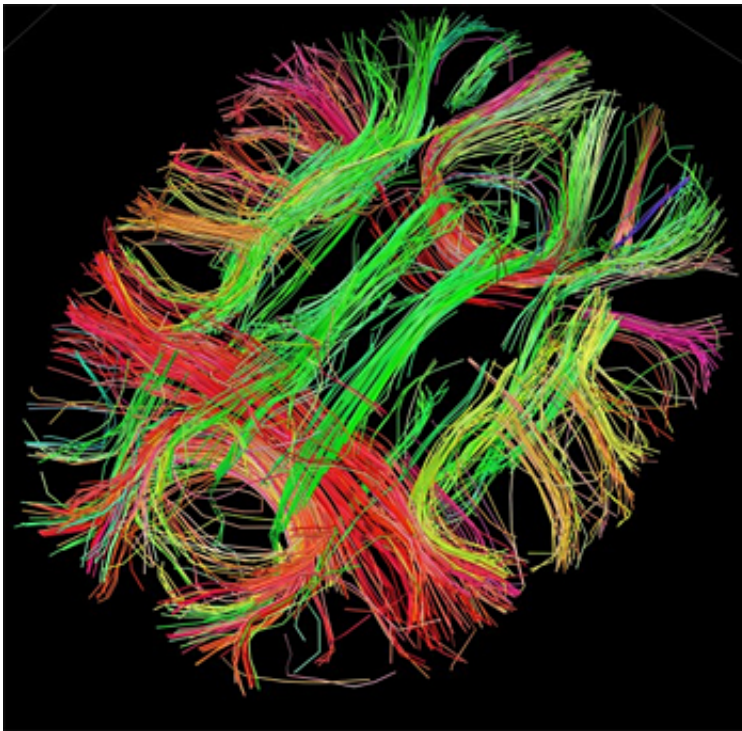


Researchers report on brain network development in young people

October 26 2015, by Christopher Packham



White matter fiber architecture of the brain. Credit: Human Connectome Project.

(Medical Xpress)—The understanding of human cognition has accelerated in the last decade thanks to the integration of network concepts derived from complex systems including airline transportation and the structure of the Internet. Cognition is now understood as a function of the interactions of networks between brain structures, though

neuroscience is still grappling with the complexity of this problem.

A multidisciplinary research group at the University of Pennsylvania reports in the *Proceedings of the National Academy of Sciences* on a new study that demonstrates how many of the major brain networks evolve from childhood to adulthood, and suggests that establishing normal measures of this development could assist in the diagnosis of various cognitive and psychological disorders.

Human cognitive functions are supported by large-scale networks that are coherent at rest, forming identifiable modules. These modules contain well-known subnetworks including the default-mode, visual, auditory, motor, and cognitive control systems. In network engineering, modularity describes the segregation between modules. In human brain development, network modularity is very high early in life, decreasing with age as modules become more integrated. Additionally, as young people transition to adulthood, networks begin favoring more interaction between hubs and non-hub subsystems.

However, it remains unknown how the cognitive roles and interactions of these specific systems evolve with age. The researchers suggest that the differentiation of specific network modules support the increased cognitive, emotional and motor capabilities observed during adolescence. Because network abnormalities are a constant feature of neuropsychiatric conditions, the authors also support the quantitative characterization of the maturation of functional networks in youth.

The researchers obtained data from a large number of subjects between the ages of eight and 22 via a collaboration between the Center for Applied Genomics at the Children's Hospital of Philadelphia and the University of Pennsylvania's Brain Behavior Laboratory. Cognition of the subjects was measured with a neurocognitive battery and the researchers obtained resting-state fMRI scans of all subjects. They used

the data to identify functional brain networks.

They report that cognitive systems become disparately sized and functionally segregated with maturation. They report that sensorimotor systems tend to be cohesive provincial systems that become increasingly segregated from other systems during development. Higher-order cognitive systems like salience, memory, and attention systems tend to be more incohesive, and perform connector roles; they also become more segregated during development.

The default-mode network is unique, a cohesive connector system that becomes increasingly cohesive and increasingly associated with other networks over time. "The connective nature of this system might underlie fluid thought processes that require interactions with other cortically based [cognitive systems](#), such as mind wandering, internal trains of thought and prospective imagination," the authors write. "Indeed, such a possibility is supported by our finding that the between-system connectivity of the default more was significantly correlated with general cognitive performance."

The authors conclude that these results provide a context for the future understanding of neuropsychiatric development, and that they are compatible with the hypothesis that individual variation in network configurations underlie vulnerability to cognitive disorders.

More information: "Emergence of system roles in normative neurodevelopment." *PNAS* 2015 ; published ahead of print October 19, 2015, [DOI: 10.1073/pnas.1502829112](https://doi.org/10.1073/pnas.1502829112)

Abstract

Adult human cognition is supported by systems of brain regions, or modules, that are functionally coherent at rest and collectively activated by distinct task requirements. However, an understanding of how the

formation of these modules supports evolving cognitive capabilities has not been delineated. Here, we quantify the formation of network modules in a sample of 780 youth (aged 8–22 y) who were studied as part of the Philadelphia Neurodevelopmental Cohort. We demonstrate that the brain's functional network organization changes in youth through a process of modular evolution that is governed by the specific cognitive roles of each system, as defined by the balance of within- vs. between-module connectivity. Moreover, individual variability in these roles is correlated with cognitive performance. Collectively, these results suggest that dynamic maturation of network modules in youth may be a critical driver for the development of cognition.

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