

# SCIENTIFIC AMERICAN

## BLACK HOLE MYSTERY

The first supermassive  
black holes formed earlier  
than seems possible.

What are scientists missing?

PLUS

### TOXIC ONLINE DISCOURSE

It's changing how we think about truth itself PAGE 44

### DIABETES VACCINE QUEST

Common viruses might be the key PAGE 48

### THE PROBLEM WITH MARINE RESERVES

There's a better way to save the seas PAGE 38

FEBRUARY 2018



U.K. £4.99 \$6.99 U.S.

ScientificAmerican.com

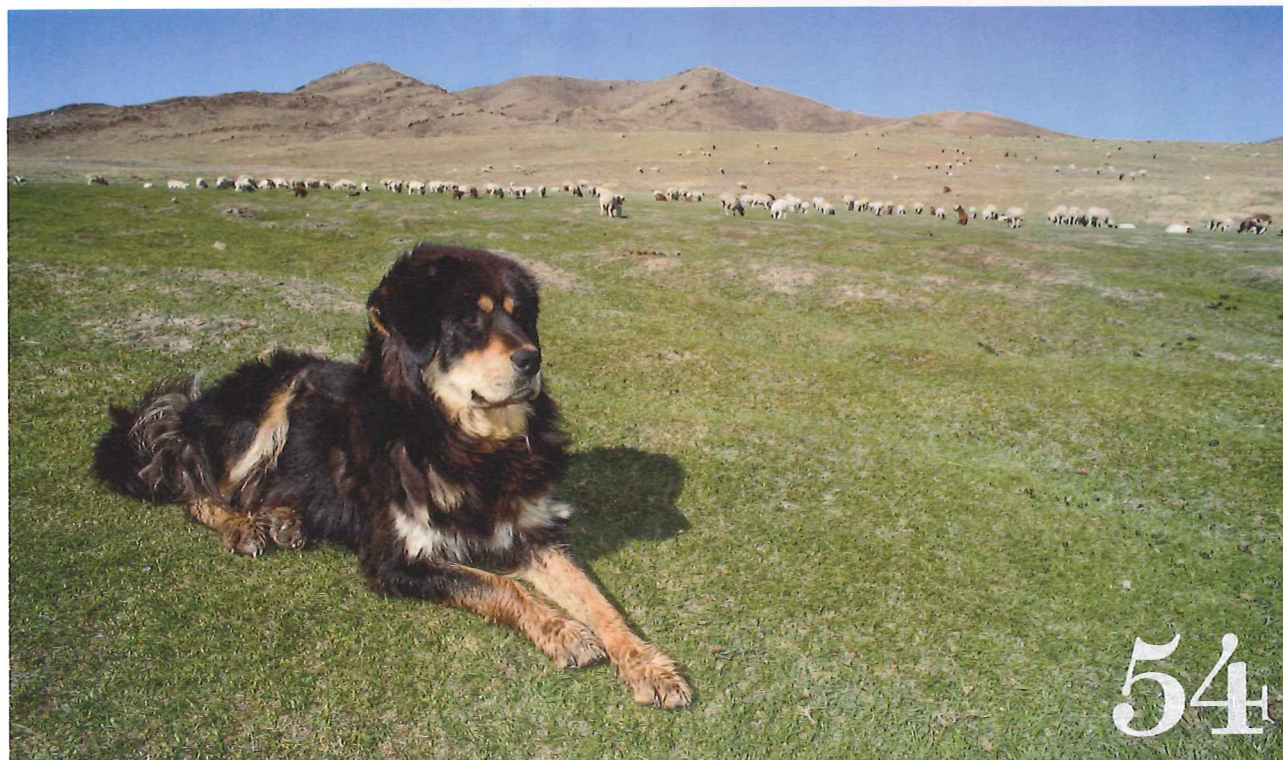


2/1/2018  
17.1.18

FEBRUARY 2018

VOLUME 318, NUMBER 2

# SCIENTIFIC AMERICAN



54

## ASTROPHYSICS

### 18 **The First Monster Black Holes**

Supermassive black holes appeared earlier in cosmic history than seems possible. How did they get there?  
*By Priyamvada Natarajan*

## TECHNOLOGY

### 24 **Are Smartphones Really Destroying the Adolescent Brain?**

Headlines tell us device-hooked teens are mentally and socially doomed. The reality isn't so simple.  
*By Carlin Flora*

## POLICY AND ETHICS

### 32 **[Redacted]**

Is the FDA covering for a pharmaceutical company? *By Charles Seife*

## BIODIVERSITY

### 38 **Troubled Waters**

Marine reserves look good on maps, but tougher rules are needed to save fisheries. *By Olive Heffernan*

## COGNITIVE SCIENCE

### 44 **The Tribalism of Truth**

Toxic online discourse and political polarization may be changing the nature of objectivity itself.  
*By Matthew Fisher, Joshua Knobe, Brent Strickland and Frank C. Keil*

## MEDICINE

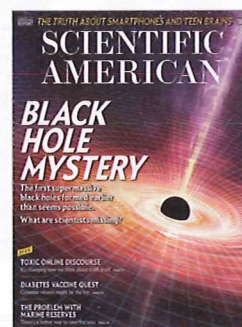
### 48 **Vanquishing Diabetes**

Cleaner environments in the industrial world led to an increase in the incidence of type 1 diabetes. Now this history is pointing the way toward a vaccine for the disease.  
*By Kristen M. Drescher and Steven Tracy*

## CONSERVATION

### 54 **Guardian Dogs of the Mongolian Steppe**

An American entrepreneur wants to turn Mongolian herders into conservationists by reintroducing the bankhar, the region's traditional livestock protection dog.  
*By Jason Overdorf*

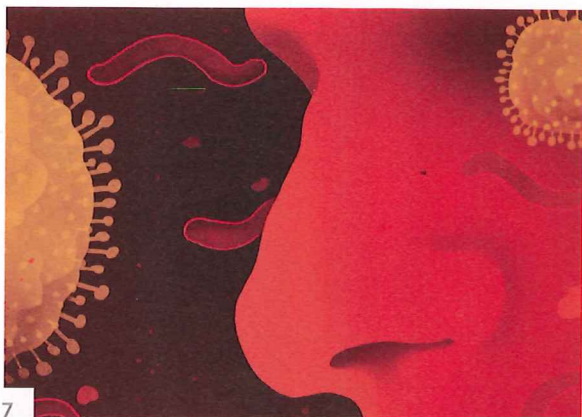


## ON THE COVER

Astronomers see evidence of gargantuan black holes as early as hundreds of millions of years after the big bang, yet no one knows how they could have grown so big so quickly. Scientists hope to test a new theory for how those first supermassive black holes might have formed when the James Webb Space Telescope launches in 2019.  
Illustration by Mark Ross.



# SCIENTIFIC AMERICAN



## 3 From the Editor

## 4 Letters

## 6 Science Agenda

Academia should encourage scientists to talk straight to the public. *By the Editors*

## 7 Forum

We urgently need a universal flu vaccine. *By Catharine I. Paules and Anthony S. Fauci*

## 8 Advances

The nighttime is becoming brighter. Watching diamonds form. How salmon move mountains. Tracing plastic pollution from rivers. Designing a greener airplane.

## 16 The Science of Health

In praise of sham surgeries. *By Claudia Wallis*

## 17 TechnoFiles

Can artificial intelligence create true art? *By David Pogue*

## 60 Recommended

The evolution of beauty. Electromagnetism created the modern world. Mysteries of Greenland. Tactics for telling our human story. *By Andrea Gawrylewski*

## 61 Skeptic

Science and the meaning of life. *By Michael Shermer*

## 62 Anti Gravity

Most people are righty, and most kangaroos are lefty. Bees? They're split. *By Steve Mirsky*

## 63 50, 100 & 150 Years Ago

## 64 Graphic Science

The death march of the penguins. *By Katie Peek*

### ON THE WEB

#### AI Searches for E.T.

Jet Propulsion Laboratory senior research scientist Steve Chien speaks with *Scientific American* about artificial intelligence's role in the Mars 2020 mission and beyond. Go to [www.ScientificAmerican.com/feb2018/ai-et](http://www.ScientificAmerican.com/feb2018/ai-et)

Scientific American (ISSN 0036-8733), Volume 318, Number 2, February 2018, published monthly by Scientific American, a division of Nature America, Inc., 1 New York Plaza, Suite 4500, New York, N.Y. 10004-1562. Periodicals postage paid at New York, N.Y., and at additional mailing offices. Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40012504. Canadian BN No. 127387652RT; TVQ1218059275 TQ0001. Publication Mail Agreement #40012504. Return undeliverable mail to Scientific American, P.O. Box 819, Stn Main, Markham, ON L3P 8A2. Individual Subscription rates: 1 year \$49.99 (USD), Canada \$59.99 (USD), International \$69.99 (USD). Institutional Subscription rates: Schools and Public Libraries: 1 year \$84 (USD), Canada \$89 (USD), International \$96 (USD). Businesses and Colleges/Universities: 1 year \$399 (USD), Canada \$405 (USD), International \$411 (USD). Postmaster: Send address changes to Scientific American, Box 3187, Harlan, Iowa 51537. Reprints available: write Reprint Department, Scientific American, 1 New York Plaza, Suite 4500, New York, N.Y. 10004-1562; fax: 646-563-7138; [reprints@SciAm.com](mailto:reprints@SciAm.com). Subscription inquiries: U.S. and Canada (800) 333-1199; other (515) 248-7684. Send e-mail to [scacustserv@cdsfulfillment.com](mailto:scacustserv@cdsfulfillment.com). Printed in U.S.A. Copyright © 2017 by Scientific American, a division of Nature America, Inc. All rights reserved.



Scientific American is part of Springer Nature, which owns or has commercial relations with thousands of scientific publications (many of them can be found at [www.springernature.com/us](http://www.springernature.com/us)). Scientific American maintains a strict policy of editorial independence in reporting developments in science to our readers. Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

TECHNOLOGY

# are smart- phones really destroying the adolescent brain?

Recent headlines would have us believe that device-hooked teens are mentally and socially doomed. The reality isn't so simple

*By Carlin Flora*

*Illustrations by Aesthetic Apparatus*

| SPECIAL REPORT | Online February 22

More coverage on the science of adolescence from our Nature partners: <https://www.nature.com/collections/adolescence>







Carlin Flora is a freelance writer and author of *Friendfluence: The Surprising Ways Friends Make Us Who We Are* (Doubleday, 2013).



## IS ANY AGE GROUP MORE MALIGNED THAN TEENAGERS?

As they roam in packs, they're feared, avoided or told to calm down. They're gawky, narcissistic, hormone-addled, shallow, angsty and entitled. And on top of all that: Have you heard? Smartphones are destroying their brains. Raised in the glow of digital devices, today's teens are depressed, anxious, antisocial and hopelessly distracted.

Smartphones have become a touchstone of adolescence in large part because they are nearly ubiquitous. As of 2015, 73 percent of teenagers in the U.S. had a smartphone, and, as of 2016, 84 percent of American households contained one, according to a new report from the Pew Research Center. With so many devices at their disposal, a full 92 percent of teens—defined in this report as those ages 13 to 17—report going online daily, including 24 percent who say they do so “almost constantly.” Only 12 percent say they go online just once a day.

The latest headlines about teenagers imply that their beloved smartphones are making them mentally ill and socially isolated. Notably, a study published online in 2017 in *Child Development*, led by Jean Twenge, a professor of psychology at San Diego State University, found that today's teens are less likely to drink, have sex, get pregnant, drive, date and work than previous generations. Writing for a general audience in the *Atlantic*, Twenge spun these ostensibly positive trends as something ultimately negative: a worrying reluctance to grow up. She wove in some stats indicating poorer mental health among teens and pinned the gloomy picture on smartphones. “There is compelling evidence,” she wrote, “that the devices we’ve placed in young people’s hands are having profound effects on their lives—and making them seriously unhappy.”

A month later a *New York Times Magazine* cover story reported on an alarming rise of students with “overwhelming anxiety” on college campuses and named social media as a contributing factor. These stories are just the recent wave. Clinical psychologist Sherry Turkle of the Massachusetts Institute of Technology generated dozens of headlines when she published her 2015 book *Reclaiming Conversation: The Power of Talk in a Digital*

*Age*. She argued that teenagers and adults alike are losing their abilities to understand and pay attention to one another because of the disjointed and solitary nature of electronic communications. These are the abilities, Turkle says, that make us human.

But perhaps unsurprisingly, the generations of adolescents who have come of age in the smartphone era—younger millennials and their successors, Generation Z—aren’t irreparably or even especially ruined. And smartphones aren’t the clean, easy culprit for behavioral changes observed in 21st-century teenagers. “Over the same time period that Twenge refers to, there have also been improvements in mental health,” says Laurence Steinberg, a professor of psychology at Temple University, who studies adolescent development. Two years ago Twenge herself published a study with two colleagues that concluded that today's teens are happier and more satisfied with life than their predecessors.

Parsing these trends is tough because researchers focus on different aspects of mental health using various measurements. But casting “kids today” in a negative light is a time-honored activity. “Every time there’s a new form of entertainment or technology, some adult says, ‘This is killing our kids,’” says Steinberg, who is also author of *Age of Opportunity*, a 2014 book focused on adolescents’ great capacity for change. “They said it about dime-store novels and rock and roll and computers. Young people around the world have survived all these things, and I’m sure they’ll survive smartphones.”

The very quality that makes teens adaptable is, however, what makes them vulnerable. At the onset of puberty, adolescent brains show heightened plasticity—an increased likelihood to rewire. Driven to seek out novelty and risks, teenagers have flexible neural circuits that help them adjust to environments as they make

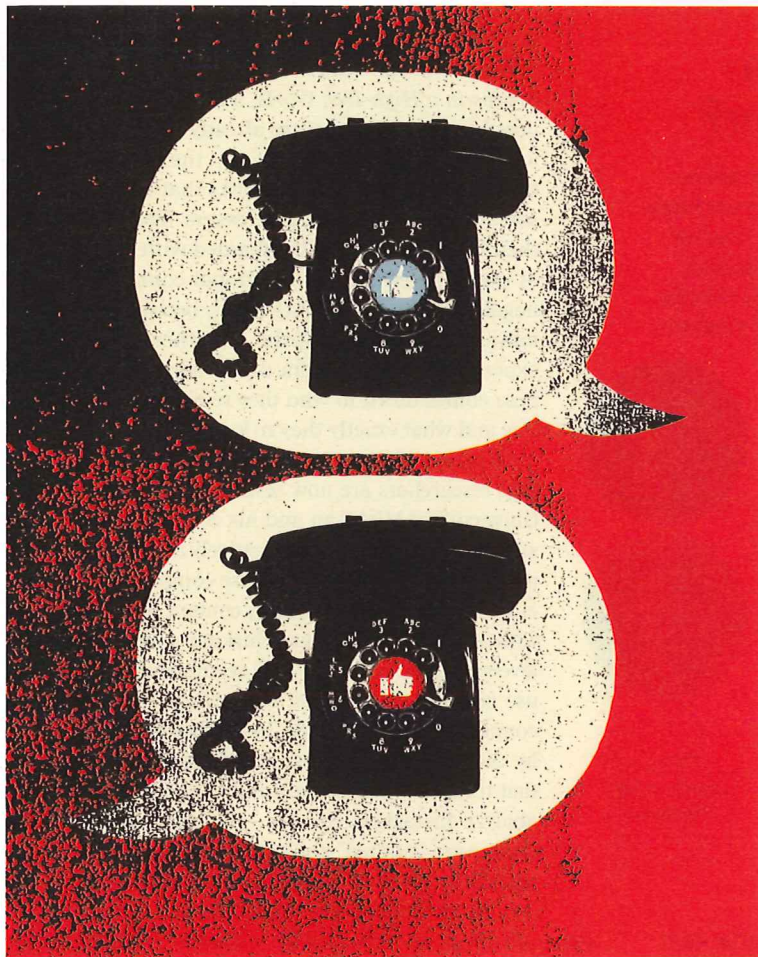
### IN BRIEF

Recent reports have suggested that smartphone usage is making adolescents more depressed, more anxious and antisocial. But these findings are correlational, and there is still a lot sci-

entists do not know about how these devices affect the development of brains and behaviors. Social media is often pegged as a culprit of teenager mental health issues.

But some of the troubling effects of smartphone use may involve less sleep, for instance, and not apps themselves. It is easy to blame new technology for the problems teens face. But issues

such as trauma and poverty are more profound. Postrecession economic instability, for example, most likely has more to do with the rise in anxiety than smartphone use.



## Whether it's a pebble thrown against a window or the ring of a rotary phone, any sign of impending social interaction has long excited teen brains.

decisions and learn. As they enter adulthood, the window where connections between brain structures are forged starts to close, hardening their behaviors. "Any experience that people have during the time when the brain is malleable has the potential to affect it," Steinberg says. Kids' brains are affected by all kinds of factors, including parents, friends and school. "Smartphones are not going to have some special significance. That said, the things people spend more time doing have a greater effect on their brains."

Scientists are only just beginning to figure out how smartphone use might affect adolescent development, both behaviorally and neurologically. What is clear is that the extent to which these digital devices are affecting teenage minds is dependent on *how* kids use smartphones, what they are *not* doing because of smartphone use, and the social context in which they use smartphones both at home and beyond.

### WHAT WE KNOW AND WHAT WE DON'T

IN 2015 LAUREN SHERMAN, now a postdoctoral fellow at Temple, witnessed firsthand the misplaced panic around smartphones and teens. Knowing that teens are reward-happy—they show greater activation in the reward regions of their brains than either children or adults—she wanted to explore neural responses to social media "likes." Sherman invited a group of high school students into the laboratory to look at a version of Instagram while inside an MRI scanner. She had manipulated a set of her own posts so that some subjects would see them with a high number of "likes," whereas others would see them with just a few "likes." Subjects submitted their own pictures for the study as well.

The subjects were more likely to "like" pictures if they believed the images were already popular. They also showed more activation in regions involved in social cognition and visual attention, as though they were thinking more about the highly liked pictures and scrutinizing them. When the subjects' own photos received a lot of "likes," they showed a response in the ventral striatum, a brain region involved in reward. "That might explain why teens are particularly avid users of social media and why they find it so motivating," Sherman says.

When the study was released in *Psychological Science*, hyperbole set in. "Because it involves the same brain circuitry, the press was saying that 'likes' are just like crack cocaine," Sherman says. "They aren't! Not even a little bit." A New Jersey television station went so far as to declare that "likes" are better than drugs *and* sex.

Sherman herself enthusiastically pored over printed-out transcripts of AOL Instant Messenger chats as a teenager. She thinks the "do-do-loo" jingle that signaled a new chat message back then is not so different from a modern teen's "likes." "Neither of these cues is inherently rewarding, like sugar is, but we learn that they represent a social reward," she says.

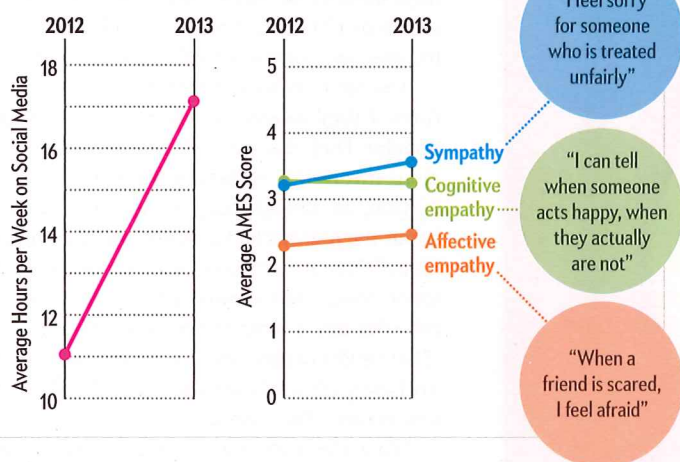
Whether it's a pebble thrown against a window at night or a long-awaited ring of the rotary phone, we can safely assume that any sign of an impending social interaction has long excited teen brains.

Unlike a rotary phone or a desktop equipped with AIM, though, smartphones are practically appendages, a fact that fuels anxiety about what they're doing to teenagers. "We don't have much clear evidence about how smartphone use is affecting brain development," says Nicholas Allen, director of the Center for Digital Mental Health at the University of Oregon. "Anyone who tells you otherwise is speculating," Steinberg agrees: "There is a growing literature, but it's still quite correlational." Even those correlational results are a mixed bag of positive and negative findings, with some studies pointing to the risks of cyberbullying and others highlighting helpful online resources for teens struggling with personal issues.



# Does Social Media Make Teens ... Nicer?

It has been said that social media brings out the worst in teens—and even impairs their social functioning. Dutch researchers Helen G. M. Vossen and Patti M. Valkenburg tested this idea. They surveyed 942 people ages 10 to 14 and gave them a test called the Adolescent Measure of Empathy and Sympathy (AMES), then did the same evaluation a year later. They found that social media use increased over the year, along with the teens' ability to understand and share their peers' feelings.



Long-term research that could show causality would be hard to execute. "You can't randomly assign kids to have a phone or not," Steinberg says. Studying teenagers requires obtaining their parents' permission—an extra logistical challenge. That means that expert predictions are often extrapolations of research on college students. "Sometimes we have good reason to think that the findings from research on young adults may generalize to younger teens, but we have no way of knowing for sure." Complicating matters is the finding that some brain structures, such as the prefrontal cortex, don't fully develop until the mid-20s.

Another research design challenge hinges on what exactly a "smartphone" is. It's a telephone, a camera, a game console and an encyclopedia. Even zeroing in on specific apps teens favor, such as Snapchat and YouTube, is insufficiently broad. "When you're asking how kids are being affected by social media," Steinberg says, "it's like asking about the effect of TV without distinguishing between *Jersey Shore* and *Masterpiece Theatre*."

Of the emerging narratives surrounding Gen Z youth, one of the most pervasive is that they are more depressed and anxious and that smartphone use is to blame. The reality is that "there is a small yet persistent cross-sectional relation between the amount of time spent online and depression and anxiety," Allen says, "but we can't assume it's causal." ("Time spent online" is defined differently, too, with some studies focusing on games or social media alone.) One plausible hypothesis, Steinberg says, is that the causal relation runs in the opposite direction. "It isn't hard to imagine a depressed teenager would rather spend time in her bedroom, online, than go to a social gathering with people from school."

Larry D. Rosen, a professor emeritus of psychology at California State University, Dominguez Hills, and co-author of the 2016 *The Distracted Mind: Ancient Brains in a High-Tech World*, suspects that while it is possible that kids who are already depressed or anxious use smartphones differently, the influence probably goes both ways. Rosen thinks that social comparison (where social media browsers feel awful about their lives after getting bombarded with rosy versions of everyone else's) and emotional contagion (where negative online outbursts affect browsers' states of mind) are possible culprits. Whether or not a teen experiences a self-esteem dip or secondhand moodiness comes down to who they're associating with online and what exactly they're looking at.

It is that precise aspect of *how* social media is used that researchers are now testing. Oscar Ybarra of the University of Michigan and his colleagues found that subjective well-being was negatively affected by passive use of social media sites because comparisons sparked envy. But active use—posting content and interacting with others rather than just "lurking"—predicted higher levels of subjective well-being, seemingly because active use creates social capital and makes users feel more connected to other people. In another example, a study by the Harvard Graduate School of Education found that teens who were successfully prompted to critically analyze Instagram streams—acknowledging that the images are "curated" and not representative of reality—had fewer bad feelings, particularly if they previously compared themselves negatively with those in their feed.

Although teens' moods may be generally resilient to the vicissitudes of social media, other areas of cognitive development are a growing concern. Temple psychologists Harry Wilmer and Jason Chein found a correlation between heavier smartphone use and less of an ability to delay gratification, for example, taking a smaller sum of money in the moment rather than waiting for a larger amount. Researchers do not yet know if impulsive people are more into phones, though, or if phones are making everyone less capable of resisting urges.

For Rosen, a big concern is not just how teens are using their phones but rather the "technological anxiety" and nomophobia (the feeling someone gets in the absence of their phone), that distract them from other tasks. Research has shown that multitasking leads to worse performance on any of the tasks in play. Using an app, Rosen monitored how many times his students unlocked their phone each day. "It was 50 times, on average," he says, "and they stayed on the phone for about five and a quarter minutes each time." Most of the near-constant checking in had to do with communication because their top apps were Facebook, Instagram, Snapchat and YouTube. "We know that half of the time people check in, it's because they get an alert or notification." Adults seem to be affected, too: a British study showed that just the presence of a phone on a table between two people chatting about a meaningful topic had a negative effect on closeness and conversation quality. The call of the phone is cognitively loud, even when it's turned off.

Temporary distraction is one thing; potential long-term brain damage from stress is more unsettling. "What I'm con-

SOURCE: "DO SOCIAL MEDIA FOSTER OR CURTAIL ADOLESCENTS' EMPATHY? A LONGITUDINAL STUDY," BY HELEN G. M. VOSSEN AND PATTI M. VALKENBURG, IN *COMPUTERS IN HUMAN BEHAVIOR*, VOL. 63, OCTOBER 2016





**“Asking how kids are affected by social media is like asking about the effect of TV without distinguishing between *Jersey Shore* and *Masterpiece Theatre*.”**

—PSYCHOLOGIST LAURENCE STEINBERG

vinced is happening,” Rosen says, “is that after someone checks in [then stops looking at the phone], cortisol leaks into the system out of the adrenal glands. A little bit of cortisol is fine, but a lot of cortisol is not. As the cortisol builds up, people get anxious. The only way to quell that feeling is to check the phone again.”

Rosen wonders if the steady stream of cortisol will affect the development of the prefrontal cortex—the part of the brain responsible for, among other things, impulse control and decision making. It is the last part of the body to get fatty cells wrapped around its neurons, a process called myelination. “My guess is that young people are using their prefrontal cortex differently and perhaps less efficiently.” He is looking at the prefrontal cortices of “heavy” and “light” tech users with functional

near-infrared spectroscopy and has found that, at least while performing one executive functioning task, light versus heavy smartphone users use their prefrontal cortices differently.

#### DIGITAL LIVES, IRL TRADE-OFFS

SMARTPHONE-WIELDING TEENS have been portrayed as reclusive, lacking in empathy, and even incapable of having “real” relationships with friends or romantic partners. The fear is that smartphone use discourages—or replaces—healthy behaviors, including face-to-face interactions (IRL—“in real life”—as the kids say).

Researchers who study teenagers are not so worried. “There’s no evidence that using social media impairs the development of social skills,” Steinberg says. “The main people kids interact with over social media are the same people they interact with face-to-face.” The irony, according to Allen, is that the opportunity to explore relationships of all kinds, without being under the direct watch of their parents, is what draws many teenagers to their phones in the first place. Connecting via smartphones may even improve empathy.

In 2016 a Dutch study surveyed 942 adolescents and then again a year later. Social media use appeared to improve their ability to understand—and to share the feelings of—their peers during that time frame. Whereas another of Sherman’s studies on how social media affects intimacy did show that in-person chats between two female teenagers yielded the highest level of connectedness, it wasn’t much higher than when they chatted over video. As communication platforms become increasingly audiovisual, Sherman thinks those shifts could bring us all closer together.

But what about incessant texting? Jay Giedd, director of child and adolescent psychiatry at the University of California, San Diego, says teenagers tend to get better

at reading facial expressions in their 20s anyway. As for how they are interacting, “you shouldn’t confuse ‘different,’ with ‘defective,’” he says. “Some say their texting style is wrong, but they’re communicating ideas, even if their prose and grammar are not what we’d like them to be.” Instead of looking for deficits, Giedd asks about the trade-offs: “What are their brains better at instead? Sorting through texts? Keeping track of more friends?”

Even the assumption that face-to-face interactions are more satisfying and profound is not always true. Sherman asked her subjects whether there are certain topics they feel more comfortable talking about via digital communications such as texting. They said that if they wanted to say something really emotional and felt like they might cry, they preferred texting. Particularly



because they are often interacting online with real-life friends, a different and maybe even deeper mode of bonding can take place as teens trade disclosures that are difficult to say out loud.

Less benign than texting is the unprecedented access to porn smartphones provide, which might affect how many teens, especially those with other risk factors, develop romantic relationships in real life. "Though there's no clear evidence, unrestricted exposure to porn could influence their understanding of sexuality and relationships, especially if it's their earliest exposure to sex," Allen says. A 2016 study found that about three quarters of teenagers (gender or background made no difference) reported a sexual problem such as low desire or inability to achieve orgasm, with clinically significant levels of distress associated with it. The study's author, Lucia O'Sullivan, a professor of psychology at the University of New Brunswick in Canada, says that most young people actually tend to habituate to porn. She thinks that general mental health issues and a focus on pregnancy and infection in sex education—rather than a broader exploration of communication and the "how to" of sexual interactions—are more to blame for her finding.

As teens navigate the complex world of sexuality and relationships of all kinds, they are also "finding themselves." Forming an identity is a big job for teens, and some wonder if smartphone immersion might hinder opportunities for them to come into their own. "Social media is a place where teens are expressing themselves and thinking about how they're presenting themselves to others," Sherman says. "One of the early hypotheses was that teens would go online and explore brand new identities, to become somebody else. That largely doesn't seem to be the case." That doesn't mean they aren't testing slightly different versions of a core identity, though.

Teens are skilled at evading detection and savvy to the cultivation of both public and private selves. "Teens sometimes have their public profile and then a 'Finsta,' or fake Instagram account, where they paradoxically show their real selves," sharing silly faces or unedited streams of thoughts, Sherman says. The trend has likely influenced the functionality of Instagram. "Now it's possible to link two accounts, which was probably a direct response to users creating secondary accounts," she adds. "Adolescents bend these online environments to fit their own purposes. We spend a lot of time talking about the effects of social media on teens, but teens are interacting with these tools—and changing them. It's a bidirectional relationship."

Theo Klimstra, an associate professor of developmental psychology at Tilburg University in the Netherlands, sees smartphones as a double-edged sword for identity formation. "One thing that teens typically do is look for people who are like them, to find a mirror," he says. If you grow up in an area where there are very few people like you, then social media makes it possible

## The Key to a \$300-Million Study of Teen Brains? Smartphones

What if the oft-maligned smartphone could protect teenagers' mental health and help researchers learn about other aspects of adolescent development?

At least 50 percent of mental illnesses start by age 14, and 75 percent start by age 24, a fact that Jay Giedd, director of child and adolescent psychiatry at the University of California, San Diego, has spent his career trying to unpack. The reason symptoms emerge at that time has to do with the plasticity of teen brains and the dynamic changes occurring during this period, which is also why they respond well to treatment. That is, when they get help: "The average time between when someone gets depression and when they get treatment is 10 years," Giedd says. "It's the shame of our profession. One in seven kids is depressed," and very few are getting treatment.

The symptoms of mental illness are often things such as moodiness, which all teens experience. "How do you know if a teen is just being a teen? I've been a psychiatrist for almost 30 years, and it's hard to tell," Giedd says. "The key to diagnosis is change. But the baseline might be all over the place—some people are outgoing; others are shy. If we have someone come in only once every six months, and we ask them, 'How happy have you been?' you're lucky if you get how happy they were that morning."

Enter smartphones: by tracking a teen's online activity, researchers can detect changes because there is a reliable baseline. As such, Giedd is optimistic that mobile technologies could one day help teens more than medications.

Now a landmark project is testing such applications to see the effects of smartphones—alongside other factors—on teen brains over time. The ABCD (Adolescent Brain Cognitive Development) study has received funding of \$300 million, "which is more than the entire history of adolescent research around the world up to this point," Giedd says.

The study is headquartered in San Diego but will unfold at 21 sites around the country. The team has so far recruited about 7,000 nine- and 10-year-olds (the target is 11,500) who will be followed for at least the next 10 years. Their brains will be scanned every two years, and they will be tracked by smartphones and other apps every three to six months. The first round of data was released in December 2017, and all data will be freely available for other researchers to use.

Giedd predicts that the brain scans will show subtle but real changes over time, not in the size of brains but in the ways they are connected. "The amount of data coming into our world has vastly increased, and I think that will show up in parts of the brain that deal with prioritizing and scanning. It's possible it will be to the point where you can say, 'Here's a digital-age brain, and here's a non-digital-age brain.' But even with autism and schizophrenia, we can't really do that." —C.F.

to find a kindred spirit. Many researchers point to the example of gay teens who do not feel they can come out in their own towns but can find positive role models and communities online. The potential downsides, Klimstra says, are the tyranny of choice and the possibility of soul-crushing feedback. The Internet could paralyze teens with its overwhelming array of possible selves and damage their self-esteem with extreme reactions on social media.

Even if smartphones are not making teens antisocial or (more) confused about who they are, they do seem to be stealing one adolescent essential: sleep. Overall, teens are sleeping less than in the past. A summary of data on 690,747 children from 20 countries, dating from 1905 to 2008, found that they sleep more than an hour less than young people did 100 years ago.



Sakari Lemola, an assistant professor of psychology at the University of Warwick in England, recently found that teenagers with smartphones fall asleep later at night. "This is probably because they're engaging with social media, communicating with friends and watching YouTube," Lemola says. "We also found that electronic media use around bedtime was related to decreased sleep duration and increased symptoms of insomnia. Short sleep and poor sleep quality were in turn related to depressive symptoms."

There are several possible connections, Lemola says. Modern flat screens emit a larger amount of blue light, which suppresses melatonin, a hormone produced by the pineal gland at night or in the dark that regulates our internal clocks. Getting messages or comments from friends on social media is arousing for teens and makes it more difficult for them to fall asleep. And it's hard to shut off the phone when endless entertainment beckons.

Lemola points to another recent study showing that, in young adults, poor sleep is a contributing causal factor for serious mental health problems such as psychotic symptoms. "On the one hand, I'm confident there is a majority of teenagers who are able to adjust well to the new opportunities offered by social media," he notes. "On the other hand, there is a minority of more vulnerable teenagers who are at higher risk for poor mental health compared with generations before them. It is likely that increases in electronic media use and decreases in sleep quality and sleep duration have played a core role in mental health, although other changes in the lives of teenagers, from urbanization to stress at school, can also play a role."

When Steinberg is flagged down by a concerned, stressed-out parent, he asks, "What is your child *not* doing because she's spending time on her phone?" If she's not sleeping, exercising, studying, and stimulating her mind with novel and challenging activities, then that's not healthy." Beliefs about what constitutes "novel and challenging" might also be shifting, though. "Before if someone asked me what's better for a teen: a violin or the video game *Assassin's Creed*, I'd think it was a joke question," Giedd says. "But I've come to see that *Assassin's Creed* requires strategy, memory, pattern recognition and reflex skills. And watching well-produced videos is probably a better way to learn than reading. Those words are hard for me to say, but in terms of how the brain absorbs information, it might be true."

## ADULTS THESE DAYS

WHEN IT COMES TO THE THREATS that teenagers face, shiny new technologies are a more interesting focal point than familiar and entrenched ones. That bias can skew our sense of proportion: along with poor sleep, Allen says, family conflict is a key source of mental health problems for teens. "Conflict and stress affect the brain, as does a lack of warmth and support. Why worry about the effect of phones when we have so much evidence for these other factors?" Steinberg agrees, saying the issues we should be focused on are trauma, poverty, exposure to violence and hard drug use because they have a huge influence on teenage development.

Smartphone anxiety could simply be a cover for the difficult parts of watching a child change and grow up. "We see that our kids are not as interested in spending time with us or are engaging in some kind of deviant behavior—all those things we associate with adolescence generally," Sherman says. But instead of ac-

cepting the changes as normal, "we say, 'Okay, what's different? Oh! It's this new technology.'" After all, Gen X-ers and Millennials spent their teen years glued to the television or immersed in primitive iterations of electronic communications.

It is also helpful to take the anthropological view, Klimstra says. Today's teenagers are "growing up in a very different world. From our perspective, selfies and social media might look narcissistic, but it's all context-related." And theirs is a context infused with economic insecurity. "Unemployment is high in many parts of the world. It makes it really hard to start a life as young person, to get away from your parents, and to become financially and psychologically independent," Klimstra adds. "That's more of a threat than smartphone use."

Researchers do see opportunities to temper the negative effects of smartphone use. Rosen urges teens to "not be a Pavlov's dog and turn off the notifications." He also advises parents to model good behavior by not yanking out their own phones so much. It is a big unanswered question: How are smartphone-obsessed parents affecting teenage brain development if they themselves are less engaged and present with their kids?

"In the U.S., parents give young people a phone at 12 and say, 'Good luck with fake news, bullying and porn.'" Allen says. "We expect teens to grow up immediately and deal with the adult world. We should scaffold those experiences and shape them successively over time, allowing teenagers to be more and more independent. It's clearly an area where education and public policy come into play." Giedd agrees: "The most sought-after therapist in the world isn't Dr. Phil, it's Siri. She fields more mental health questions than anyone. That's not Apple's responsibility. How can we do better if this is where teens are going to turn?"

Because researchers agree that having a close and caring relationship with parents is one of the most important contributors to an adolescent's positive mental health, the best thing parents can do is bond with their teens around tech use. "Ask what they find compelling about their phones," Allen says. "Ask them what their fears and their interests are. That kind of discussion is much more productive than saying, 'Put the phone down at the table.'"

A little faith in scrappy teen spirit can also offset smartphone panic. "The reason we're here and Neandertals aren't is because we have teenagers," Giedd says. "Neandertals didn't really have teenagers; at 12 they had their own children. Neandertal tool use didn't change at all for about 200,000 years. Their brains were bigger than ours, but what they couldn't do is adapt when the climate started changing. By its very design, the teen brain adapts to its environment. Today's teenagers might not memorize how high mountains are and how long rivers are, but they will be able to find the signal in the noise." ■

---

## MORE TO EXPLORE

**Adolescents' Electronic Media Use at Night, Sleep Disturbance, and Depressive Symptoms in the Smartphone Age.** Sakari Lemola et al. in *Journal of Youth and Adolescence*, Vol. 44, No. 2, pages 405–418; February 2015.

**The Teenage Brain: A Neuroscientist's Survival Guide to Raising Adolescents and Young Adults.** Frances E. Jensen, with Amy Ellis Nutt. Harper, 2015.

## FROM OUR ARCHIVES

**Generation Z: Online and at Risk?** Nicholas Kardaras; *Scientific American Mind*, September/October 2016.

[scientificamerican.com/magazine/sa](http://scientificamerican.com/magazine/sa)