How brain maturation changes uninhibited teens to self-controlled adults

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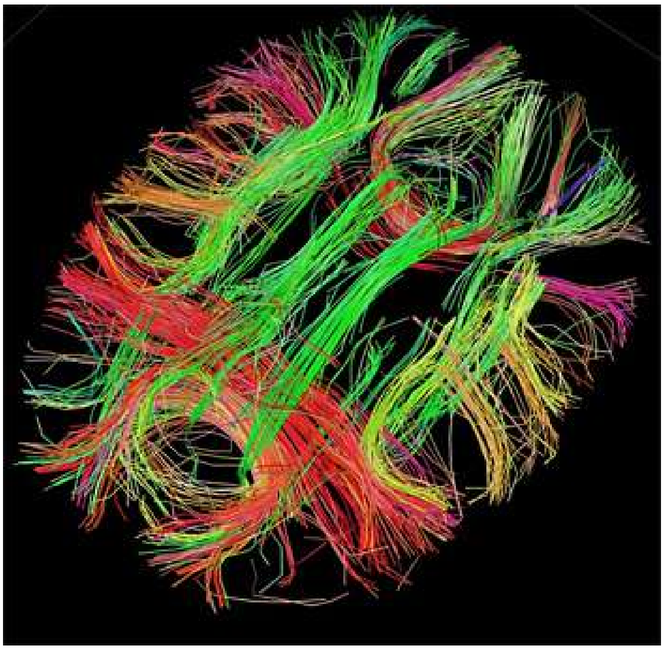

White matter fiber architecture of the brain. Credit: Human Connectome Project.

(Medical Xpress)—One of the biggest problems in the U.S. justice system is the expanding number of states that treat teens as adults for certain crimes. While harsh treatment of adolescents might generate votes for tough-on-crime policies and candidates, an increasing amount of neurological research strongly suggests that the brain function of teens is vastly different than adult brains, and that impulsivity in adolescents is largely unavoidable.

However, little is yet known about the physiological development of prefrontal neurons after puberty. In the past, it's been established that the ability to resist impulsive responses matures after puberty, but neurologists want to know how this maps to changes in the brain. Recently, a collaborative of U.S. researchers published the results of a longitudinal study in the *Proceedings of the National Academy of Sciences* that tracked the neuronal responses of monkeys as they transitioned from puberty to adulthood, comparing brain activity at different stages of development.

Puberty begins in monkeys around 3.5 years of age, and they reach sexual maturity at around five years old. This corresponds to the human ages of approximately 11 years and 16 years, respectively. The researchers made neurophysiological recordings with a group of monkeys trained in an antisaccade task—meaning that they were trained not to look at a particular visual stimulus. They were tested once in puberty and again as adults.

The researchers demonstrate that behavioral response inhibition to the stimulus significantly improved in adulthood. "Performance benefits were observed for all types of errors, including the ability to resist making an eye movement toward the cue," the authors write. But this finding came with one surprising conclusion: "This enhanced control was not achieved through a general slowing of reaction times in the adult stage; to the contrary, adult monkeys needed less time to process the cue and plan a correct saccade."

In the adults, the researchers observed an increase in baseline neural activity, even before the appearance of a cue. This was a significant finding, because low levels of baseline activity—as observed in adolescents—are predictive of errors. The researchers believe that this baseline neural activity is related to the preparation of a response, which is critical to inhibitory control.

The researchers report increased activity of purely visual neurons, and activity associated with vector inversion in the lateral intraparietal area, writing, "It is likely that this change between stages is associated with the neural representation of the goal through processes such as shifting of attention and vector inversion, which correspond to the encoding of a spatial location away from the stimulus." Furthermore, they observed that neurons in the dorsolateral prefrontal cortex exhibited vector-inversion behavior away from the stimulus without imposing a delay on response time.

The researchers note that their results leave open the possibility that neurophysiological changes may also occur in areas outside the prefrontal cortex that could also contribute to the improved responses of the adult monkeys, but which were not within the scope of the study.

More information: Behavioral response inhibition and maturation of goal representation in prefrontal cortex after puberty. *PNAS* 2016 ; published ahead of print March 7, 2016, DOI: 10.1073/pnas.1518147113

Abstract
Executive functions including behavioral response inhibition mature after puberty, in tandem with structural changes in the prefrontal cortex. Little is known about how activity of prefrontal neurons relates to this profound cognitive development. To examine this, we tracked neuronal responses of the prefrontal cortex in monkeys as they transitioned from puberty into adulthood and compared activity at different developmental stages. Performance of the antisaccade task greatly improved in this period. Among neural mechanisms that could facilitate it, reduction of stimulus-driven activity, increased saccadic activity, or enhanced representation of the opposing goal location, only the latter was evident in adulthood. Greatly accentuated in adults, this neural correlate of vector inversion may be a prerequisite to the formation of a motor plan to look away from the stimulus. Our results suggest that the prefrontal mechanisms that underlie mature performance on the antisaccade task are more strongly associated with forming an alternative plan of action than with suppressing the neural impact of the prepotent stimulus.