**It Says/I Say/So**

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| **It Says** | **I Say** (what you think the passage means) | **So** (why the passage matters) |
| “Most kids are not depressed, insecure, anxious…the media stereotypes have mislead us.”  “…the presence of peers increases the risk-taking behavior in teens.”  “If you are going to be functioning as a successful human, you really do have to take risks.”  “Substance abuse is a bad idea during adolescence because it’s messing with the scoring system…introducing substance abuse couldn’t be worse timing.” |  |  |

[**Texting teens learn to talk face to face**](http://schoolsofthought.blogs.cnn.com/2012/04/24/texting-teens-learn-to-talk-face-to-face/)

by **Jim Roope**, CNN

**Los Angeles** **(CNN)** It's an often-observed teenage obsession: texting. Kids today spend an awful lot of time bent over cell phones sending text messages to each other. In fact, you can observe them sitting within normal talking distance from each other yet instead of talking, they'll be texting a conversation.

"I see that the kids are so involved in texting that they shy away from communicating face-to-face," said Lori Kelman, founder of the program 'Enhancing Teen Communication.'

"They bury themselves in text, hide behind texting, will say things through text that they wouldn't in a million years say to somebody face-to-face. That's not a good thing," Kelman said.

Kelman, who spent most of her professional life as a broadcaster for Los Angeles radio station KFWB and in corporate marketing and public relations, said she got the idea for the program when attending her daughter's class one day and as the kids would stand to introduce themselves and talk a little about themselves, many could barely string two words together. On child she said, stood there, hands folded, staring up for five minutes, not able to utter a word. "My heart broke for her," Kelman said.

This lack of fundamental communications skills, she believes, is a result of texting technology. It can hurt teens, she says, as they interview for jobs or college.

"We teach them resume writing, interviewing, public speaking, marketing, broadcast news writing, public relations and media relations," said Kelman. "They're going to have to communicate in the real world and that's part of the reason I developed the program is so that they could."

According to a recent study by the Pew Research Center, teens are twice as likely to communicate with their friends by text every day than calling them on the phone.

Ron Ye saw a flyer about Enhancing Teen Communication and brought his 17-year-old son Zack to check it out.

"You never really get a second chance to make a first impression," Ye said.

Zack Ye took the first eight-week session.

"Learning how to communicate with the world, learning how to get yourself out there and...for instance, applying for a job. She taught us how to do that," said Ye.

California's unemployment rate is still among the highest in the nation at just under 11-percent and in this state, the jobless rate for teens, 16-to-19-years-old, is 34-percent.

Kelman hopes the first 28 teens in her program should have an advantage when going out for job interviews. She has secured a copyright for her program and hopes to make it a business as the number of texting teens is growing.

## Texting may rewire young brains

#### Adriana Barton

##### Vancouver— From Monday's Globe and Mail

##### Published Monday, Aug. 17, 2009 12:00AM EDT

##### Last updated Monday, Mar. 14, 2011 12:12PM EDT

Texting is not only a nuisance for teachers struggling to keep their students' attention - it's a brain-altering habit, according to a new study.

Researchers say text messaging trains young people to be speedy yet sloppy. The culprit, they suggest, is mobile-phone technology that figures out the word a user wants to type after just a few keystrokes, a system called predictive text messaging. It's easy on the thumbs, but notoriously inaccurate. With frequent use, scientists say, texting may rewire a child's developing brain to be more careless.

Young people who are heavy cellphone users make more mistakes in tasks involving memory, attention span and learning, according to Michael Abramson, an epidemiologist who carried out the publicly funded research.

"We suspect it's a learned pattern of behaviour," he says.

In one of the first studies of its kind, Dr. Abramson and colleagues compared the cellphone use of 317 children aged 11 to 14 with their scores in a battery of tests taken on computers.

You have a brain that's open and still changing, and you have a technology that's demanding that you get faster and more automatic. The natural consequence is that it increases your likelihood of making errors. — Laura-Ann Petitto, a cognitive neuroscientist at the University of Toronto

The children who used mobile phones a lot were faster on the tests, but significantly less accurate, says Dr. Abramson, a professor at Monash University in Melbourne, Australia.

Their scores are "evidence of impulsivity," he says.

The study did not include children with ADHD or learning disabilities. A quarter of the children made more than 15 cellphone calls a week and a quarter of them sent more than 20 text messages a week.

Researchers ruled out cellphone radiation as the cause of the brain effects. Dr. Abramson notes that radiation transmitted in texting is just 0.03 per cent of that emitted during a phone call.

Although texting was slow to take off in North America, recently it has overtaken the number of calls made on cellphones. According to a 2008 Nielsen Mobile survey, an American mobile subscriber sends an average of 357 text messages each month - a 450-per-cent increase since 2006.

Children may be especially susceptible to the brain-altering effects of cellphones, according to Laura-Ann Petitto, a cognitive neuroscientist at the University of Toronto.

Their reliance on the gadgets happens at a crucial stage in brain development, she explains.

"You have a brain that's open and still changing, and you have a technology that's demanding that you get faster and more automatic," she says. "The natural consequence is that it increases your likelihood of making errors."

Whether a specific device can affect how the brain functions in unrelated activities remains uncertain, Dr. Petitto says. But, she adds, "it's not a stretch."

Studies have shown that certain technologies, such as video games, can actually enhance various cognitive functions, Dr. Petitto says.

When it comes to texting, however, the jury is still out.

Researchers at England's Coventry University who studied adolescents found a positive link between skilled texting and proper spelling.

Predictive texting goes hand in hand with good language skills, they surmised. If the desired word doesn't appear because of bad spelling, the texter must retype until the cellphone finds the right word, which forces the user to learn proper spelling quickly.

But other studies have blamed predictive texting for creating a generation of lazy spellers who are stumped by everyday words such as "existence" and "occurrence."

Youth are so tolerant of errors in texting that common mistakes - which occur because many words share the same keys - have become part of the lexicon.

In some circles, for instance, the word "jazz" means "lame" because both words are texted starting with 5-2, and "jazz" is the first word many cellphone programs predict.

Texting is troubling because it taps into a domain of the brain that is central to the human species - language, Dr. Petitto says. "While text is visual, it's also parasitic on language."

In the Australian study, however, few of the tests involved literacy or language. In the eyes of some observers, this makes the frequent cellphone users' poor performance even more alarming.

For the brain to develop cognitive skills such as speed or accuracy, it's a case of "use it or lose it," experts say.

When people spend a lot of time on repeated mental activities, such as crossword puzzles or texting, specific neural circuits will grow, according to Gary Small, a neuroscientist and author of iBrain: Surviving the Technological Alteration of the Modern Mind.

"But if you neglect other mental tasks, the neural circuits or wires that control them will weaken," he says.

Luckily, the adolescent brain is highly resilient, according to Dr. Petitto. Dealing with a teen's chronic texting is another matter, though.

"You could reverse the [brain] effects of frequent texting," Dr. Petitto says, "but you have to first get the kid off of the cellphone."

<http://www.theonion.com/video/braindead-teen-only-capable-of-rolling-eyes-and-te,27225/>

<http://www.cbc.ca/natureofthings/episode/surviving-the-teenage-brain.html#>

**National Geographic Piece**

## Beautiful Brains

### Moody. Impulsive. Maddening. Why do teenagers act the way they do? Viewed through the eyes of evolution, their most exasperating traits may be the key to success as adults.

**By David Dobbs**

**Photograph by Kitra Cahana**

**Although you know your teenager takes some chances, it can be a shock to hear about them.**

One fine May morning not long ago my oldest son, 17 at the time, phoned to tell me that he had just spent a couple hours at the state police barracks. Apparently he had been driving "a little fast." What, I asked, was "a little fast"? Turns out this product of my genes and loving care, the boy-man I had swaddled, coddled, cooed at, and then pushed and pulled to the brink of manhood, had been flying down the highway at 113 miles an hour.

"That's more than a little fast," I said.

He agreed. In fact, he sounded somber and contrite. He did not object when I told him he'd have to pay the fines and probably for a lawyer. He did not argue when I pointed out that if anything happens at that speed—a dog in the road, a blown tire, a sneeze—he dies. He was in fact almost irritatingly reasonable. He even proffered that the cop did the right thing in stopping him, for, as he put it, "We can't all go around doing 113."

He did, however, object to one thing. He didn't like it that one of the several citations he received was for reckless driving.

"Well," I huffed, sensing an opportunity to finally yell at him, "what would you call it?"

"It's just not accurate," he said calmly. " 'Reckless' sounds like you're not paying attention. But I was. I made a deliberate point of doing this on an empty stretch of dry interstate, in broad daylight, with good sight lines and no traffic. I mean, I wasn't just gunning the thing. I was driving.

"I guess that's what I want you to know. If it makes you feel any better, I was really focused."

Actually, it did make me feel better. That bothered me, for I didn't understand why. Now I do.

**My son's high-speed** adventure raised the question long asked by people who have pondered the class of humans we call teenagers: What on Earth was he doing? Parents often phrase this question more colorfully. Scientists put it more coolly. They ask, What can explain this behavior? But even that is just another way of wondering, What is wrong with these kids? Why do they act this way? The question passes judgment even as it inquires.

Through the ages, most answers have cited dark forces that uniquely affect the teen. Aristotle concluded more than 2,300 years ago that "the young are heated by Nature as drunken men by wine." A shepherd in William Shakespeare's *The Winter's Tale* wishes "there were no age between ten and three-and-twenty, or that youth would sleep out the rest; for there is nothing in the between but getting wenches with child, wronging the ancientry, stealing, fighting." His lament colors most modern scientific inquiries as well. G. Stanley Hall, who formalized adolescent studies with his 1904 *Adolescence: Its Psychology and Its Relations to Physiology, Anthropology, Sociology, Sex, Crime, Religion and Education,* believed this period of "storm and stress" replicated earlier, less civilized stages of human development. Freud saw adolescence as an expression of torturous psychosexual conflict; Erik Erikson, as the most tumultuous of life's several identity crises. Adolescence: always a problem.

Such thinking carried into the late 20th century, when researchers developed brain-imaging technology that enabled them to see the teen brain in enough detail to track both its physical development and its patterns of activity. These imaging tools offered a new way to ask the same question—What's wrong with these kids?—and revealed an answer that surprised almost everyone. Our brains, it turned out, take much longer to develop than we had thought. This revelation suggested both a simplistic, unflattering explanation for teens' maddening behavior—and a more complex, affirmative explanation as well.

**The first full series** of scans of the developing adolescent brain—a National Institutes of Health (NIH) project that studied over a hundred young people as they grew up during the 1990s—showed that our brains undergo a massive reorganization between our 12th and 25th years. The brain doesn't actually grow very much during this period. It has already reached 90 percent of its full size by the time a person is six, and a thickening skull accounts for most head growth afterward. But as we move through adolescence, the brain undergoes extensive remodeling, resembling a network and wiring upgrade.

For starters, the brain's axons—the long nerve fibers that neurons use to send signals to other neurons—become gradually more insulated with a fatty substance called myelin (the brain's white matter), eventually boosting the axons' transmission speed up to a hundred times. Meanwhile, dendrites, the branchlike extensions that neurons use to receive signals from nearby axons, grow twiggier, and the most heavily used synapses—the little chemical junctures across which axons and dendrites pass notes—grow richer and stronger. At the same time, synapses that see little use begin to wither. This synaptic pruning, as it is called, causes the brain's cortex—the outer layer of gray matter where we do much of our conscious and complicated thinking—to become thinner but more efficient. Taken together, these changes make the entire brain a much faster and more sophisticated organ.

This process of maturation, once thought to be largely finished by elementary school, continues throughout adolescence. Imaging work done since the 1990s shows that these physical changes move in a slow wave from the brain's rear to its front, from areas close to the brain stem that look after older and more behaviorally basic functions, such as vision, movement, and fundamental processing, to the evolutionarily newer and more complicated thinking areas up front. The corpus callosum, which connects the brain's left and right hemispheres and carries traffic essential to many advanced brain functions, steadily thickens. Stronger links also develop between the hippocampus, a sort of memory directory, and frontal areas that set goals and weigh different agendas; as a result, we get better at integrating memory and experience into our decisions. At the same time, the frontal areas develop greater speed and richer connections, allowing us to generate and weigh far more variables and agendas than before.

When this development proceeds normally, we get better at balancing impulse, desire, goals, self-interest, rules, ethics, and even altruism, generating behavior that is more complex and, sometimes at least, more sensible. But at times, and especially at first, the brain does this work clumsily. It's hard to get all those new cogs to mesh.

Beatriz Luna, a University of Pittsburgh professor of psychiatry who uses neuroimaging to study the teen brain, used a simple test that illustrates this learning curve. Luna scanned the brains of children, teens, and twentysomethings while they performed an antisaccade task, a sort of eyes-only video game where you have to stop yourself from looking at a suddenly appearing light. You view a screen on which the red crosshairs at the center occasionally disappear just as a light flickers elsewhere on the screen. Your instructions are to not look at the light and instead to look in the opposite direction. A sensor detects any eye movement. It's a tough assignment, since flickering lights naturally draw our attention. To succeed, you must override both a normal impulse to attend to new information and curiosity about something forbidden. Brain geeks call this response inhibition.

Ten-year-olds stink at it, failing about 45 percent of the time. Teens do much better. In fact, by age 15 they can score as well as adults if they're motivated, resisting temptation about 70 to 80 percent of the time. What Luna found most interesting, however, was not those scores. It was the brain scans she took while people took the test. Compared with adults, teens tended to make less use of brain regions that monitor performance, spot errors, plan, and stay focused—areas the adults seemed to bring online automatically. This let the adults use a variety of brain resources and better resist temptation, while the teens used those areas less often and more readily gave in to the impulse to look at the flickering light—just as they're more likely to look away from the road to read a text message.

If offered an extra reward, however, teens showed they could push those executive regions to work harder, improving their scores. And by age 20, their brains respond to this task much as the adults' do. Luna suspects the improvement comes as richer networks and faster connections make the executive region more effective.

These studies help explain why teens behave with such vexing inconsistency: beguiling at breakfast, disgusting at dinner; masterful on Monday, sleepwalking on Saturday. Along with lacking experience generally, they're still learning to use their brain's new networks. Stress, fatigue, or challenges can cause a misfire. Abigail Baird, a Vassar psychologist who studies teens, calls this neural gawkiness—an equivalent to the physical awkwardness teens sometimes display while mastering their growing bodies.

The slow and uneven developmental arc revealed by these imaging studies offers an alluringly pithy explanation for why teens may do stupid things like drive at 113 miles an hour, aggrieve their ancientry, and get people (or get gotten) with child: They act that way because their brains aren't done! You can see it right there in the scans!

This view, as titles from the explosion of scientific papers and popular articles about the "teen brain" put it, presents adolescents as "works in progress" whose "immature brains" lead some to question whether they are in a state "akin to mental retardation."

The story you're reading right now, however, tells a different scientific tale about the teen brain. Over the past five years or so, even as the work-in-progress story spread into our culture, the discipline of adolescent brain studies learned to do some more-complex thinking of its own. A few researchers began to view recent brain and genetic findings in a brighter, more flattering light, one distinctly colored by evolutionary theory. The resulting account of the adolescent brain—call it the adaptive-adolescent story—casts the teen less as a rough draft than as an exquisitely sensitive, highly adaptable creature wired almost perfectly for the job of moving from the safety of home into the complicated world outside.

This view will likely sit better with teens. More important, it sits better with biology's most fundamental principle, that of natural selection. Selection is hell on dysfunctional traits. If adolescence is essentially a collection of them—angst, idiocy, and haste; impulsiveness, selfishness, and reckless bumbling—then how did those traits survive selection? They couldn't—not if they were the period's most fundamental or consequential features.

**The answer is that those troublesome traits don't really characterize adolescence; they're just what we notice most because they annoy us or put our children in danger. As B. J. Casey, a neuroscientist at Weill Cornell Medical College who has spent nearly a decade applying brain and genetic studies to our understanding of adolescence, puts it, "We're so used to seeing adolescence as a problem. But the more we learn about what really makes this period unique, the more adolescence starts to seem like a highly functional, even adaptive period. It's exactly what you'd need to do the things you have to do then."**

**To see past the distracting, dopey teenager and glimpse the adaptive adolescent within, we should look not at specific, sometimes startling, behaviors, such as skateboarding down stairways or dating fast company, but at the broader traits that underlie those acts.**

**Let's start with the teen's love of the thrill. We all like new and exciting things, but we never value them more highly than we do during adolescence. Here we hit a high in what behavioral scientists call sensation seeking: the hunt for the neural buzz, the jolt of the unusual or unexpected.**

**Seeking sensation isn't necessarily impulsive. You might plan a sensation-seeking experience—a skydive or a fast drive—quite deliberately, as my son did. Impulsivity generally drops throughout life, starting at about age 10, but this love of the thrill peaks at around age 15. And although sensation seeking can lead to dangerous behaviors, it can also generate positive ones: The urge to meet more people, for instance, can create a wider circle of friends, which generally makes us healthier, happier, safer, and more successful.**

**This upside probably explains why an openness to the new, though it can sometimes kill the cat, remains a highlight of adolescent development. A love of novelty leads directly to useful experience. More broadly, the hunt for sensation provides the inspiration needed to "get you out of the house" and into new terrain, as Jay Giedd, a pioneering researcher in teen brain development at NIH, puts it.**

**Also peaking during adolescence (and perhaps aggrieving the ancientry the most) is risk-taking. We court risk more avidly as teens than at any other time. This shows reliably in the lab, where teens take more chances in controlled experiments involving everything from card games to simulated driving. And it shows in real life, where the period from roughly 15 to 25 brings peaks in all sorts of risky ventures and ugly outcomes. This age group dies of accidents of almost every sort (other than work accidents) at high rates. Most long-term drug or alcohol abuse starts during adolescence, and even people who later drink responsibly often drink too much as teens. Especially in cultures where teenage driving is common, this takes a gory toll: In the U.S., one in three teen deaths is from car crashes, many involving alcohol.**

Are these kids just being stupid? That's the conventional explanation: They're not thinking, or by the work-in-progress model, their puny developing brains fail them.

Yet these explanations don't hold up. As Laurence Steinberg, a developmental psychologist specializing in adolescence at Temple University, points out, even 14- to 17-year-olds—the biggest risk takers—use the same basic cognitive strategies that adults do, and they usually reason their way through problems just as well as adults. Contrary to popular belief, they also fully recognize they're mortal. And, like adults, says Steinberg, "teens actually overestimate risk."

So if teens think as well as adults do and recognize risk just as well, why do they take more chances? Here, as elsewhere, the problem lies less in what teens lack compared with adults than in what they have more of. Teens take more risks not because they don't understand the dangers but because they weigh risk versus reward differently: In situations where risk can get them something they want, they value the reward more heavily than adults do.

A video game Steinberg uses draws this out nicely. In the game, you try to drive across town in as little time as possible. Along the way you encounter several traffic lights. As in real life, the traffic lights sometimes turn from green to yellow as you approach them, forcing a quick go-or-stop decision. You save time—and score more points—if you drive through before the light turns red. But if you try to drive through the red and don't beat it, you lose even more time than you would have if you had stopped for it. Thus the game rewards you for taking a certain amount of risk but punishes you for taking too much.

When teens drive the course alone, in what Steinberg calls the emotionally "cool" situation of an empty room, they take risks at about the same rates that adults do. Add stakes that the teen cares about, however, and the situation changes. In this case Steinberg added friends: When he brought a teen's friends into the room to watch, the teen would take twice as many risks, trying to gun it through lights he'd stopped for before. The adults, meanwhile, drove no differently with a friend watching.

To Steinberg, this shows clearly that risk-taking rises not from puny thinking but from a higher regard for reward.

"They didn't take more chances because they suddenly downgraded the risk," says Steinberg. "They did so because they gave more weight to the payoff."

Researchers such as Steinberg and Casey believe this risk-friendly weighing of cost versus reward has been selected for because, over the course of human evolution, the willingness to take risks during this period of life has granted an adaptive edge. Succeeding often requires moving out of the home and into less secure situations. "The more you seek novelty and take risks," says Baird, "the better you do." This responsiveness to reward thus works like the desire for new sensation: It gets you out of the house and into new turf.

As Steinberg's driving game suggests, teens respond strongly to social rewards. Physiology and evolutionary theory alike offer explanations for this tendency. Physiologically, adolescence brings a peak in the brain's sensitivity to dopamine, a neurotransmitter that appears to prime and fire reward circuits and aids in learning patterns and making decisions. This helps explain the teen's quickness of learning and extraordinary receptivity to reward—and his keen, sometimes melodramatic reaction to success as well as defeat.

The teen brain is similarly attuned to oxytocin, another neural hormone, which (among other things) makes social connections in particular more rewarding. The neural networks and dynamics associated with general reward and social interactions overlap heavily. Engage one, and you often engage the other. Engage them during adolescence, and you light a fire.

This helps explain another trait that marks adolescence: Teens prefer the company of those their own age more than ever before or after. At one level, this passion for same-age peers merely expresses in the social realm the teen's general attraction to novelty: Teens offer teens far more novelty than familiar old family does.

**Yet teens gravitate toward peers for another, more powerful reason: to invest in the future rather than the past. We enter a world made by our parents. But we will live most of our lives, and prosper (or not) in a world run and remade by our peers. Knowing, understanding, and building relationships with them bears critically on success. Socially savvy rats or monkeys, for instance, generally get the best nesting areas or territories, the most food and water, more allies, and more sex with better and fitter mates. And no species is more intricately and deeply social than humans are.**

This supremely human characteristic makes peer relations not a sideshow but the main show. Some brain-scan studies, in fact, suggest that our brains react to peer exclusion much as they respond to threats to physical health or food supply. At a neural level, in other words, we perceive social rejection as a threat to existence. Knowing this might make it easier to abide the hysteria of a 13-year-old deceived by a friend or the gloom of a 15-year-old not invited to a party. These people! we lament. They react to social ups and downs as if their fates depended upon them! They're right. They do.

**Excitement, novelty, risk,** the company of peers. These traits may seem to add up to nothing more than doing foolish new stuff with friends. Look deeper, however, and you see that these traits that define adolescence make us more adaptive, both as individuals and as a species. That's doubtless why these traits, broadly defined, seem to show themselves in virtually all human cultures, modern or tribal. They may concentrate and express themselves more starkly in modern Western cultures, in which teens spend so much time with each other. But anthropologists have found that virtually all the world's cultures recognize adolescence as a distinct period in which adolescents prefer novelty, excitement, and peers. This near-universal recognition sinks the notion that it's a cultural construct.

Culture clearly shapes adolescence. It influences its expression and possibly its length. It can magnify its manifestations. Yet culture does not create adolescence. The period's uniqueness rises from genes and developmental processes that have been selected for over thousands of generations because they play an amplified role during this key transitional period: producing a creature optimally primed to leave a safe home and move into unfamiliar territory.

The move outward from home is the most difficult thing that humans do, as well as the most critical—not just for individuals but for a species that has shown an unmatched ability to master challenging new environments. In scientific terms, teenagers can be a pain in the ass. But they are quite possibly the most fully, crucially adaptive human beings around. Without them, humanity might not have so readily spread across the globe.

**This adaptive-adolescence** view, however accurate, can be tricky to come to terms with—the more so for parents dealing with teens in their most trying, contrary, or flat-out scary moments. It's reassuring to recast worrisome aspects as signs of an organism learning how to negotiate its surroundings. But natural selection swings a sharp edge, and the teen's sloppier moments can bring unbearable consequences. We may not run the risk of being killed in ritualistic battles or being eaten by leopards, but drugs, drinking, driving, and crime take a mighty toll. My son lives, and thrives, sans car, at college. Some of his high school friends, however, died during their driving experiments. Our children wield their adaptive plasticity amid small but horrific risks.

We parents, of course, often stumble too, as we try to walk the blurry line between helping and hindering our kids as they adapt to adulthood. The United States spends about a billion dollars a year on programs to counsel adolescents on violence, gangs, suicide, sex, substance abuse, and other potential pitfalls. Few of them work.

Yet we can and do help. We can ward off some of the world's worst hazards and nudge adolescents toward appropriate responses to the rest. Studies show that when parents engage and guide their teens with a light but steady hand, staying connected but allowing independence, their kids generally do much better in life. Adolescents want to learn primarily, but not entirely, from their friends. At some level and at some times (and it's the parent's job to spot when), the teen recognizes that the parent can offer certain kernels of wisdom—knowledge valued not because it comes from parental authority but because it comes from the parent's own struggles to learn how the world turns. The teen rightly perceives that she must understand not just her parents' world but also the one she is entering. Yet if allowed to, she can appreciate that her parents once faced the same problems and may remember a few things worth knowing.

**Meanwhile,** in times of doubt, take inspiration in one last distinction of the teen brain—a final key to both its clumsiness and its remarkable adaptability. This is the prolonged plasticity of those late-developing frontal areas as they slowly mature. As noted earlier, these areas are the last to lay down the fatty myelin insulation—the brain's white matter—that speeds transmission. And at first glance this seems like bad news: If we need these areas for the complex task of entering the world, why aren't they running at full speed when the challenges are most daunting?

The answer is that speed comes at the price of flexibility. While a myelin coating greatly accelerates an axon's bandwidth, it also inhibits the growth of new branches from the axon. According to Douglas Fields, an NIH neuroscientist who has spent years studying myelin, "This makes the period when a brain area lays down myelin a sort of crucial period of learning—the wiring is getting upgraded, but once that's done, it's harder to change."

The window in which experience can best rewire those connections is highly specific to each brain area. Thus the brain's language centers acquire their insulation most heavily in the first 13 years, when a child is learning language. The completed insulation consolidates those gains—but makes further gains, such as second languages, far harder to come by.

So it is with the forebrain's myelination during the late teens and early 20s. This delayed completion—a withholding of readiness—heightens flexibility just as we confront and enter the world that we will face as adults.

This long, slow, back-to-front developmental wave, completed only in the mid-20s, appears to be a uniquely human adaptation. It may be one of our most consequential. It can seem a bit crazy that we humans don't wise up a bit earlier in life. But if we smartened up sooner, we'd end up dumber.

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| **From PBS Frontline Series “Inside the Teenage Brain”**  In making "Inside the Teenage Brain," we seemed to hit a nerve -- a parental one -- when we began looking into the world of teenagers and how they sleep. The patterns that young teens seemed to be experiencing -- an inability to go to sleep at night, followed by profound drowsiness on waking -- seemed so pervasive that it should come as no a surprise that what parents were seeing at home had already been corroborated in university sleep labs at Stanford and Brown.  Reseachers had always believed that sleep was governed by what was called the sleep-wake homeostasis, that is: "All other things being equal, ... the longer one is awake, the greater the pressure for sleep to occur. ... This process accounts for the increased need for sleep after staying awake all night." [[1]](http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/from/sleep.html" \l "fn0) It seemed perfectly reasonable that people would want to sleep when they were very tired. But it didn't account for a number of patterns that were obvious outside the lab: jet travellers woke up at 2 a.m. despite being exhausted after flying from Boston to London, teenagers had trouble falling asleep though they also seemed to be very tired, older people often woke up very early in the morning.  http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/headdot.gif**The Biological Clock**  What researchers discovered is an internal biological clock, a clock that sometimes acts against the sleep-wake cycle by keeping us alert when we should be feeling tired. Sleep researchers [Mary Carskadon](http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/interviews/carskadon.html), now at Brown University, and Bill Dement at Stanford had seen this biological clock in action when they tested a group of 10-12 year olds at Stanford. Dement, who pioneered sleep research at Stanford, wrote about these experiments: "After centuries of assuming the longer we are awake, the sleepier we will become and the more we will tend to fall asleep, we were confronted by the surprising result that after 12 hours of being awake, the subjects were *less* sleepy than they had been earlier in the same day, and at the 10 o'clock test, after more than 14 hours of wakefulness had elapsed ...they were even less sleepy." [[2]](http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/from/sleep.html" \l "fn1)  The researchers found that the biological clock opposed the sleep-wakefulness cycle at certain points of the day and at certain ages. It kept people awake when they were very tired. Just before puberty, that internal clock helped teens stay alert at night when they should have been falling asleep. The researchers called this a "phase-delay." | |  |
|  | http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/blank.gif  The biological clock or circadian rhythms (from the Latin words "circa" and "dies," or "around day") of smaller children don't show the same delays. Nothing is opposing their need to sleep in the evening. Until the age of 10, many children wake up fresh and energetic to start the day. In contrast, the biological clock of pre-teens shifts forward, creating a "forbidden" zone for sleep around 9 or 10 p.m. It is propping them up just as they should be feeling sleepy. Later on, in middle-age, the clock appears to shift back, making it hard for parents to stay awake just when their teens are at their most alert.  Carskadon discovered other important patterns in adolescent sleep. By studying alertness, she determined that teens, far from needing less sleep, actually needed as much or more sleep than they had gotten as children -- nine and a quarter hours. Most teenagers weren't getting nearly enough -- an hour and a half less sleep than they needed to be alert. And the drowsiness wasn't only in the early morning. Teens had a kind of sleep trough in the mid-afternoon and then perked up at night, even though they hadn't had a nap.  Carskadon is now exploring the effect of light in setting adolescent sleep patterns, for darkness seems to trigger the release of melatonin, often called the "sleep" hormone. Measuring melatonin also helps researchers define the different circadian rhythms of children, teens, and adults.  http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/headdot.gif**Sleep Debt**  A great concern of sleep researchers is that teens are so sleep-deprived. Bill Dement speaks about the huge sleep debt that many teens and adults carry around with them every day. With most high schools in the U.S. starting around 7:20 a.m. and with many teens going to bed between 11 and 12 p.m., sleep researchers worry that teenagers are suffering an epidemic that is largely hidden. Since students are often driving to school, to sporting events, and home from late-night parties, this sleep debt holds huge risks. Many high school students know of someone, often a high-achieving kid, who on the drive back from a sporting event or dance simply fell asleep at the wheel. On a less dramatic note, there are literally millions of adolescents who feel despondent, get poor marks, or are too tired to join high-school teams all because they are getting too little sleep. Because of their deep concern about these issues, sleep researchers are pushing for later school start times and are trying to introduce sleep issues into the high school curriculum.  http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/headdot.gif**Sleep, Learning, and Memory**  The other area of sleep research relevant to teenagers, their parents, and teachers is the effect of sleep on learning and memory. In experiments done at Harvard Medical School and Trent University in Canada, students go through a battery of tests and then sleep various lengths of time to determine how sleep affects learning. What these tests show is that the brain consolidates and practices what is learned during the day after the students (or adults, for that matter) go to sleep. Parents always intuitively knew that sleep helped learning, but few knew that learning actually continues to take place while a person is asleep. That means sleep *after* a lesson is learned is as important as getting a good night's rest before a test or exam.  This research is done by giving students a series of tests. The students are trained, for instance, to catch a ball attached by a string to a cone-like cup. As they repeat the skill during the test day, they are able do it faster and more accurately. Let's say they go from catching a ball 50 percent to 70 percent of the time over a period of half an hour. The students who get a good night's sleep improve when they are retested. On a retest three days after they have a good night's sleep, they might catch a ball 85 percent of the time. The other students who got less than six hours sleep either do not improve or actually fall behind.  Some of the tests are more demanding. They are called cognitive procedural tasks and they mimic what a student might learn in physics or math, or in certain sports. They present the student with something new to be learned or require an ability to conceptualize, to form a picture of the task in their minds.  http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/adsc.gif  The brain consolidates learning during two particular phases of sleep. According to Dr. Robert Stickgold of Harvard University Medical School, who conducted a series of tests involving visual tasks, the brain seems to need lots of slow-wave sleep and a good chunk of another kind of sleep, Rapid Eye Movement, or REM. Dr. Stickgold hypothesizes that the reason the brain needs these particular kinds of sleep is that certain brain chemicals plummet during the first part of the night, and information flows out of the hippocampus (the memory region) and into the cortex. He thinks the brain then distributes the new information into appropriate networks and categories. Inside the brain, proteins strengthen the connections between nerve cells consolidating the new skills learned the day before. Then later, during REM, the brain re-enacts the lessons from the previous day and solidifies the newly-made connections through the memory banks.  What these studies show is that learning a new task, whether it is sports or music, will be greatly helped by getting a good night's sleep and that students' ability to remember things, be it a lesson on geometry or the causes of the Second World War, is mediated by sleep.  The proposition that sleep aids the learning process is accepted by many researchers. In a review of the Harvard studies, the late Chris Gilpin described the research as "the most believable data ever collected that a specific memory function is associated with sleep." However, a recent study published in the November 2001 issue of the journal *Science* challenges that conclusion. After conducting a literature review, Jerome M. Siegel of the UCLA Department of Psychiatry and Brain Research and the Center for Sleep Research, judged the evidence of a link between REM sleep and learning to be "weak and contradictory." He pointed to inconsistent results from human and animal studies, and argued that studies of humans who do not experience REM sleep (due to brain injuries or pharmacological reasons) do not show memory problems. Siegel concludes, however, that although he does not believe that the existing literature points to a link between REM sleep and memory consolidation, "just as nutritional status, ambient temperature, level of stress, blood oxygenation, and other variables clearly affect the ability to learn, adequate sleep is vital for optimal performance in learning tasks."  http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/art/headdot.gif**Learning Good Sleep Habits**  Putting good sleep habits into practice is particularly difficult for teenagers. Not only do their own circadian rhythms fight against going to sleep early, but many teens don't have any control over the time they wake up. Teens can do something to try to bring their internal body clock forward. Sleep experts say dimming the lights at night and getting lots of daylight in the morning can help. Having a routine bedtime of 10 p.m., sleeping in a cool environment and turning off music, the Internet, and televisions would help to reset the body clock. And though sleeping in is a good thing, trying to get up after only an extra hour or two is a lot better than "binge-sleeping" on the weekends. If a student is used to getting up at 6:30 a.m., they shouldn't sleep until noon on the weekend. That simply confuses their bodies. And lots of sports helps, too -- better earlier in the day than late.  Sleep research not only points out the importance of sleep to teenagers, but explodes some of the myths around sleep: principally the idea that people need less and less sleep as they grow up. There are many factors in the lives of adolescents that elude their control. Sleep is one area where the lessons are clear and the benefits of following them are quickly apparent. |

**http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/view/**