than the infants of the mothers in the low-cash gift group. Indeed, the **infants of the mothers receiving $333 per month in unconditional cash support appear to show more fast-paced brain activity, particularly in key brain regions that support the development of thinking and learning.** The size of this effect was similar in magnitude to that reported in many large-scale education interventions. [xvii]



Because of the pandemic, we were only able to measure brain activity data in about half of the originally anticipated sample. That meant that, while all the findings on fast-paced brain activity were in the direction we anticipated, only some of those findings were statistically significant. Putting together all of the evidence from the various analyses we conducted, we concluded that the weight of the evidence supported the conclusion that **monthly unconditional cash support given to low-income families early in childhood can change children's brain activity, in a pattern associated with the development of subsequent thinking and learning**. This suggests that monthly unconditional economic support, particularly early in childhood, can potentially serve as a mechanism to facilitate parents' investments in children. We look forward to continuing to follow up with the families, to discover whether these brain changes persist at older ages, and also whether they translate into differences in children's cognitive and behavioral development.

Conclusion

Brain science suggests that the developing brain is highly sensitive to economic circumstances in the first few years of life. Economic support to lower-income families with very young children may therefore have a marked impact on child development.

ENDNOTES

[i] Duncan, G.J., Ziol-Guest, K.M., Kalil, A. (2010) Early-childhood poverty and adult attainment, behavior, and health. *Child Dev.* **81**, 306–325.; Duncan, G.J., Brooks-Gunn, J. (1997) *Consequences of Growing Up Poor* (Russell Sage Foundation).; Duncan, G.J., Brooks-Gunn, J., Jean Yeung, W., Smith, J. R. (1998) How much does childhood poverty affect the life chances of children? *Am. Sociol. Rev.* **63**, 406–423.; McLoyd, V. C. Socioeconomic disadvantage and child development. (1998)*Am. Psychol.* **53**, 185–204.

[ii] McLoyd, V. C. Socioeconomic disadvantage and child development. (1998)*Am. Psychol.* **53**, 185–204.

[iii] Noble, K. G., *et al.*, (2015) Family income, parental education and brain structure in children and adolescents. *Nat. Neurosci.* https:/doi.org/10.1038/nn.3983 (March 31, 2015).; McDermott, C. L., *et al.*, Longitudinally mapping childhood socioeconomic status associations with cortical and subcortical morphology. *J. Neurosci.* **39**, 1365–1373 (2019).

[iv]Noble, K. G., *et al.*, (2015) Family income, parental education and brain structure in children and adolescents. *Nat. Neurosci.* https:/doi.org/10.1038/nn.3983 (March 31, 2015).

[v] Shore, R. (1997). *Rethinking the brain: new insights into early development*. Families and Work Institute.

[vi] Edelman, G. M. (1987). *Neural Darwinism: The theory of neuronal group selection*. Basic Books., Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and brain development. *Child Development*, *58*(3), 539-559.

[vii] Belsky, J., & de Haan, M. (2011). Annual research review: Parenting and children's brain development: The end of the beginning. *Journal of Child Psychology and Psychiatry*, *52*(4), 409-428.

[viii] Halle, T., Forry, N., Hair, E., Perper, K., Wandner, L., Wessel, J., & Vick, J. (2009). Disparities in early learning and development: Lessons from the Early Childhood Longitudinal Study–Birth Cohort (ECLS-B). *Washington, DC: Child Trends*, 1-7., Noble, K. G., Engelhardt, L. E., Brito, N. H., Mack, L. J., Nail, E. J., Angal, J., Barr, R., Fifer, W. P., & Elliott, A. J. (2015). Socioeconomic disparities in neurocognitive development in the first two years of life. *Developmental Psychobiology*, *57*(5), 535-551., Tomalski, P., *et al.*, (2013) Socioeconomic status and functional brain development - associations in early infancy. *Dev. Sci.* **16**, 676–687.

[ix] Farah, M.J. (2018) Socioeconomic status and the brain: Prospects for neuroscience-informed policy. *Nat. Rev. Neurosci.* **19**, 428–438.

[x] Noble, K.G., Magnuson, K.A., Gennetian, L.A., Duncan, G.J., Yoshikawa, H., Fox, N.A., Halpern-Meekin, S. (2021). Baby's First Years: Design of a Randomized Controlled Trial of Poverty Reduction in the United States. *Pediatrics.* doi: 10.1542/peds.2020-049702

[xi] G. J. Duncan, P. A. Morris, C. Rodrigues, Does Money Really Matter? Estimating Impacts of Family Income on Young Children's Achievement With Data From Random-Assignment Experiments. *Dev. Psychol.* **47**, 1263–1279 (2011)., P. Morris, G. J. Duncan, E. Clark-Kauffman, Child well-being in an era of welfare reform: The sensitivity of transitions in development to policy change. *Dev. Psychol.* **41**, 919–932 (2005)., S. Baird, F. H. G. Ferreira, B. Özler, M. Woolcock, Relative Effectiveness of Conditional and Unconditional Cash Transfers for Schooling Outcomes in Developing Countries: A Systematic Review. *Campbell Syst. Rev.* **9**, 1–124 (2013)., Dahl G, Lochner L. The impact of family income on child achievement: Evidence from changes in the Earned Income Tax Credit. *American Economic Review*. 2012.

[xii] Troller-Renfree, S.V., Costanzo, M.A., Duncan, G.J., Magnuson, K.A., Gennetian, L.A., Yoshikawa, H., Fox, N.A., Halpern-Meekin, S, and Noble, K.G. (2022). The impact of a poverty reduction intervention on infant brain activity. *Proceedings of the National Academies of Sciences.* doi: 10.1073/pnas.2115649119

[xiii] Troller-Renfree, S.V., Morales, S., Leach, S.C., Bowers, M.E., Debnath, R., Fifer, W.P., Fox, N.A., & Noble, K.G. (2021). Feasibility of Assessing Brain Activity using Mobile, In-home Collection of Electroencephalography: Theory, Methods, and Analysis. *Developmental Psychobiology*. doi: 10.1002/dev.22128

[xiv] P. J. Marshall, Y. Bar-Haim, N. A. Fox, Development of the EEG from 5 months to 4 years of age. *Clin. Neurophysiol.* **113**, 1199–1208 (2002), M. Matousek, I. Peterson, "Frequency analysis of the EEC in normal children and adolescents" in *Automation of Clinical Electroencephalography*, P. Kelloway, I. Peterson, Eds. (Raven Press, 1973), pp. 75–102., T. Takano, T. Ogawa, Characterization of developmental changes in EEG-gamma band activity during childhood using the autoregressive model. *Pediatr. Int.* **40**, 446–452 (1998)., P. J. Uhlhaas, F. Roux, E. Rodriguez, A. Rotarska-Jagiela, W. Singer, Neural synchrony and the development of cortical networks. *Trends Cogn. Sci.* **14**, 72–80 (2010).

[xv] A. A. Benasich, Z. Gou, N. Choudhury, K. D. Harris, Early cognitive and language skills are linked to resting frontal gamma power across the first 3 years. *Behav. Brain Res.* **195**, 215–222 (2008)., Z. Gou, N. Choudhury, A. A. Benasich, Resting frontal gamma power at 16, 24 and 36 months predicts individual differences in language and cognition at 4 and 5 years. *Behav. Brain Res.* **220**, 263–270 (2011), N. H. Brito, W. P. Fifer, M. M. Myers, A. J. Elliott, K. G. Noble, Associations among family socioeconomic status, EEG power at birth, and cognitive skills during infancy. *Dev. Cogn. Neurosci.* **19**, 144–151 (2016)., M. J. Maguire, J. M. Schneider, Socioeconomic status related differences in resting state EEG activity correspond to differences in vocabulary and working memory in grade school. *Brain Cogn.* **137** (2019)., I. A. Williams, *et al.*, Fetal cerebrovascular resistance and neonatal EEG predict 18-month neurodevelopmental outcome in infants with congenital heart disease. *Ultrasound Obstet. Gynecol.* **40**, 304–309 (2012)., N. H. Brito, *et al.*, Neonatal EEG linked to individual differences in socioemotional outcomes and autism risk in toddlers. *Dev. Psychobiol.* **61**, 1110–1119 (2019).

[xvi] G. A. Otero, F. . Pliego-Rivero, T. Fernández, J. Ricardo, EEG development in children with sociocultural disadvantages: a follow-up study. *Clin. Neurophysiol.* **114**, 1918–1925 (2003)., G. A. Otero, Poverty, cultural disadvantage and brain development: a study of pre-school children in Mexico. *Electroencephalogr. Clin. Neurophysiol.* **102**, 512–516 (1997)., P. Tomalski, *et al.*, Socioeconomic status and functional brain development - associations in early infancy. *Dev. Sci.* **16**, 676–687 (2013)., N. H. Brito, *et al.*, Associations among the home language environment and neural activity during infancy. *Dev. Cogn. Neurosci.* **43**, 100780 (2020).

[xvii] M. A. Kraft, Interpreting Effect Sizes of Education Interventions: *https://doi.org/10.3102/0013189X20912798* **49**, 241–253 (2020).