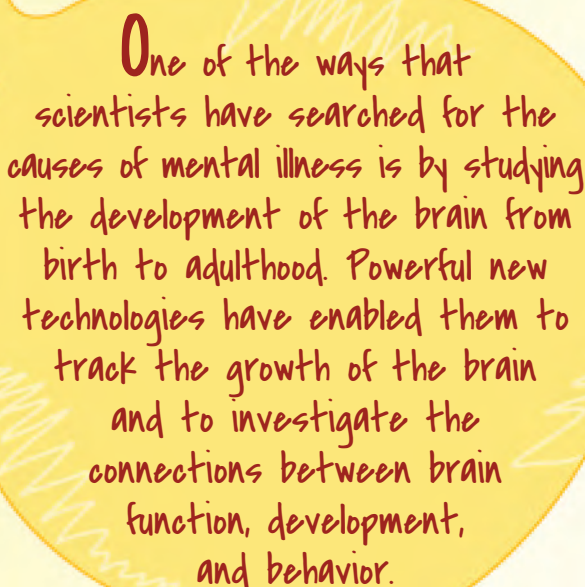


The Teen Brain:

STILL UNDER CONSTRUCTION





One of the ways that scientists have searched for the causes of mental illness is by studying the development of the brain from birth to adulthood. Powerful new technologies have enabled them to track the growth of the brain and to investigate the connections between brain function, development, and behavior.

The research has turned up some surprises, among them the discovery of striking changes taking place during the teen years. These findings have altered long-held assumptions about the timing of brain maturation. In key ways, the brain doesn't look like that of an adult until the early 20s.

An understanding of how the brain of an adolescent is changing may help explain a puzzling contradiction of adolescence: young people at this age are close to a lifelong peak of physical health, strength, and mental capacity, and yet, for some, this can be a hazardous age. Mortality rates jump between early and late adolescence. Rates of death by injury between ages 15 to 19 are about six times that of the rate between ages 10 and 14. Crime rates are highest among young males and rates of alcohol abuse are high relative to other ages. Even though most adolescents come through this transitional age well, it's important to understand the risk factors for behavior that can have serious consequences. Genes, childhood experience, and the environment in which a young person reaches adolescence all shape behavior. Adding to this complex picture, research is revealing how all these factors act in the context of a brain that is changing, with its own impact on behavior.

The more we learn, the better we may be able to understand the abilities and vulnerabilities of teens, and the significance of this stage for life-long mental health.

The fact that so much change is taking place beneath the surface may be something for parents to keep in mind during the ups and downs of adolescence.

The "Visible" Brain

A clue to the degree of change taking place in the teen brain came from studies in which scientists did brain scans of children as they grew from early childhood through age 20. The scans revealed unexpectedly late changes in the volume of gray matter, which forms the thin, folding outer layer or cortex of the brain. The cortex is where the processes of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases and then declines. A decline in volume is normal at this age and is in fact a necessary part of maturation.

The assumption for many years had been that the volume of gray matter was highest in very early childhood, and gradually fell as a child grew. The more recent scans, however, revealed that the high point of the volume of gray matter occurs during early adolescence.

While the details behind the changes in volume on scans are not completely clear, the results push the timeline of brain maturation into adolescence and young adulthood. In terms of the volume of gray matter seen in brain images, the brain does not begin to resemble that of an adult until the early 20s.

The scans also suggest that different parts of the cortex mature at different rates. Areas involved in more basic functions mature first: those involved, for example, in the processing of information from the senses, and in controlling movement. The parts of the brain responsible for more "top-down" control, controlling impulses, and planning ahead—the hallmarks of adult behavior—are among the last to mature.

What's Gray Matter?

The details of what is behind the increase and decline in gray matter are still not completely clear. Gray matter is made up of the cell bodies of neurons, the nerve fibers that project from them, and support cells. One of the features of the brain's growth in early life is that there is an early blooming of synapses—the connections between brain cells or neurons—followed by pruning as the brain matures. Synapses are the relays over which neurons communicate with each other and are the basis of the working circuitry of the brain. Already more numerous than an adult's at birth, synapses multiply rapidly in the first months of life. A 2-year-old has about half again as many synapses as an adult. (For an idea of the complexity of the brain: a cube of brain matter, 1 millimeter on each side, can contain between 35 and 70 million neurons and an estimated 500 billion synapses.)

Scientists believe that the loss of synapses as a child matures is part of the process by which the brain becomes more efficient. Although genes play a role in the decline in synapses, animal research has shown that experience also shapes the decline. Synapses "exercised" by experience survive and are strengthened, while others are pruned away. Scientists are working to determine to what extent the changes in gray matter on brain scans during the teen years reflect growth and pruning of synapses.



A Spectrum of Change

Research using many different approaches is showing that more than gray matter is changing:

- Connections between different parts of the brain increase throughout childhood and well into adulthood. As the brain develops, the fibers connecting nerve cells are wrapped in a protein that greatly increases the speed with which they can transmit impulses from cell to cell. The resulting increase in connectivity—a little like providing a growing city with a fast, integrated communication system—shapes how well different parts of the brain work in tandem. Research is finding that the extent of connectivity is related to growth in intellectual capacities such as memory and reading ability.
- Several lines of evidence suggest that the brain circuitry involved in emotional responses is changing during the teen years. Functional brain imaging studies, for example, suggest that the responses of teens to emotionally loaded images and situations are heightened relative to younger children and adults. The brain changes underlying these patterns involve brain centers and signaling molecules that are part of the reward system with which the brain motivates behavior. These age-related changes shape how much different parts of the brain are activated in response to experience, and in terms of behavior, the urgency and intensity of emotional reactions.
- Enormous hormonal changes take place during adolescence. Reproductive hormones shape not only sex-related growth and behavior, but overall social behavior. Hormone systems involved in the brain's response to stress are also changing during the teens. As with reproductive hormones, stress hormones can have complex effects on the brain, and as a result, behavior.
- In terms of sheer intellectual power, the brain of an adolescent is a match for an adult's. The capacity of a person to learn will never be greater than during adolescence. At the same time, behavioral tests, sometimes combined with functional brain imaging, suggest differences in how adolescents and adults carry out

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