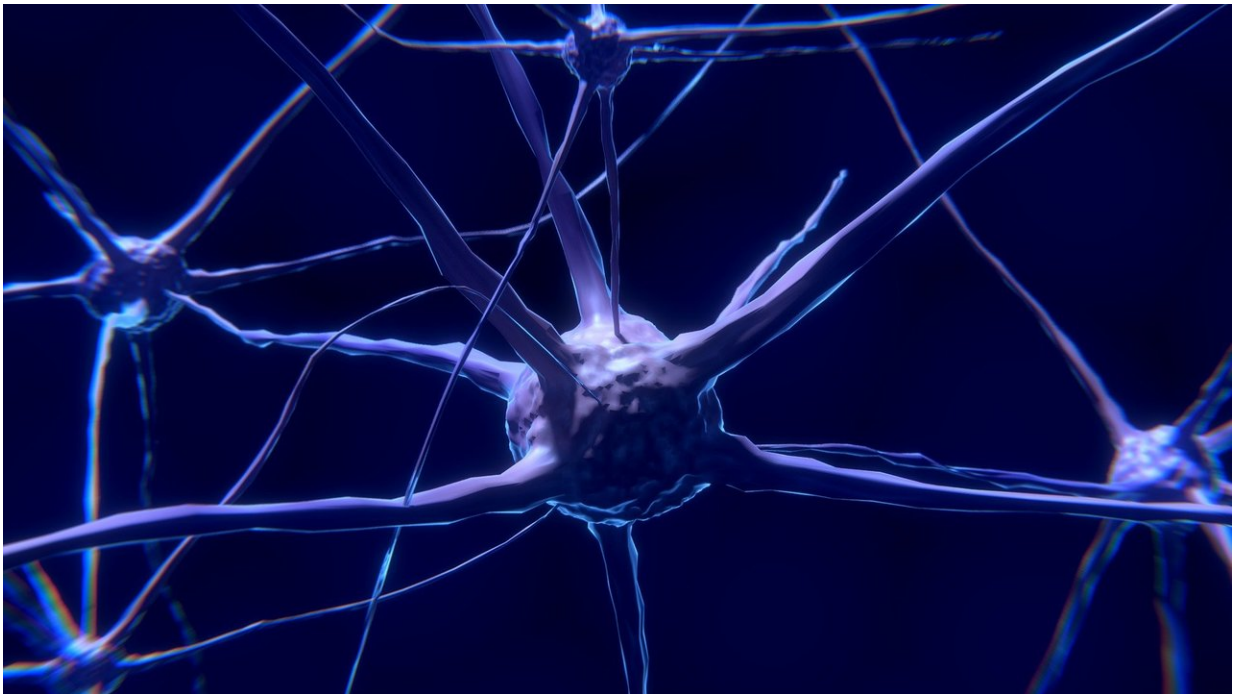


# Machine learning identifies personalized brain networks in children

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Machine learning is helping Penn Medicine researchers identify the size and shape of brain networks in individual children, which may be useful for understanding psychiatric disorders. In a new study published today in the journal *Neuron*, a multidisciplinary team showed how brain networks unique to each child can predict cognition. The study—which used machine learning techniques to analyze the functional magnetic

resonance imaging (fMRI) scans of nearly 700 children, adolescents, and young adults—is the first to show that functional neuroanatomy can vary greatly among kids, and is refined during development.

The human brain has a pattern of folds and ridges on its surface that provide physical landmarks for finding brain areas. The functional networks that govern cognition have long been studied in humans by lining up activation patterns—the software of the brain—to the hardware of these physical landmarks. However, this process assumes that the functions of the brain are located on the same landmarks in each person. This works well for many simple brain systems, for example, the motor system controlling movement is usually right next to the same specific fold in each person. However, multiple recent studies in adults have shown this is not the case for more complex brain systems responsible for executive function—a set of mental processes which includes self-control and attention. In these systems, the functional networks do not always line up with the brain's physical landmarks of folds and ridges. Instead, each adult has their own specific layout. Until now, it was unknown how such person-specific networks might change as kids grow up, or relate to executive function.

"The exciting part of this work is that we are now able to identify the spatial layout of these functional networks in individual kids, rather than looking at everyone using the same 'one size fits all' approach," said senior author Theodore D. Satterthwaite, MD, an assistant professor of Psychiatry in the Perelman School of Medicine at the University of Pennsylvania. "Like adults, we found that functional neuroanatomy varies quite a lot among different kids—each child has a unique pattern. Also like adults, the networks that vary the most between kids are the same executive networks responsible for regulating the sorts of behaviors that can often land adolescents in hot water, like risk taking and impulsivity."

To study how functional networks develop in children and supports executive function, the team analyzed a large sample of adolescents and [young adults](#) (693 participants, ages 8 to 23). These participants completed 27 minutes of fMRI scanning as part of the Philadelphia Neurodevelopmental Cohort (PNC) a large study that was funded by the National Institute of Mental Health. Machine learning techniques developed by the laboratory of Yong Fan, Ph.D., an assistant professor of Radiology at Penn and co-author on the paper, allowed the team to map 17 functional networks in individual children, rather than relying on the average location of these networks.

The researchers then examined how these functional networks evolved over adolescence, and were related to performance on a battery of cognitive tests. The team found that the functional neuroanatomy of these networks was refined with age, and allowed the researchers to predict how old a child with a high degree of accuracy.

"The spatial layout of these networks predicted how good kids were at executive tasks," said Zaixu Cui, Ph.D., a post-doctoral fellow in Satterthwaite's lab and the paper's first author. "Kids who have more 'real estate' on their cortex devoted to networks responsible for executive function in fact performed better on these complex tasks." In contrast, youth with lower executive function had less of their cortex devoted to these executive networks.

Taken together, these results offer a new account of developmental plasticity and diversity and highlight the potential for progress in personalized diagnostics and therapeutics, the authors said.

"The findings lead us to interesting questions regarding the developmental biology of how these networks are formed, and also offer potential for personalizing neuromodulatory treatments, such as brain stimulation for depression or attention problems," said Satterthwaite.

"How are these systems laid down in the first place? Can we get a better response for our patients if we use neuromodulation that is targeted using their own personal networks? Focusing on the unique features of each person's [brain](#) may provide an important way forward."

**More information:** Zaixu Cui et al. Individual Variation in Functional Topography of Association Networks in Youth, *Neuron* (2020). DOI: 10.1016/j.neuron.2020.01.029

Provided by Perelman School of Medicine at the University of Pennsylvania

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