Medical Xpress

Scientists say active early learning shapes the adult brain

June 1 2021

A teacher guides a student through a task in this historical photo of the Abecedarian Project, an early education, randomized controlled trial that began at the University of North Carolina and has followed the participants since 1971. Now, Virginia Tech researchers including Craig Ramey, Sharon Landesman Ramey, and Read Montague have revealed discoveries about the lasting effects of that early education on brain structure. Credit: Virginia Tech

An enhanced learning environment during the first five years of life

shapes the brain in ways that are apparent four decades later, say Virginia Tech and University of Pennsylvania scientists writing in the June edition of the *Journal of Cognitive Neuroscience*.

The researchers used structural brain imaging to detect the developmental effects of linguistic and cognitive stimulation starting at six weeks of age in infants. The influence of an enriched environment on brain structure had formerly been demonstrated in animal studies, but this is the first experimental study to find a similar result in humans.

"Our research shows a relationship between brain structure and five years of high-quality, educational and social experiences," said Craig Ramey, professor and distinguished research scholar with Fralin Biomedical Research Institute at VTC and principal investigator of the study. "We have demonstrated that in vulnerable children who received stimulating and emotionally supportive learning experiences, statistically significant changes in brain structure appear in middle age."

The results support the idea that early environment influences the brain structure of individuals growing up with multi-risk socioeconomic challenges, said Martha Farah, director of the Center for Neuroscience and Society at Penn and first author of the study.

"This has exciting implications for the basic science of brain development, as well as for theories of social stratification and social policy," Farah said.

The study follows children who have continuously participated in the Abecedarian Project, an early intervention program initiated by Ramey in Chapel Hill, North Carolina, in 1971 to study the effects of educational, social, health, and family support services on high-risk infants.

Both the comparison and treatment groups received extra health care, nutrition, and family support services; however, beginning at six weeks of age, the treatment group also received five years of high quality educational support, five days a week, 50 weeks a year.

When scanned, the Abecedarian study participants were in their late 30s to early 40s, offering the researchers a unique look at how childhood factors affect the adult brain.

"People generally know about the potentially large benefits of early education for children from very low resource circumstances," said co-author Sharon Landesman Ramey, professor and distinguished research scholar at Fralin Biomedical Research Institute. "The new results reveal that biological effects accompany the many behavioral, social, health, and economic benefits reported in the Abecedarian Project. This affirms the idea that positive early life experiences contribute to later positive adjustment through a combination of behavioral, social, and brain pathways."

During follow-up examinations, structural MRI scans of the brains of 47 study participants were conducted at the Fralin Biomedical Research Institute Human Neuroimaging Lab. Of those, 29 individuals had been in the group that received the educational enrichment focused on promoting language, cognition, and interactive learning.

The other 18 individuals received the same robust health, nutritional, and social services supports provided to the educational treatment group, and whatever community childcare or other learning their parents provided. The two groups were well matched on a variety of factors such as maternal education, head circumference at birth and age at scanning.

Analyzing the scans, the researchers looked at brain size as a whole, including the cortex, the brain's outermost layer, as well as five regions

selected for their expected connection to the intervention's stimulation of children's language and cognitive development.

Those included the left inferior frontal gyrus and left superior temporal gyrus, which may be relevant to language, and the right inferior frontal gyrus and bilateral anterior cingulate cortex, relevant to cognitive control. A fifth, the bilateral hippocampus, was added because its volume is frequently associated with early life adversity and socioeconomic status.

The researchers determined that those in the early education treatment group had increased size of the whole brain, including the cortex.

Several specific cortical regions also appeared larger, according to study co-authors Read Montague, professor and director of the Human Neuroimaging Lab and Computational Psychiatry Unit at the Fralin Biomedical Research Institute, and Terry Lohrenz, research assistant professor and member of the institute's Human Neuroimaging Laboratory.

The scientists noted the group intervention treatment results for the brain were substantially greater for males than for females. The reasons for this are not known, and were surprising, since both the boys and girls showed generally comparable positive behavioral and educational effects from their early enriched education. The current study cannot adequately explain the sex differences.

"When we launched this project in the 1970s, the field knew more about how to assess behavior than it knew about how to assess brain structure," Craig Ramey said. "Because of advances in neuroimaging technology and through strong interdisciplinary collaborations, we were able to measure structural features of the brain. The prefrontal cortex and areas associated with language were definitely affected; and to our knowledge,

this is the first experimental evidence on a link between known early educational experiences and long-term changes in humans."

"We believe that these findings warrant careful consideration and lend further support to the value of ensuring positive learning and social-emotional support for all children—particularly to improve outcomes for children who are vulnerable to inadequate stimulation and care in the early years of life," Craig Ramey said.

More information: Martha J. Farah et al, Randomized Manipulation of Early Cognitive Experience Impacts Adult Brain Structure, *Journal of Cognitive Neuroscience* (2021). DOI: 10.1162/jocn_a_01709

Provided by Virginia Tech