The Teen Brain: STILL UNDER CONSTRUCTION

NATIONAL INSTITUTE OF MENTAL HEALTH
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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. Causes 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. Genes, childhood experience, and the environment in which a young person resides can 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 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 adolescence. These studies revealed that the volume of gray matter in the brain comes from studies in which scientists did brain scans of children as they grew from early childhood through adolescence. 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.

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 comes from studies in which scientists did brain scans of children as they grew from early childhood through adolescence. 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.

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 The Changing Brain and Behavior in Teens

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 may allow the brain involved in keeping emotional, impulsive responses in check to age more slowly. Maturing brain structures. Aging brain may contribute to teens’ tendency to stay up late at night. Along with the obvious effects of sleep deprivation, 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 aggression. Adequate sleep may be central to physical and emotional health.

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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 the teen years: Although many studies have shown that the "visible" brain—thehallmarks of adult behavior—are among the first to mature, the "top-down" control, controlling impulses, and planning for the future—the hallmarks of adult behavior—are among the last to mature.

What’s Gray Matter?

The details of what is behind the increase in decline in gray matter are not 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 pruning of synapses—the connections between brain cells or neurons—followed by pruning as the brain matures. Synapses are the relay stations through which neurons communicate with each other and are the basic bricks in the working circuitry of the brain. Already more numerous than an adult’s at birth, synapses multiply rapidly in the first years of life. By age 2, a boy and half a boy have many more 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 more than 1 billion neurons 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 general play activity is in the 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 gray matter.

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 increases in connectivity—little like providing a growing city with a fast, integrated communication system—shapes how 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 responsiveness is changing during the teen years. Functional brain imaging studies, for example, suggest that the response to threatening situations differs between young and old. A decline in connectivity—little like providing a growing city with a fast, integrated communication system—shapes how 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. Hormonal systems involving 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, behavior matters. Teens, 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 calculation, motor control, or reaction 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 deprivation, 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 find that it is a factor in the frequency Adequate sleep is central to both physical and emotional health.

The Changing Brain and Behavior in Teens

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 than in adults, while the parts of the brain involved in keeping emotional, impulsive responses in check are still reaching maturity. Such a changing 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. Changes in the brain take place in the context of many other factors, among them, inborn traits, personal history, family, friends, community, and culture.
The research has turned up some surprises, among them the discovery of striking changes taking place during the teen years. These findings have altered longstanding 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, in part because rates of death by injury between 15 and 19 are about six times that of the rate between ages 10 and 14. Crime rates are highest among the very young, and gradually fall as a child grows. The more recent scans, however, revealed that the high point of the volume of gray matter occurs during early adolescence. The brain does not begin to resemble that of an adult until the early 20s. The “Visible” Brain

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—little like providing a growing city with a fast, integrated communication system—shapes how 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 this pattern of responses are consistent with 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. Enormous hormonal changes take place during adolescence. Reproductive hormones shape not only sex-related growth and behavior, but overall social behavior. Hormonal 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 a young person reaches adolescence all shape behavior. Genes, childhood experience, and the environment in which an adolescent lives help determine the brain’s developing state. 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. 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. 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 unexpected late changes in the volume of gray matter, which forms the thin, folding outer layer 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 the brain grows. 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 generally fell as a child grew. The more scans scientists reviewed, 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 scans, 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 enlarge at different rates. Although all parts 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. 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 parts of the brain involved in keeping emotions in check are still reaching maturity. Such a changing 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 feature in brain structure. Changing brain places the brain in the context of other factors, among them, inborn traits, personal history, family, friends, and culture. The Changing Brain and Behavior in Teens

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The Visible Brain

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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.

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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 unexpected 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 at different rates in different areas. In many 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. The times of death by injury between ages 15 and 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.

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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.

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Researchers believe that the loss of synapses as a child grows up is about one-third 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, contains about 86 billion 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. Although many play an active role in the formation of synapses, animal research has shown that experience also shapes the decline. Synapses “win” 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.

What’s Gray Matter?

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

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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 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 illnesses 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 mental health. Ongoing research is providing information on how genetic factors increase or reduce vulnerability to mental illness; and how experiences during infancy, childhood, and adolescence can increase the risk of mental illness or protect against it.

It is 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 illness or protect against it. 

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Alcohol and the Teen Brain

Adults drink more frequently than teens, but when teens drink they tend to drink larger quantities than adults. There is evidence to suggest that the adolescent brain responds to alcohol differently than the adult brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol dependence. 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.
Teens and the Brain: More Questions for Research

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The Adolescent and Adult Brain

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- 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 illnesses as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuity of the brain develops, scientists hope to identify when and for what reasons development goes off track.

- It is 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 behavior that is destructive to themselves and others.

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The Teen Brain: STILL UNDER CONSTRUCTION

The Adolescent and Adult Brain

Alcohol and the Teen Brain

Adults drink more frequently than teens, but when teens drink they tend to drink larger quantities than adults. There is evidence to suggest that the adolescent brain responds to alcohol differently than the adult brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol dependence. 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.
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 environment and experience 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 reason 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 mental health. Ongoing research is providing information on how genetic factors increase or reduce vulnerability to mental illness; and how experiences during infancy, childhood, and adolescence can increase the risk of mental illness or protect against it.

It is 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 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.

Alcohol and the Teen Brain

Alcohol use is a complex issue, and the reasons why teens drink and the role of alcohol in their lives are not well understood. However, we do know that teen drinking is a major public health concern and a risk factor for a variety of health problems. The teen brain is still under construction, and the formation of critical brain structures continues throughout childhood and adolescence. Thus, the teen brain responds differently to alcohol compared to the adult brain. Research has shown that the adolescent brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol dependence. 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.