Intense prep for law school admission test alters brain structure

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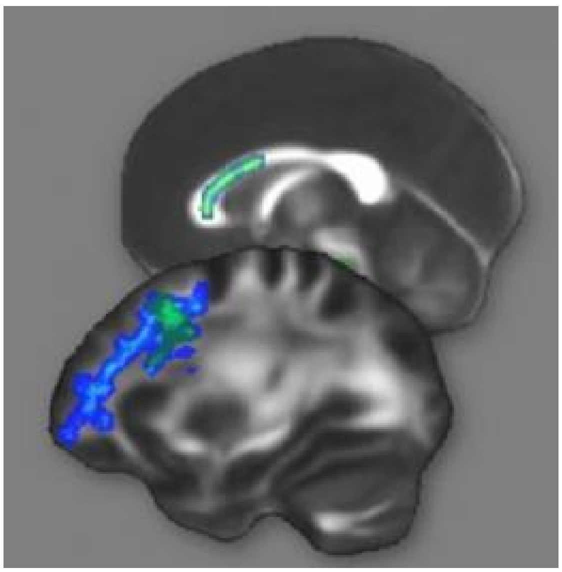

The brain's white matter, shown above, contains the connections between neurons. The white matter regions highlighted in green or blue showed changes after intense preparation for the LSAT, suggesting improved interconnections among reasoning areas of the brain. Credit: Bunge lab image

Intensive preparation for the Law School Admission Test (LSAT) actually changes the microscopic structure of the brain, physically bolstering the connections between areas of the brain important for reasoning, according to neuroscientists at the University of California, Berkeley.

The results suggest that training people in reasoning skills – the main focus of LSAT prep courses – can reinforce the brain's circuits involved in thinking and reasoning and could even up people's IQ scores.

"The fact that performance on the LSAT can be improved with practice is not new. People know that they can do better on the LSAT, which is why preparation courses exist," said Allyson Mackey, a graduate student in UC Berkeley's Helen Wills Neuroscience Institute who led the study. "What we were interested in is whether and how the brain changes as a result of LSAT preparation, which we think is, fundamentally, reasoning training. We wanted to show that the ability to reason is malleable in adults."

The new study shows that reasoning training does alter brain connections, which is good news for the test prep industry, but also for people who have poor reasoning skills and would like to improve them. The findings are reported today (Wednesday, Aug. 22) in the open access journal *Frontiers in Neuroanatomy*.

"A lot of people still believe that you are either smart or you are not, and sure, you can practice for a test, but you are not fundamentally changing your brain," said senior author Silvia Bunge, associate professor in the UC Berkeley Department of Psychology and the Helen Wills Neuroscience Institute. "Our research provides a more positive message. How you perform on one of these tests is not necessarily predictive of your future success, it merely reflects your prior history of cognitive engagement, and potentially how prepared you are at this time to enter a graduate program or a law school, as opposed to how prepared you could ever be."

John D. E. Gabrieli, a professor of cognitive neuroscience at the Massachusetts Institute of Technology, who was not involved in the research, noted that researchers in the past have shown anatomical changes in the brain from simpler tasks, such as juggling or playing a musical instrument, but not for tasks as complex and abstract as thinking or reasoning, which involve many areas of the brain.

"I think this is an exciting discovery," he said. "It shows, with rigorous analysis, that brain pathways important for thinking and reasoning remain plastic in adulthood, and that intensive, real-life educational experience that trains reasoning also alters the brain pathways that support reasoning ability."

Harnessing brain's spatial areas improves deductive reasoning

The results also suggest that LSAT training improves students' reasoning ability by strengthening the connections between the left and right hemispheres of the brain. According to Bunge, director of the Building Blocks of Cognition Laboratory, deductive reasoning, such as language comprehension, taxes a predominantly left-hemisphere brain network, whereas spatial cognition taxes a predominantly right-hemisphere network.

"You could argue that, to the extent that you can employ spatial cognition to think through a verbal problem, you would have the edge," she said.

The structural changes were revealed by diffusion tensor imaging (DTI) scans of the brains of 24 college students or recent graduates before and after 100 hours of LSAT training over a three-month period. When compared with brain scans of a matched control group of 23 young adults, the trained students developed increased connectivity between the frontal lobes of the brain, and between frontal and parietal lobes.

"A lot of data on reasoning has suggested that it is left-hemisphere dominant," Mackey said. "But what we thought originally was that this kind of reasoning training would require repeated co-activation of frontal and parietal cortices on both sides of the brain. Our data are consistent with the idea that, while reasoning is left-hemisphere dominant, with training you learn to compensate; if you are not very good at reasoning, you start bringing on the right side."

The study focused on fluid reasoning –- that is, the ability to tackle a novel problem, which is central to IQ tests and has been shown to predict academic performance and performance in demanding careers, Bunge said.

"People assume that IQ tests measure some stable characteristic of an individual, but we think this whole assumption is flawed," Bunge said. "We think that the skills measured by an IQ test wax and wane over time depending on the individual's level of cognitive activity." One fascinating question, Gabrieli noted, is whether the brain changes observed in this study persist for months or longer after the training.

For the past decade, Bunge has studied the ability to integrate multiple pieces of information, "which we see as central to all tests of reasoning," she said.

LSAT prep students are highly motivated study group

Mackey and Bunge showed several years ago that children can improve their reasoning skills by regularly playing commercially available games that involve reasoning, though the researchers did not have the opportunity to test for actual physical changes in the brain. In searching for a program that provides adults with intensive reasoning training, they hit upon the idea of recruiting aspiring lawyers preparing for the LSAT. Allyson discovered that the company Blueprint Test Preparation offered

100 hours of class time, including 70 hours of reasoning training. With the company's cooperation, she recruited students as they signed up for a Blueprint LSAT course. This arrangement allowed her to test whether training changes brain structure in a group of highly motivated young adults.

Mackey and Bunge tested for changes in the white matter of the brain, the brain tissue that contains the connections between the brain's neurons. These connections, called axons, are surrounded by a variety of support cells called glia, some of which form myelin that insulates the axons and speeds the passage of signals. In animal studies, increased myelination and glial support cells are associated with learning, and a recent study found that some of these glial cells provide energy to the axons.

Using diffusion tensor imaging (DTI), they followed water movement in the white matter and found differences, on average, between the trained group and the control group. Specifically, the trained group showed a change in the directionality of water diffusion that is consistent with increased myelination. Also, near the boundary between the white matter and gray matter, the trained group showed a reduction in water diffusion, possibly because of more densely packed glial cells. While the real cause of the changes in water diffusion is unclear, the researchers said, it reflects an alteration in the microstructure of the brain associated with a change in cognitive activity.

"One thing that gives us confidence in these data is that a lot of these changes are in the tracts that connect frontal and parietal cortex, or between different hemispheres in those areas, and frontal and parietal regions are absolutely essential for reasoning," Bunge said. "So, we are seeing the changes exactly where we would expect to see them. And we think that they reflect strengthening of the connections between them."

"This work could inspire further research in non-human animals, because there seems to be a resurgence of interest in environmental influences on the brain," Bunge said, noting that, in the 1960s and '70s, UC Berkeley Professors Mark Rosenzweig and Marion Diamond conducted landmark research on the effects of environmental enrichment on behavior and brain anatomy in rats.

Provided by University of California - Berkeley

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