The Adolescent Behavior Disorders Update

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What Makes My Teenager so Moody and Impulsive? New Insights From Neuroscience

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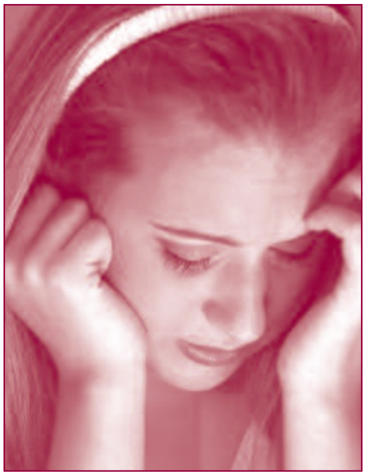
Have you seen the movie, "Little Miss Sunshine?" Remember the teenage boy Dwayne who doesn't speak? He decided to prepare for a career as a jet pilot by exercising every day and by taking a vow of silence. When he learns while on a car trip that he is color-blind, and so will not be able to be a pilot, he goes into a rage and nearly punches out the car window. After the dad stops the car alongside the road, the boy screams as he runs down an embankment. "You are NOT my family! You're all losers! I hate you! Just leave me here!" he yells in his first burst of speech in nine months. While the parents stand speechless alongside the highway, the seven year old sister tentatively climbs down the bank and puts her head on Dwayne's shoulder. Dwayne quietly gets up and takes her hand. They walk up the embankment and he apologizes to everyone. They get in the van and go on their way.

Sound like your teenager? If so, you're not alone. Parents of teenagers can vouch for the fact that many teens are sometimes intensely focused on impractical goals, are prone to sudden angry outbursts, and often blame their troubles on the family. Their moods can just as easily turn on a dime, and they can be loving, apologetic, and affectionate. In the past we chalked it up to "raging hormones," and this is still a popular explanation. However, new research in the field of neuroscience has changed our thinking about the causes of the ups and downs of adolescent behavior. This shift has come about since the 1990's and is due, in large part, to the development of the MRI (magnetic resonance imaging) scanner. In the past the only technique available to examine details in brain growth was the autopsy. With the latest technology we can now look at very slight brain changes in living adolescents and see how these structures change with age and maturity.



Much of these new discoveries come from the laboratory of child psychiatrist and neuroscientist, Dr. Jay Giedd, of the National Institute of Health. Giedd has now mapped the brains of 1,800 children and teenagers, and his work continues to follow them into young adulthood, mapping their brains every few years. Another major project is headed up by John Mazziotta, a pioneer in brain scanning at UCLA and one of the directors of the Santa Fe project. Their discoveries have found that the brain is not fully developed by the age of 12 as we once thought, even though the size of the preadolescent brain is about that of an adult.

The brain is made of billions of cells called neurons which connect with other neurons at intersections called synapses. The long arm of each cell, the axon, transmits information from one cell to the next through a chemical process. Many brain chemicals, called neurotransmitters, are involved in this process of sending signals from one neuron to another across the synapse.

We have known for some time that the brain of a fetus undergoes a rapid growth in the number of neurons from the third through the sixth month of gestation. During the final months before birth, our brains undergo a kind of pruning in which unnecessary brain cells are eliminated. By the time a baby is born, it arrives with 100 billion neurons, each of which has an average of 10,000 branches. The size of a child's brain grows rapidly, and by the age of 6 it is 90% to 95% the size of an adult's brain. In fact, Dr. Marvin Teicher, director of biopsychiatry at McLean Hospital in Boston, suggests that this surge in gray matter between ages 5 and 7 may account in some way for the development of ADHD at this age.

During this period of development, the many connections between the neurons that have been used frequently get strengthened. Those that don't "fire" very much will shrink, wither, and eventually disappear. Genes have a major contribution to what gets strengthened and what gets pruned, but experience plays a big part as well. Thus, there are windows of opportunity for skills to be established, such as using language, riding a bike, or learning to play the piano, and the brain is particularly sensitive to some kinds of trauma at certain times of development also.

What Giedd and others have discovered is that there is a second wave of proliferation and pruning that occurs later in childhood and is not fully completed until late adolescence, even into the early 20's. Between the ages of 6 and 12, the neurons grow bushier as they develop more connections to other neurons. Giedd found particular growth of gray matter in the prefrontal lobes, which we'll discuss in the next section. The thickening of all this gray matter occurs when girls are about 11 and boys are around 12. As pruning occurs, the amount of gray matter diminishes in the average teenage brain by 7 to 10 per cent between ages 12 and 20, with some smaller areas losing 20% of their volume. Teicher also suggests that the development of schizophrenia in adolescence may be due to abnormalities in the pruning process. MRI studies show that teens who become schizophrenic lose 25% of their gray matter.

At the same time as pruning occurs, the white matter of the brain begins to thicken. The white matter is what forms the myelin sheath around the axon. Like insulation around an electrical cord, myelin makes the sending of signals occur faster and more efficiently. The myelin continues to thicken with age like tree rings. Studies show that the myelination process in certain parts of the

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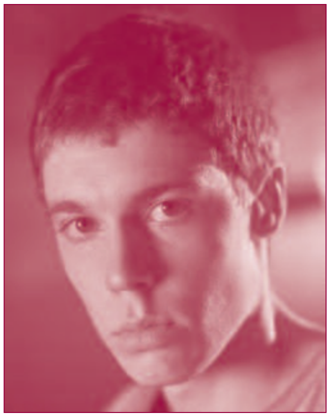
teen brain increases by 100% from the beginning to the end of adolescence.

Another discovery about the teen brain is that this process of blossoming and pruning occurs at different stages in different parts of the brain. The structures that are located in the back of the brain seem to mature the earliest. These are the structures in the occipital and parietal lobes that are associated with controlling sensory functions such as hearing, touch, vision, and spatial processing. Giedd found that the cerebellum, a little known structure at the base of the brain continues to change through adolescence and is perhaps the last to mature. It has been recently found to play a part in recognizing social cues, even getting jokes. Recent studies have suggested that metabolic disorders in the cerebellum may play a role in Asperger's disorder, a mild form of autism.

Why Adolescents Are Impulsive

I have sat with countless parents in my office who ask their befuddled teenager, "Why did you *do* that? What were you *thinking*?" only to hear their teen say, "I don't know. I wasn't thinking anything." They are telling the truth. They typically weren't thinking of the implications of their actions at all. We now know why. One of the last structures to be pruned and fully myelinated is the prefrontal cortex. Called the "executive" center of the brain, the prefrontal cortex is like the conductor of a symphony. It integrates information from the incoming receptors, organizes that information, decides what to pay attention to and what to ignore. It reviews the urge or impulse to engage in a behavior and decides to "act" or "don't' act" on that impulse. It reviews options and determines what plan of action is best. It helps us plan ahead, and set long range goals. It is where the mature ability to delay gratification is located. It tempers emotion with rationality. The prefrontal cortex is what enables your teen to first do her homework, then pick up her room, then instant message her friends about what dress to wear to the prom, in that order. The prefrontal cortex also is an area that seems to be functioning poorly in children and adolescents diagnosed with Attention Deficit Hyperactivity Disorder.



The prefrontal cortex, we now know, is a work in progress. Avis does not lease cars to people under the age of 25, and most likely they have the statistics to back up the claim that good judgment and less frequent car accidents occur around that time of life. Neuroscientists now are discovering that the prefrontal cortex is not fully developed, pruned, and myelinated until around that age. This goes part of the way to explain why teens have such a high rate of car accidents. Their brains have not fully mastered the ability to multi-task: to talk, listen to the radio, and pay attention to weather and road conditions, and changing traffic demands simultaneously. (Interestingly, parts of the frontal cortex appear to be first to deteriorate in diseases such as Alzheimer's).

Adolescents and Thrill Seeking

Mazziotta, the neurologist at UCLA has said, "People don't realize that the brain is really an inhibition machine." By this he means that the lower brain structures, which the first to develop, are largely systems that involve instinctual impulses—to eat, to walk, to explore, to cry, etc. The higher brain functions, and the last to mature, are those that are distinctive to human beings. Those are the functions that largely inhibit the lower centers. These centers tell us to "wait," "think it over," "maybe not," "go slowly, looks dangerous," etc. Not only do they develop later in teens than we thought, but the picture is complicated by surges of dopamine in adolescence. Dopamine is a neurotransmitter that is involved in seeking out new experiences, in exploring, in ramping up the intensity of experiences. Dopamine appears to be involved in our tendency to seek excitement, to seek novelty, to take risks. Dopamine also seems to activate centers of the brain that say, "Wow! Look at this! This is important!"

In the past we attributed much of teenagers' reckless behavior—their pursuit of drugs, alcohol, and excessive driving speed--to peer pressure. While some teens may feel a need to fit in with the group, we are zeroing in more now on dopamine rich centers of the brain. Rapid changes in dopamine receptors in the brain may account for some of their need for stimulation and the addictive effects of drugs and alcohol. Dopamine is particularly abundant and active in the teen years and slowly diminishes to adult levels.

In other words, the increased tendency to seek out new experiences, to go for the "wow," may be taking place long before there is adequate development in the prefrontal cortex to curb these impulses. "Puberty may rev up thrill seeking," according to Ron Dahl, a child psychiatric researcher at the University of Pittsburgh Medical Center, "before there is coordination across symptoms—before the frontal cortex comes on line to say 'whoa.' Then what you have," Dahl says, "is an engine without a driver."

Raging Emotions

Neuroscientists have also made new discoveries about changes in the limbic system of the brain, especially in the amygdala. This small almond shaped structure is the emotional center of the brain, especially the emotions of fear and rage. Information comes into the amygdala and is then sent to the prefrontal cortex to be sorted out and responded to. We know that the sex hormones of estrogen and testosterone undergo a surge at puberty and send messages to the body to develop secondary sex characteristics such as facial hair and breast development. Advances in MRI scanning have found that the sex hormones also send messages to receptors in the hypothalamus which regulates sex drive, ovulation, hunger, and thirst, but also to receptors in the amygdala.

Deborah Yurgelun-Todd, a researcher at McLean Hospital outside Boston, found that teenagers process information about emotions differently from adults. In a series of important experiments, she had teenagers and adults look at a series of photographs of people whose facial expressions conveyed emotions such as anger, sadness, surprise, and fear. She found that adults used their prefrontal cortex to identify emotions, and that they correctly distinguished surprise from fear, for example. Adolescents often mistook fear or surprise for anger. In fact, when processing emotional signals, it was the amygdala that lit up on brain scans in adolescents, not the prefrontal cortex. Yurgelun-Todd theorized that this was because the prefrontal cortex was not fully wired up yet. This may explain why adolescents are so quick to perceive threats and get into fistfights. It may also help to explain why, when you ask your daughter to clean up her room before going out that she comes back with, "You hate me!! You want my life to be miserable!"

Recent studies have also found that estrogen seems to stimulate the dopamine receptors the brain. This is the neurotransmitter associated with novelty and thrill seeking. The hippocampus, a horseshoe shaped structure deep in the brain, which is associated with short and long term memory, is peppered with estrogen receptors and grows faster in girls after puberty than it does in boys. This may have something to do with why teenage girls seem to make better students than boys. Cynthia Bethea of the Oregon Primate Center found estrogen receptors deep in areas of the brain that produce serotonin. Serotonin is another neurotransmitter that is associated with feelings of calm and well being in high levels and feelings of depression when levels are low. Neuroscientists suggest that there may be a link between this discovery and the high rates of depression in teenage girls.

Falling in Love

And what's love got to do with it? Psychologist Arthur Aron at the State University of New York at Stony Brook has found that people fall in love more readily when they're already in a highly aroused state—not necessarily sexually aroused, but aroused by intense states of fear, dread, or laughter. Given that teens seek out new and intense situations that arouse their emotions, and given that their emotions are running on high volume anyway, it is no surprise that they fall in love rapidly and intensely. That need for a thrill, the rush of emotion from a crush, a "love high," and the impulsivity that teens are prone to may cause them to enter into romantic and sexual relationships with poor judgment.

Brain scientists Battels and Zeki at University College, London, have conducted the first studies of what is happening inside the brains of teens in love. They did brain scans of the teens both while they looked at pictures of their boyfriends and girlfriends, as well as photos of social acquaintances. They found that when they looked at the picture of the girl or boy they were madly in love with, four different cortical centers lit up—two in the cortex and two deeper in the brain. The area of the prefrontal cortex—the area of reason, inhibition, and planning—was inactive.

Dr. Helen Fisher, an anthropologist at Rutgers University, who specializes in the brain chemistry of love—found that falling in love elevates dopamine, which explains the feeling of euphoria. It also elevates norepinephrine—which explains the racing heart and sweaty palms—and decreases the serotonin level in the brain. Serotonin is a mood stabilizing brain chemical, so this may explain some of the sadness and obsessiveness typical of falling in love, as well as some of the moody ups and downs. As exhilarating as it all might be, the brain can't sustain these emotional fireworks forever. The average length of infatuation for adolescents is three to four months.

What Parents Might Keep in Mind

If you would like to read a self help book for parents on understanding your teenager's brain and how it works, I would suggest the two in the reference list by Strauch and Walsh. Here are simply a few pointers that are suggested as an outcome of these new discoveries in neuroscience:

• Don't' ask, "Why did you do that?" Why questions imply a conscious thought process and a level of planning and weighing options that simply didn't take place. Ask instead, "Tell me what happened."

• Stay calm. Teenagers do have very volatile emotions and they are highly reactive to the emotions of those around them. Not only that, but they misread your worry and confusion as a threat and an attack. If you get emotional, the situation can get out of control fast. Remember that things she says, she doesn't really mean. Remember, too, that she is depending on you to help her calm down.

• Focus on short-term consequences, since he can't focus on the long-term. Don't say, "If you keep drinking, you'll end up on skid row," say, "If you keep drinking, you'll get a DUI, you'll lose your license for a year, and you can't pick up your girlfriend on a bicycle."

• You must be her prefrontal cortex because hers isn't wired up yet. Help her anticipate problems, obstacles before they happen. Help her weigh out the pros and cons of a troubled relationship, sort through problem solving strategies, and review the consequences of her choices.

• Consider a gap year after high school if he doesn't seem mature or motivated for college. He probably isn't. It may save you a lot of money.

• When you're really discouraged, step back from the situation and take the long view. His brain won't be fully mature until he is 24 or 25. He may be a very different person then than the person he is now. There is hope and consolation in that.

One of my favorite cartoons is ZITS. If you've seen it you are familiar with the large, gangly adolescent boy who lies around slothfully eating all the food in the kitchen. This past Christmas the cartoon featured "More Cheap Gift Cards that Your Parents Will Love." Though I can't reproduce the artwork without permission, I can reprint the text:

"15 Seconds of Eye Contact--not including half-lidded incomprehensible staring."

"1 Actual Conversation--on a complex topic of your choice. Limit 30 seconds."

"One, Sincere Unsolicited Compliment—for anything past, present, or future."

"Five Complete Sentences—not necessarily consecutive."

"A Response to a Question First Time It's Asked—Bonus! Must be in a civil tone."

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Dr. Ellis has been in practice in the Atlanta area since 1977. She works primarily with children, adolescents, and families and has specialized in child and family forensic evaluations since 1986. She is the author of two books:

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as well as numerous papers in the field of child and family forensic work. Her paper "Help for the Alienated Parent" appeared in the *Journal of Family Therapy* in the Fall of 2005 and "Ten Ethical Pitfalls to Avoid When Doing Child and Family Forensic Work" appeared in the May 2006 issue of the *Georgia Psychologist*.

Dr. Ellis' most recent paper, "A Stepwise Approach to Evaluating Children for Parental Alienation Syndrome" is currently under review by the *Journal of Child Custody*.

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Coming Soon...

Bipolar disorder is being diagnosed more often now than in the past. How do we distinguish bipolar disorder from the rebelliousness, the high energy, the moody ups and down of normal adolescence? Is it more common in children with ADHD? Does it run in families? We'll review new research on bipolar disorder in teens in the next issue.

Plus, tips on "How to Love a Teenager."