Brains of low-income children function differently from brains of high-income kids

University of California, Berkeley, researchers have shown for the first time that the brains of low-income children function differently from the brains of high-income kids.

In a study recently accepted for publication in the *Journal of Cognitive Neuroscience*, scientists at UC Berkeley's Helen Wills Neuroscience Institute and the School of Public Health report that normal 9- and 10-year-olds differing only in socioeconomic status have detectable differences in the response of their prefrontal cortex, the part of the brain that is critical for problem solving and creativity.

Brain function was measured by means of an electroencephalograph (EEG) - basically, a cap fitted with electrodes to measure electrical activity in the brain - like that used to assess epilepsy, sleep disorders and brain tumours.

"Kids from lower socioeconomic levels show brain physiology patterns similar to someone who actually had damage in the frontal lobe as an adult," said Robert Knight, director of the institute and a UC Berkeley professor of psychology. "We found that kids are more likely to have a low response if they have low socioeconomic status, though not everyone who is poor has low frontal lobe response."

Possible link

Previous studies have shown a possible link between frontal lobe function and behavioural differences in children from low and high socioeconomic levels. However, according to cognitive psychologist Mark Kishiyama, first author of the new paper, "those studies were only indirect measures of brain function and could not disentangle the effects of intelligence, language proficiency and other factors that tend to be associated with low socioeconomic status. Our study is the first with direct measure of brain activity where there is no issue of task complexity."

Co-author W. Thomas Boyce, UC Berkeley professor emeritus of public health who currently is the British Columbia Leadership Chair of Child Development at the University of British Columbia (UBC), is not surprised by the results. "We know kids growing up in resource-poor environments have more trouble with the kinds of behavioural control that the prefrontal cortex is involved in regulating. But the fact that we see functional differences in prefrontal cortex response in lower socioeconomic status kids is definitive."

Boyce, a paediatrician and developmental psychobiologist, heads a joint UC Berkeley/UBC research program called WINKS - Wellness in Kids - that looks at how the disadvantages of growing up in low socioeconomic circumstances change children's basic neural development over the first several years of life.

An alert

"This is a wake-up call," Knight said. "It's not just that these kids are poor and more likely to have health problems, but they might actually not be getting full brain development from the stressful and relatively impoverished environment associated with low socioeconomic status: fewer books, less reading, fewer games, fewer visits to museums."

Kishiyama, Knight and Boyce suspect that the brain differences can be eliminated by proper training. They are collaborating with UC Berkeley neuroscientists who use games to improve the prefrontal cortex function, and thus the reasoning ability, of school-age children.

"It's not a life sentence," Knight emphasized. "We think that with proper intervention and training, you could get improvement in both behavioural and physiological indices."

Kishiyama, Knight, Boyce and their colleagues selected 26 children ages 9 and 10 from a group of children in the WINKS study. Half were from families with low incomes and half from families with high incomes. For each child, the researchers measured brain activity while he or she was engaged in a simple task: watching a sequence of triangles projected on a screen. The subjects were instructed to click a button when a slightly skewed triangle flashed on the screen.

Dramatic difference

The researchers were interested in the brain's very early response - within as little as 200 milliseconds, or a fifth of a second - after a novel picture was flashed on the screen, such as a photo of a puppy or of Mickey and Minnie Mouse.

"An EEG allows us to measure very fast brain responses with millisecond accuracy," Kishiyama said.

The researchers discovered a dramatic difference in the response of the prefrontal cortex not only when an unexpected image flashed on the screen, but also when children were merely watching the upright triangles waiting for a skewed triangle to appear. Those from low socioeconomic environments showed a lower response to the unexpected novel stimuli in the prefrontal cortex that was similar, Kishiyama said, to the response of people who have had a portion of their frontal lobe destroyed by a stroke.

"When paying attention to the triangles, the prefrontal cortex helps you process the visual stimuli better. And the prefrontal cortex is even more involved in detecting novelty, like the unexpected photographs," he said. However, in both cases, "the low socioeconomic kids were not detecting or processing the visual stimuli as well. They were not getting that extra boost from the prefrontal cortex."

Stressful environments may play a role

"These kids have no neural damage, no prenatal exposure to drugs and alcohol, no neurological damage," Kishiyama said. "Yet, the prefrontal cortex is not functioning as efficiently as it should be. This difference may manifest itself in problem solving and school performance."

The researchers suspect that stressful environments and cognitive impoverishment are to blame, since in animals, stress and environmental deprivation have been shown to affect the prefrontal cortex. UC Berkeley's Marian Diamond, professor emeritus of integrative biology, showed nearly 20 years ago in rats that enrichment thickens the cerebral cortex as it improves test performance. Moreover, as Boyce noted, previous studies have shown that children from poor families hear 30 million fewer words by the time they are four than do kids from middle-class families.

"In work that we and others have done, it really looks like something as simple and easily done as talking to your kids" can boost prefrontal cortex performance, Boyce said.

A bit frightening

"We are certainly not blaming lower socioeconomic families for not talking to their kids - there are probably a zillion reasons why that happens," he said. "But changing developmental outcomes might involve something as accessible as helping parents to understand that it is important that kids sit down to dinner with their parents, and that over the course of that dinner it would be good for there to be a conversation and people saying things to each other."

"The study is suggestive and a little bit frightening that environmental conditions have such a strong impact on brain development," said Silvia Bunge, UC Berkeley assistant professor of psychology who is leading the intervention studies on prefrontal cortex development in teenagers by using functional magnetic resonance imaging (fMRI).

Boyce's UBC colleague, Adele Diamond, showed last year that 5- and 6-year-olds with impaired executive functioning, that is, poor problem solving and reasoning abilities, can improve their academic performance with the help of special activities, including dramatic play.

Bunge hopes that, with fMRI, she can show improvements in academic performance because of these games, actually boosting the activity of the prefrontal cortex.

"People have tried for a long time to train reasoning, largely unsuccessfully," Bunge said. "Our question is, 'Can we replicate these initial findings and at the same time give kids the tools to succeed?'"

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