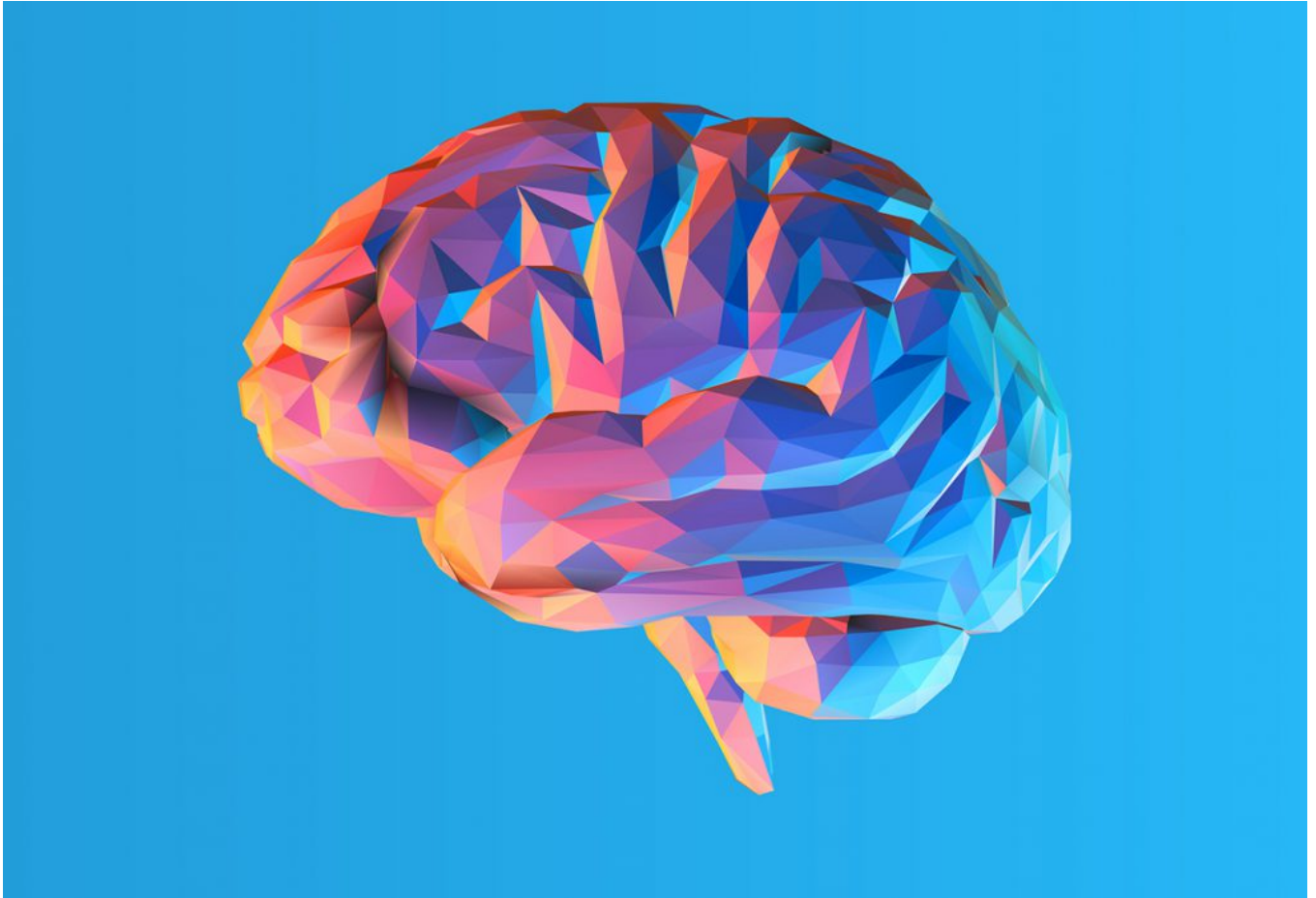


# Bigger Brains Linked With Slightly Better Cognitive Performance

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For more than 200 years, scientists have looked for a link between brain size and cognitive performance, yet the connection has remained hazy and fraught. Research led by Gideon Nave of the University of Pennsylvania's Wharton School and Philipp Koellinger of Vrije Universiteit Amsterdam has clarified the connection, with the [largest study of its kind](#).

Using MRI-derived information about brain size in connection with cognitive performance test results and a measure of educational attainment, obtained from more than 13,600 individuals, the researchers found that, as previous studies have suggested, there is a positive relationship between brain volume and performance on cognitive tests. But that finding comes with important caveats. The [research](#) is published in *Psychological Science*, a journal of the [Association for Psychological Science](#).

“The effect is there,” says Nave, an assistant professor of marketing at Wharton. “On average, a person with a larger brain will tend to perform better on tests of cognition than one with a smaller brain. But size is only a small part of the picture, explaining only about two percent of the variability in test performance. For educational attainment the effect was even smaller: an additional 100cm<sup>3</sup> cup full of

brain would increase an average person's years of schooling by less than 5 months."

Koellinger adds, "this implies that factors other than this one single variable that has received so much attention over the years account for 98% of the variation in cognitive test performance. Yet, the effect is strong enough that all future studies that will try to unravel the relationships between more fine-grained measures of brain anatomy and cognitive health should control for total brain volume. Thus, we see our study as a small, but important, contribution to better understanding differences in cognitive health among people."

Nave and Koellinger's collaborators included Joseph Kable, Baird Term Professor in Penn's Department of Psychology; Wi Hoon Jung, a former postdoctoral researcher in Kable's lab; and Richard Karlsson Linnér, a postdoc in Koellinger's group.

From the outset, the researchers sought to minimize as much as possible the effects of bias and confounding factors in their research. They preregistered the study, meaning they published their methods and committed to publishing ahead of time so they couldn't simply bury the results if the findings appeared to be insignificant. Their analyses also systematically controlled for sex, age, height, socioeconomic status, and population structure (measured from the participant's genes). Height is correlated with better cognitive performance, for example, but also with bigger brain size, so their study attempted to zero in only on the contribution of brain size.

Earlier studies had consistently identified a correlation between brain size and cognitive performance tests, but the relationship seemed to grow weaker as studies included more participants, so Nave and Koellinger hoped to pursue the question with a sample size that dwarfed previous efforts.

The study relied on a recently amassed dataset, the UK Biobank, a repository of information from more than half a million people across the United Kingdom. The Biobank includes participants' health and genetic information as well as brain scan images of a subset of roughly 20,000 people—a number that is growing by the month.

"This gives us something that never existed before," Koellinger says. "This sample size is gigantic—70 percent larger than all prior studies on this subject put together—and allows us to test the relationship between brain size and cognitive performance with much greater reliability."

Measuring cognitive performance is a difficult task, and the researchers note that even the evaluation used in this study has weaknesses. Participants took brief tests for logic, memory, and reaction time, but not acquired knowledge, yielding a relatively noisy measure of general cognitive performance.

Using a model that incorporated a variety of variables, the team looked to see which were predictive of better cognitive performance and educational attainment. Even controlling for other factors, like height, socioeconomic status, and genetic ancestry, total brain volume was positively correlated with both.

The findings are somewhat intuitive. "It's a simplified analogy, but think of a computer," Nave says. "If you have more transistors, you can compute faster and transmit more information. It may be similar in the brain to some extent. If you have more neurons, this may allow you to have a better memory, or complete more tasks in parallel. However, things are likely to be much more complex in reality. For

example, consider the possibility that a bigger brain – which is highly heritable – is associated with being a better parent. In this case, the association between a bigger brain and test performance may simply reflect the influence of parenting on cognition. We won't be able to get to the bottom of this without more research."

One of the notable findings related to differences between male and females. "Just like with height, there is a pretty substantial difference between males and females in brain volume, but this doesn't translate into differences in cognitive performance," Nave says.

A more nuanced look at the brain scans may explain this result. Other studies reported that in females, the cerebral cortex—the outer layer of the front part of the brain—tends to be thicker than in males.

"This might account for the fact that, despite having relatively smaller brains on average, there is no effective difference in cognitive performance between males and females," Nave says. "And of course, many other things could be going on."

Yet the authors underscore that the overarching correlation between brain volume and "braininess" was a weak one; no one should be measuring job candidates' head sizes during the hiring process, Nave jokes. Indeed, what stands out from the analysis is how little total brain volume seems to explain. Factors such as parenting style, education, nutrition, personality traits, and others, are likely major contributors that were not specifically tested in the study.

In follow-up work, the researchers plan to zoom in to determine whether certain regions of the brain, or connectivity between them, play an outsized role in contributing to braininess.

They're also hopeful that a deeper understanding of the biological underpinnings of cognitive performance can help shine a light on environmental factors that contribute, some of which can be influenced by our actions and our governments' policies.

"Suppose you have the necessary biology to become a fantastic golf or tennis player, but you never have the opportunity to play, so you'll never realize your potential," Nave says. And Koellinger adds, "We're hopeful that if we can understand the biological factors that are linked to cognitive performance, it will allow us to identify the environmental circumstances under which people can best manifest their potential and remain cognitively healthy. We've just started to scratch the top of the iceberg here."

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All data and materials are available via [UK Biobank](#). Data scripts for the present analyses can be found on the [Open Science Framework \(OSF\)](#). The design and analysis plans were [preregistered on the OSF](#). This article has received the [badges for Open Data, Open Materials, and Preregistration](#).