Poverty may affect the growth of children's brains

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The brain's cerebral cortex is often larger in children from richer families and from families whose parents have more education.

By Michael Balter 30 March 2015

Stark and rising inequality plagues many countries, including the United States, and politicians, economists, and—fortunately—scientists, are debating its causes and solutions. But inequality's effects may go beyond simple access to opportunity: a new study finds that family differences in income and education are directly correlated with brain size in developing children and adolescents. The findings could have important policy implications and provide new arguments for early antipoverty interventions, researchers say.

Researchers have long known that children from families with higher socioeconomic status do better on a number of cognitive measures, including IQ scores, reading and language batteries, and tests of so-called executive function—the ability to focus attention on a task. More recently, some studies have found that key brain areas in children of higher socioeconomic status—such as those involved in memory or language—tend to be either larger in volume, more developed, or both. However, these studies have suffered from some important limitations: For one thing, they don't adequately distinguish socioeconomic status from racial background, which in the United States are difficult to tease apart because nonwhite groups tend to have higher poverty levels. And few studies treat family income and education levels as independent factors, even though they can act differently on the child's developing brain. For example, income may be a better indicator of the material resources (such as healthy food and medical care) available to a child, whereas more highly educated parents may be better able to stimulate their child's intellectual development.

To get around some of these limitations, a research team scanned the brains of 1099 children and young adults, ranging from 3 to 20 years old, using MRI. The researchers, led by Kimberly Noble of Columbia University and Elizabeth Sowell of Children's Hospital Los Angeles in California, both cognitive neuroscientists specializing in child development, recruited subjects in collaboration with researchers at nine U.S. universities and hospitals, using Internet and community advertising as well as word of mouth.

The MRI scans allowed the team to measure the surface area of the subjects' cerebral cortices, the outer layer of the brain where most advanced cognitive processing takes place, including language, reading, and executive functions. The researchers chose to measure cortical surface area because previous research had shown that it increases throughout childhood and adolescence as the brain develops, thus making it a potentially sensitive indicator of intellectual abilities. Studies in both animals and humans have suggested that the cortex can grow larger as a result of life experiences, although genetic factors may partly influence its overall size. The team also administered a battery of standard cognitive tests to the subjects and took DNA samples to control for the factors of race and genetic ancestry.

The results, published online this week in *Nature Neuroscience*, showed that cortical surface area was indeed correlated with different measures of socioeconomic status. Parental education—the number of years that parents had gone to school—showed a linear correlation with overall cortical surface area, especially for regions of the brain involved in language, reading, and executive functions. As a rough approximation, the children of parents with only a high school education (12 years of education or less) had 3% less cortical surface area than children whose parents had attended universities (15 years or more), Noble and Sowell told *Science*.

The team also found a significant correlation between cortical surface area and family income levels, which ranged from less than $5000 per year to more than $300,000. This was not a linear correlation, however. Instead, at the very lowest income levels, each incremental increase in income led to relatively greater increases in cortical surface area, whereas the influence of income tended to level off at higher levels. Nevertheless, Noble and Sowell say, the difference between lower and higher incomes is dramatic: Children from families making $25,000 per year or less have cortical surface areas roughly 6% smaller than those making more than $150,000.

The team also found that cortical surface area was related to performance on at least some cognitive tests, especially those measuring executive functions and memory. Finally, race and ethnicity had no effect on any of these correlations. "The links between socioeconomic status and brain structure were the same across individuals, regardless of racial background," Noble says.

In their paper, the team cautions that despite these clear correlations between socioeconomic status and the size of the cerebral cortex, the reasons for the correlations are not yet clear. Low socioeconomic status could inhibit brain growth due to family stress, greater exposure to environmental toxins, or insufficient nutrition, while higher status families might be able to provide more "cognitive stimulation" to their children. Nevertheless, the researchers point to the particularly low cortical surface areas of low-income children—and the differences that even small, incremental increases in income can make—as evidence that antipoverty measures could make a big difference in both brain size and intellectual achievement. "The implications for public policy are substantial," Sowell says. "The brain develops over a very long period, throughout childhood and adolescence," she adds, suggesting that enriching the environment of a child "at any point in development" can make a big difference in his or her abilities.

But unknown genetic factors that influence brain size and also correlate with income could play a role in the results, says Ian Deary, a psychologist at the University of Edinburgh in the United Kingdom who is well known for his work on intelligence. He cites recent studies concluding that both genetic and environmental factors influence socioeconomic status.

Still, Martha Farah, a cognitive neuroscientist at the University of Pennsylvania, says that the study is "a real advance in characterizing how brain development differs" between children of lower and higher socioeconomic status, calling it a "crucial first step" in understanding how income and education levels "shape human development." She agrees that the study provides compelling support for the idea of alleviating childhood poverty. "Even without neuroscience, the case for investment in society's poor children is very strong," she says. "But if brain imaging helps to focus people's attention on the problem of childhood poverty, that's great."

Poverty shrinks brains from birth

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Studies show that children from low-income families have smaller brains and lower cognitive abilities.

by Sara Reardon

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A new study finds that children's cognitive skills are linked to family income.

The stress of growing up poor can hurt a child's brain development starting before birth, research suggests — and even very small differences in income can have major effects on the brain.

Researchers have long suspected that children's behaviour and cognitive abilities are linked to their socioeconomic status, particularly for those who are very poor. The reasons have never been clear, although stressful home environments, poor nutrition, exposure to industrial chemicals such as lead and lack of access to good education are often cited as possible factors.

In the largest study of its kind, published on 30 March in *Nature Neuroscience*[1], a team led by neuroscientists Kimberly Noble from Columbia University in New York City and Elizabeth Sowell from Children's Hospital Los Angeles, California, looked into the biological underpinnings of these effects. They imaged the brains of 1,099 children, adolescents and young adults in several US cities. Because people with lower incomes in the United States are more likely to be from minority ethnic groups, the team mapped each child's genetic ancestry and then adjusted the calculations so that the effects of poverty would not be skewed by the small differences in brain structure between ethnic groups.

The brains of children from the lowest income bracket — less than US$25,000 — had up to 6% less surface area than did those of children from families making more than US$150,000, the researchers found. In children from the poorest families, income disparities of a few thousand dollars were associated with major differences in brain structure, particularly in areas associated with language and decision-making skills. Children's scores on tests measuring cognitive skills, such as reading and memory ability, also declined with parental income.

Martha Farah, a cognitive neuroscientist at the University of Pennsylvania in Philadelphia, calls the research "unbelievably cool". Having such a large sample of children allowed the researchers to show the great impact of poverty on developing brains, she says, although the study cannot measure how individual brains change over time.

Nature versus nurture

The findings are in line with unpublished research conducted by Farah and her colleagues that scanned the brains of 44 African American girls, each approximately a month old, from various socioeconomic groups in Philadelphia.

Even at this early age, the researchers found, infants in the lower socioeconomic brackets had smaller brains than their wealthier counterparts. The scientists presented their research on 19 March at the Society for Research in Child Development meeting in Philadelphia.

Jamie Hanson, a psychologist at Duke University in Durham, North Carolina, says that both papers underscore the impact of adversity on child development. "These early life circumstances make it tougher for many children and it's on many of us in society to make sure that children have equal possibilities," he says. While he praises the cross-sectional studies, he adds that it is important to follow children over time in order to see how individual brains are affected by socioeconomic status.

Farah and her colleagues plan to continue to observe these infants for two years and watch how their brain's surface area change over time. They also plan to visit the infants' homes in the hopes of pinpointing factors that might contribute to the differences, such as how many stimulating toys they have and how much attention they get from their parents.

Neither study explains the cause of the cognitive differences. Although the authors of both studies admit that genetic factors could be involved, they suspect that environmental exposures such as stress and nutrition are more important and begin even before the babies are born.

"It does make us think the focus should be redirected at gestation and stresses like nutrition and exposure to toxins," says Hallam Hurt, a neonatologist at Children's Hospital of Philadelphia who led the infant research study.

Older children may be affected in different ways. For instance, poorer parents who work multiple jobs to make ends meet may have less time to spend with their children, and less money to buy toys to stimulate their children's minds as they grow, says Laura Betancourt, a paediatrician at the Children's Hospital of Philadelphia who authored the infant study.

And Hanson suggests that epigenetics — modifications to DNA caused by environmental factors such as stress — could also be playing an important role, and can be passed down through generations.

Still, the researchers are hopeful that the impacts could be reversible through interventions such as providing better child care and nutrition. Research in humans and in other animals suggests that is the case: a study in Mexico, for instance, showed that supplementing poor families' income improved their children's cognitive and language skills within 18 months[2].

"It's important for the message not to be that if you're poor your brain is smaller and will be smaller forever," Sowell says.

References

1. Noble, K. G. *et al.* Nature Neurosci. http://dx.doi.org/10.1038/nn.3983 (2015).
2. Fernald, L., *et al.* Lancet 371, 828–37 (2008).