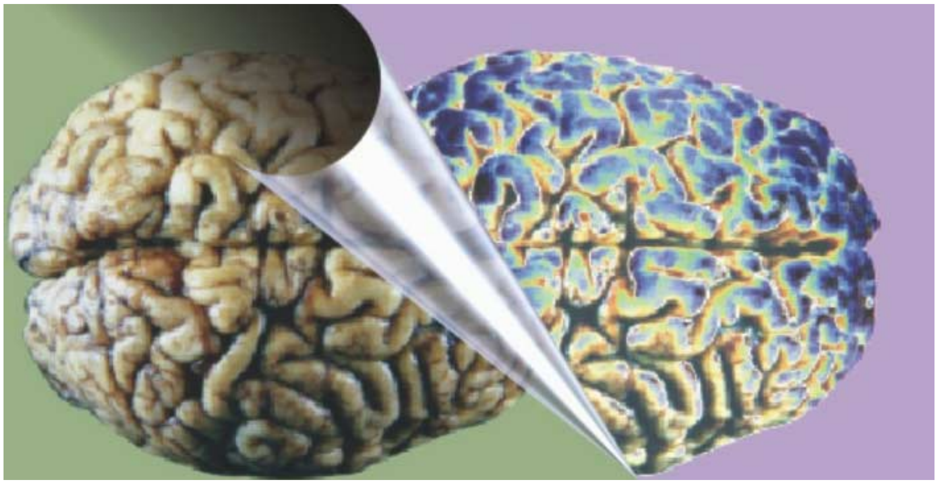
Teenage brain:

a work in progress



New imaging studies are revealing—for the first time—patterns of brain development that extend into the teenage years. Although scientists don't know yet what accounts for the observed changes, they may parallel a pruning process that occurs early in life that appears to follow the principle of "use-it-or-lose-it:" neural connections, or synapses, that get exercised are retained, while those that don't are lost. At least, this is what studies of animals' developing visual systems suggest. While it's known that both genes and environment play major roles in shaping early brain development, science still has much to learn about the relative influence of experience versus genes on the later maturation of the brain. Animal studies support a role for experience in late development, but no animal species undergoes anything comparable to humans' protracted childhood and adolescence. Nor is it yet clear whether experience actually creates new neurons and synapses, or merely establishes transitory functional changes. Nonetheless, it's tempting to interpret the new findings as empowering teens to protect and nurture their brain as a work in progress.

The newfound appreciation of the dynamic nature of the teen brain is emerging from MRI (magnetic resonance imaging) studies that scan a child's brain every two years, as he or she grows up. Individual brains differ enough that only broad generalizations can be made from comparisons of different individuals at different ages. But following the same brains as they mature allows scientists a much finer-grained view into developmental changes. In the first such longitudinal study of 145 children and adolescents, reported in l999, NIMH's Dr. Judith Rapoport and colleagues were surprised to discover a second wave of overproduction of gray matter, the thinking part of the brain—neurons and their branch-like extensions—just prior to puberty.[1] Possibly related to the influence of surging sex hormones, this thickening peaks at around age 11 in girls, 12 in boys, after which the gray matter actually thins some.

Prior to this study, research had shown that the brain overproduced gray matter for a brief period in early development—in the womb and for about the first 18 months of life—and then underwent just one bout of pruning. Researchers are now confronted with structural changes that occur much later in adolescence. The teen's gray matter waxes and wanes in different functional brain areas at different times in development. For example, the gray matter growth spurt just prior to puberty predominates in the frontal lobe, the seat of "executive functions"—planning, impulse control and reasoning. In teens affected by a rare, childhood onset form of schizophrenia that impairs these functions, the MRI scans revealed four times as much gray matter loss in the frontal lobe as normally occurs.[2]

Unlike gray matter, the brain's white matter—wire-like fibers that establish neurons' long-distance connections between brain regions—thickens progressively from birth in humans. A layer of insulation called myelin progressively envelops these nerve fibers, making them more efficient, just like insulation on electric wires improves their conductivity.

Advancements in MRI image analysis are providing new insights into how the brain develops. UCLA's Dr. Arthur Toga and colleagues turned the NIMH team's MRI scan data into 4-D time-lapse animations of children's brains morphing as they grow up—the 4th dimension being rate-of-change.[3] Researchers report a wave of white matter growth that begins at the front of the brain in early childhood, moves rearward, and then subsides after puberty. Striking growth spurts can be seen from ages 6 to 13 in areas connecting brain regions specialized for language and understanding spatial relations, the temporal and parietal lobes. This growth drops off sharply after age 12, coinciding with the end of a critical period for learning languages.

While this work suggests a wave of brain white matter development that flows from front to back, animal, functional brain imaging and postmortem studies have suggested that gray matter maturation flows in the opposite direction, with the frontal lobes not fully maturing until young adulthood. To confirm this in living humans, the UCLA researchers compared MRI scans of young adults, 23–30, with those of teens, 12–16.[4] They looked for signs of myelin, which would imply more mature, efficient connections, within gray matter. As expected, areas of the frontal lobe showed the largest differences between young adults and teens. This increased myelination in the adult frontal cortex likely relates to the maturation of cognitive processing and other "executive" functions. Parietal and temporal areas mediating spatial, sensory, auditory and language functions appeared largely mature in the teen brain. The observed late maturation of the frontal lobe conspicuously coincides with the typical age-of-onset of schizophrenia—late teens, early twenties—which, as noted earlier, is characterized by impaired "executive" functioning.

Another series of MRI studies is shedding light on how teens may process emotions differently than adults. Using functional MRI (fMRI), a team led by Dr. Deborah Yurgelun-Todd at Harvard's McLean Hospital scanned subjects' brain activity while they identified emotions on pictures of faces displayed on a computer screen.[5] Young teens, who characteristically perform poorly on the task, activated the amygdala, a brain center that mediates fear and other "gut" reactions, more than the frontal lobe. As teens grow older, their brain activity during this task tends to shift to the frontal lobe, leading to more reasoned perceptions and improved performance. Similarly, the researchers saw a shift in activation from the temporal lobe to the frontal lobe during a language skills task, as teens got older. These functional changes paralleled structural changes in temporal lobe white matter.

While these studies have shown remarkable changes that occur in the brain during the teen years, they also demonstrate what every parent can confirm: the teenage brain is a very complicated and dynamic arena, one that is not easily understood.

For More Information

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