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brain BRIEFINGS

SCIENTISTS ONCE THOUGHT THE BRAIN'S KEY DEVELOPMENT ENDED WITHIN THE FIRST FEW YEARS OF LIFE. CURRENT FINDINGS, HOWEVER, INDICATE THAT IMPORTANT BRAIN REGIONS UNDERGO REFINEMENT THROUGH ADOLESCENCE AND AT LEAST INTO A PERSON'S TWENTIES. THANKS TO ADVANCED BRAIN IMAGING TECHNIQUES, SCIENTISTS NOW CAN MAP BRAIN TISSUE GROWTH SPURTS AND LOSSES, ALLOWING RESEARCHERS TO COMPARE BRAIN GROWTH IN BOTH HEALTH AND DISEASE AND TO PINPOINT WHERE BRAIN CHANGES ARE MOST PROMINENT IN DISEASE. ALREADY BRAIN MAPPING RESEARCH IS UNDERWAY FOR DISEASES THAT OFTEN EMERGE IN ADOLESCENCE, INCLUDING SCHIZOPHRENIA AND BIPOLAR DISORDER. FROM THIS RESEARCH, MORE TARGETED INTERVENTIONS ARE LIKELY TO BE DEVELOPED AND ADMINISTERED EARLY TO TREAT OR PREVENT ENSUING DISORDERS.

SOCIETY FOR NEUROSCIENCE

THE ADOLESCENT BRAIN

Teenagers and adults often don't see eye to eye, but new brain research is shedding light on why.

Although adolescence is often characterized by increased independence and a desire for knowledge and exploration, it is also a time when brain changes can result in high-risk behaviors, addiction vulnerability, and mental illness, as different parts of the brain mature at different rates.

Many teens, for example, use adolescence as a time to experiment with drugs. A 2004 study found that 70 percent of high school seniors used alcohol in the previous year. What's more, the adolescent's brain may be particularly vulnerable to the negative effects of drugs, including becoming addicted later in life more so than people who don't use drugs before age 21.

Atypical brain changes and behaviors also can appear in adolescence. A 2005 report found that an estimated 2.7 million children and adolescents are reported by their parents to suffer from severe emotional or behavioral difficulties. These difficulties may persist throughout development and lead to lifelong disability, including more serious and co-occurring mental illnesses.

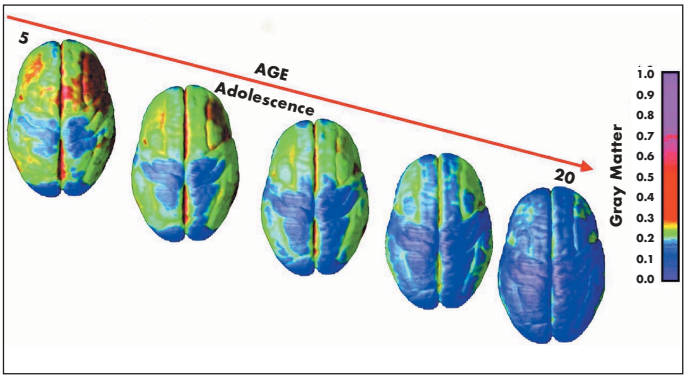

IMAGE ADAPTED FROM GOGTAY N, ET AL. DYNAMIC MAPPING OF HUMAN CORTICAL DEVELOPMENT DURING CHILDHOOD THROUGH EARLY ADULTHOOD. *PNAS 2004;101(21):* 8174–79, FIG. 3.

▲ THE ABOVE COMPOSITE MRI BRAIN IMAGES SHOW TOP VIEWS OF THE SEQUENCE OF GRAY MATTER MATURATION OVER THE SURFACE OF THE BRAIN. RESEARCHERS FOUND THAT, OVERALL, GRAY MATTER VOLUME INCREASED AT EARLIER AGES, FOLLOWED BY SUSTAINED LOSS AND THINNING STARTING AROUND PUBERTY, WHICH CORRELATES WITH ADVANCING COGNITIVE ABILITIES. SCIENTISTS THINK THIS PROCESS REFLECTS GREATER ORGANIZATION OF THE BRAIN AS IT PRUNES REDUNDANT CONNECTIONS, AND INCREASES IN MYELIN, WHICH ENHANCE TRANSMISSION OF BRAIN MESSAGES.

Scientists once thought the brain's key development ended within the first few years of life. Now, thanks to advanced brain imaging technology and adolescent research, scientists are learning more about the teenage brain both in health and in disease. They know now that the brain continues to develop at least into a person's twenties. What's more, these findings are starting to lead to earlier and more targeted treatments for diseases that begin with abnormal brain changes in adolescence or earlier. Advances in adolescent brain research are leading to:

- A better understanding of the growing adolescent brain, both in typical and atypical development.
- Earlier detection of atypical brain changes that may serve as markers for diseases or disorders later in life.
- Improved and targeted interventions that can be administered early enough to potentially prevent the development of more serious illness.

During adolescence, brain connections and signaling mechanisms selectively change over time to meet the needs of the environment. Overall, gray matter volume increases at earlier ages, followed by sustained loss and thinning start-

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ing around puberty, which correlates with advancing cognitive abilities. Scientists think this process reflects greater organization of the brain as it prunes redundant connections, and increases in myelin, which enhance transmission of brain messages.

Other parts of the brain also undergo refinement during the teen years. Areas associated with more basic functions, including the motor and sensory areas, mature early. Areas involved in planning and decision-making, including the prefrontal cortex—the cognitive or reasoning area of the brain important for controlling impulses and emotions—appear not to have yet reached adult dimension during the early twenties. The brain's reward center, the ventral striatum, also is more active during adolescence than in adulthood, and the adolescent brain still is strengthening connections between its reasoning- and emotion-related regions.

Scientists believe these collective findings may indicate that cognitive control over high-risk behaviors is still maturing during adolescence, making teens more apt to engage in risky behaviors. Also, with the brain's emotion-related areas and connections still maturing, adolescents may be more vulnerable to psychological disorders.

Current research is looking at the manifestations of psychological disorders in adolescents, particularly schizophrenia and bipolar disorder. Large imaging studies have shown that brain changes associated with schizophrenia typically begin in adolescence when the brain undergoes the normal pruning sequence of myelination growth spurts and gray matter loss. It appears that a larger and more severe wave of gray matter loss occurs in the brains of adolescents developing schizophrenia, which eventually engulfs much of the cortex after a period of five years. Scientists believe that the natural teenage process of pruning may be accelerated or otherwise altered in schizophrenia, bipolar disorder, and other neurodevelopmental disorders.

This research is leading to treatment implications, including a newer antipsychotic medication that, if administered early, may prevent or slow the severe wave of gray matter loss in schizophrenia and keep the disorder from progressing. Scientists also are exploring the use of low doses of medication to prevent the functional alterations in brain cells in bipolar disorder.

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