The Teen Brain: Still Under Construction

NATIONAL INSTITUTE OF MENTAL HEALTH
Adding to this complex picture, research is revealing how all a young person reaches adolescence all shape behavior. Genes, childhood experience, and the environment in which this transitional age well, it’s important to understand the other ages. Even though most adolescents come through young males and rates of alcohol abuse are high relative to rate between ages 10 and 14. Crime rates are highest among injury between ages 15 to 19 are about six times that of the jump between early and late adolescence. Rates of death by adolescence: young people at this age are close to a lifelong changing may help explain a puzzling contradiction of brain doesn’t look like that of an adult until the early 20s. The research has turned up some surprises, among them technologies have enabled them to track the growth of the brain and to investigate the connections between brain function, development, and behavior.

The Visible Brain

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 lifelong 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.

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. However, the rates at which the volume of gray matter changes is not completely clear, the results push the timeline of brain maturation into adolescence and young adulthood.

The scans also suggest that different parts of the cortex mature at different rates. Areas involved in more basic processes of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases. However, the rates at which the volume of gray matter changes.

The “Visible” Brain

Connections between different parts of the brain increase throughout childhood and well into adult- hood. 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 increases a little like providing a growing city with a fast, integrated communication system—shapes why different parts of the brain work in tandem. Research is finding that the extent of connectivity is related to growth in intellectual capaci- ties 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 regions of the brain that are involved in regulating impulses and planning affect 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 adoles- cence. Reproductive hormones shape not only sex-related growth and behavior, but overall social behavior. Hormone systems over the brain respond to stress are also changing during the teens. As with reproductive, 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, behavior tests, some- times combined with functional brain imaging, suggest differences in how adolescents and adults carry out mental tasks. Adolescents and adults seem to engage different parts of the brain to different extents during tests requiring calculation or impulse control, or in reaction to emotional content.

Research suggests that adolescence brings with brain-based changes in the regulation of sleep that may contribute to teens’ tendency to stay up late at night. Along with the obvious effects of sleep depriva- tion, such as fatigue and difficulty managing attention, inadequate sleep is a powerful contributor to irritability and depression. Studies of childhood and adolescents have found that sleep deprivation can increase impulsive behavior; some researchers find that it’s a factor in the frequency of inadequate sleep is central to physical and emotional health.

One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responses are fully online, or even more active than in adults, which could explain the part of the brain involved in keeping emotional, impulsive responses in check at older reaching maturity. Such a balancing of the brain changes under- loaded images and situations are heightened relative to younger children and adults. The brain changes under- loading patterns and timing of the 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.

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External factors such as stress, sleep, and hormonal changes can affect the brain development during adolescence. The brain is still developing during this time, and external factors can influence its development. For example, poor sleep habits can impact brain development, and stress can affect the production of neurochemicals that are important for brain development. During adolescence, the brain is particularly vulnerable to the effects of drugs and alcohol, and excessive use of these substances can have long-lasting effects on brain development.

The Changing Brain and Behavior in Teens

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Adding to this complex picture, research is revealing how all risk factors for behavior that can have serious consequences. To rate between ages 10 and 14. Crime rates are highest among injury between ages 15 to 19 are about six times that of the jump between early and late adolescence. Rates of death by adolescence: young people at this age are close to a lifelong changing may help explain a puzzling contradiction of An understanding of how the brain of an adolescent is The research has turned up some surprises, among them The assumption for many years had been that the vol- at this age and is in fact a necessary part of maturation. 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. Animal research has shown that experience also 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 pro- cesses of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases, but this process is not linear. A decline in volume 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. Animal research has shown that experience also scientists have searched for the powerful new connections between brain function, development, and behavior.

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What’s Gray Matter?

The details of what is behind the increase and decline in gray matter are not clear. Given how 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 pruning of synapses—the connections between brain cells or neurons—followed by pruning as the brain matures. Synapses are the relay stations where neurons communicate with each other and are the basic blocks in working circuits of the brain. Already more numerous than an adult at birth, synapses multiply rapidly in the first months of life. By age 4, a child has formed a few billion synapses, and an adult has 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 up to 2 billion synapses (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 a general play a role in shaping the brain, 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.

Connections between different parts of the brain increase throughout childhood and well into adult- hood. 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 increases in the size of axons—little like providing a growing city with a fast, integrated communica- tion system—shapes how well different parts of the brain work in tandem. Researchers have found that the extent of connectivity is related to growth in intellectual capaci- ties such as memory and reading ability.

Several lines of evidence suggest that the brain circuitry involved in emotional responsiveness is changing during the teen years. Functional brain imaging studies, for example, suggest that the so-called “emotional center” of the brain responds to loaded images and situations are heightened relative to younger children and adults. The brain changes under- lying this pattern are the timing and in response to emotional signals 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 adoles- cence. Reproductive hormones shape not only sex-related growth and behavior, but overall social behavior. Hormone systems involved in the 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 the experience, the brain of an adolescent is a match for an adult. The capacity of a person to learn will never be greater than during adolescence. At the same time, behavior traits, sometimes combined with functional brain imaging, suggest differences in how adolescents and adults carry out mental tasks. Adolescents and adults seem to engage different parts of the brain to different extents during tests requiring calling out or suppressing control, or in response to emotional content.

Research suggests that adolescence brings with it brain-based changes in the regulation of sleep that may contribute to teens’ tendency to stay up late at night. Along with the obvious effects of sleep depriva- tion, such as fatigue and difficulty maintaining attention, inadequate sleep is a powerful contributor to irritability and depression. Studies of children and adolescents have found that sleep deprivation can increase impulsive behavior; some researchers report finding that it’s a factor in suicide. Adequate sleep is central to physical and emotional health.

One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responses are fully online, or even more active than in adults, while some parts of the brain involved in keeping emotional, impulsive responses in check are not yet reaching maturity. Such a balance might provide clues to a youthful appetite for novelty and a tendency to act on impulse— without regard for risk. While much is being learned about the teen brain, it is not yet possible to know to what extent a parti- cular behavior or ability is the result of a feature of brain structure— or a change in brain structure. Changes in the brain take place in the context of many other fac- tors, among them, inborn traits, personal history, family, community, and culture.
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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 adolescence. 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. Overall, the changes of the childhood, the volume of gray matter in the cortex increased. A decline in volume is normal at this age and in fact is 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. The process of growth and pruning of 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 what extent the changes in gray matter on brain scans during the teen years affect growth and pruning of synapses.

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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: the chances of death by injury between ages 15 to 19 are about six times that of the rate between ages 10 and 14. Crime rates 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. Genetics, childhood experience, and the environment in which a young person resides 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 theorems that scientist have sarted 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.

One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responses are fully online, or even more active than in adults, while the parts that fill the brain involved in emotional responses, and sometimes reaching maturity. Such a changing balance might provide clues to a youthful appetite for novelty and a tendency to act impulsively with little regard for risk. While much is being learned about the teen brain, it is not yet possible to know to what extent a particular behavior or ability is a result of a feature of the brain structure or a change in brain structure. Changes in the brain take place in the context of many other factors, among them, inborn traits, personal history, family, and culture.
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**A Spectrum of Change**

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

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  hood. 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 increases in connectivity—a little like providing a growing city with a fast, integrated communica-
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- 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 teen brain is in a different place—adolescents (at 16 million volumes) or 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 a child plays a role, but half a lifetime, researchers have many synapses as an adult. (For an idea of the complexity of the brain a cube of matter brain, 1 millimeter on each side, contains about 16 billion volumes of gray matter. What’s Gray Matter?

- In terms of sheer intellectual power, the brain of an adolescent is a match for an adult’s. The capacity of 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. Those action, what needs to happen when something happens, and whether it is safe or dangerous. What you experience is related to the neural structures that your brain constructs. You experience the world through your brain, and your brain constructs the world.

**The Visible Brain**

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One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responsiveness are fully online, or even more active in young people in ways that parallel the shift in the brain involved in keeping emotional, impulsive responses in check and adult reaching maturity. Such a balance might provide clues to a youthful appetite for novelty, and a tendency to act impulsively—without regard for risk. While much is being learned about the teen brain, it is not yet possible to know to what extent a particular behavior or ability is the result of a feature of brain structure—or a change in brain structure. Changing the brain begins at birth in the context of other factors, among them, inborn traits, personal history, family, community, and culture. The Changing Brain and Behavior in Teens

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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 as a process called synaptic pruning occurs. 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 early in childhood.

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. The scans also suggest that different parts of the cortex mature at different rates. Areas involved in more basic processes of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases as a process called synaptic pruning occurs. 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 early in childhood.

The scans also suggest that different parts of the cortex mature at different rates, or a change in brain structure. 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 not known. Gray matter consists of the cell bodies of neurons, the nerve fibers that connect with them, and support cells. One of the features of the brain’s growth in early life is that there is an early pruning of synapses—the connections between brain cells or neurons—followed by pruning as the brain matures. Synapses are the relays which neurons communicate with each other and are the basic bricks in working circuitry of the brain. Already more numerous than an adult at birth, synapses multiply rapidly in the first months of life and then halve by age 2, but they multiply in 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 billions of neurons (an estimated 50 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. All this synaptic play seems to last a lifetime, however, revealed that the high point of the volume of gray matter occurs during early adolescence.

Connections between different parts of the brain increase throughout childhood and well into adult- hood. 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 increases make possible the complex connections of the brain. Already more numerous than an adult at birth, synapses multiply rapidly in the first months of life and then halve by age 2, but they multiply in 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 billions of neurons (an estimated 50 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. All this synaptic play seems to last a lifetime, however, revealed that the high point of the volume of gray matter occurs during early adolescence. The scans also suggest that different parts of the cortex mature at different rates, or a change in brain structure. 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.

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Scientists continue to investigate the development of the brain and the relationship between the changes taking place, behavior, and health. The following questions are among the important ones that are targets of research:

- How do experience and environment interact with genetic preprogramming to shape the maturing brain, and as a result, future abilities and behavior? In other words, to what extent does what a teen does and learns shape his or her brain over the rest of a lifetime?

- In what ways do features unique to the teen brain play a role in the high rates of illicit substance use and alcohol abuse in the late teen to young adult years? Does the adolescent capacity for learning make this a stage of particular vulnerability to addiction?

- Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood?

It’s not surprising that the behavior of adolescents would be a study in change, since the brain itself is changing in such striking ways. Scientists emphasize that the fact that the teen brain is in transition doesn’t mean it is somehow not up to par. It is different from both a child’s and an adult’s in ways that may equip youth to make the transition from dependence to independence. The capacity for learning at this age, an expanding social life, and a taste for exploration and limit testing may all, to some extent, be reflections of age-related biology. Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the developing brain should help clarify the role of the changing brain in youthful drinking, and the relationship between youth drinking and the risk of addiction later in life.

Alcohol and the Teen Brain

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The Adolescent and Adult Brain

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Scientists continue to investigate the development of the brain and the relationship between the changes taking place, behavior, and health. The following questions are among the important ones that are targets of research:

- How do experience and environment interact with genetic preprogramming to shape the maturing brain, and as a result, future abilities and behavior? In other words, to what extent does what a teen does and learns shape his or her brain over the rest of a lifetime?

- In what ways do features unique to the teen brain play a role in the high rates of illicit substance use and alcohol abuse in the late teen to young adult years? Does the adolescent capacity for learning make this a stage of particular vulnerability to addiction?

- Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood?

This last question has been the central reason to study brain development from infancy to adulthood. Scientists increasingly view mental illness as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuitry of the brain develops, scientists hope to identify when and for what reasons development goes off track. Brain imaging studies have revealed distinctive variations in growth patterns of brain tissue in youth who show signs of conditions affecting brain development from infancy to adulthood. Scientists increasingly view mental illnesses as developmental disorders that may equip youth to make the transition from dependency to independence. The capacity for learning at this age, an expanding social life, and a taste for exploration and limit testing may all, to some extent, be reflections of age-related biology.

Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the brain may also serve to help adults understand the importance of creating an environment in which teens can explore and experiment while helping them avoid behavior that is destructive to themselves and others.

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The Adolescent and Adult Brain

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