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# The Brain, Decoded

A cryptography-inspired strategy translates neural signals into movement

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# FROM THE EDITOR

## Extreme Brain Teaser

In 2005 neuroscientist Rodrigo Quian Quiroga published a paper identifying single neurons that would light up in an individual's brain every time that person saw a particular celebrity—Jennifer Aniston and Michael Jordan were two examples. As amusing and remarkable as this finding seemed, even more than a decade later, researchers are still no closer to understanding how neurons firing in certain brain areas leads to recognition of faces or, most important, how the brain controls specific behaviors in the human body.

Looking for new ways to study this mystifying organ, researchers are now turning to computer science algorithms to help them gather data on the brain. Their discoveries could mean big strides in creating brain-controlled prosthetic devices. Helen Shen covers these exciting new findings in this issue's cover story, "[Cracking the Brain's Enigma Code.](#)"

There are other surprising findings this month. In "[The Importance of Fostering Emotional Diversity in Boys,](#)" June Gruber and Jessica L. Borelli reveal new research that suggests that boys may be more emotional than girls but are culturally trained away from displaying those emotions. As David Z. Hambrick and Madeline Marquardt write in "[Bad News for the Highly Intelligent,](#)" people with higher IQs tend to be more successful and longer-lived but also grapple with more mental health disorders. And Angus Chen examines the nuanced psychological impacts of our smartphone culture ("[Social Networking: Is Generation Smartphone Really More Prone to Unhappiness?](#)"). As always, enjoy!

**Andrea Gawrylewski**  
Collections Editor



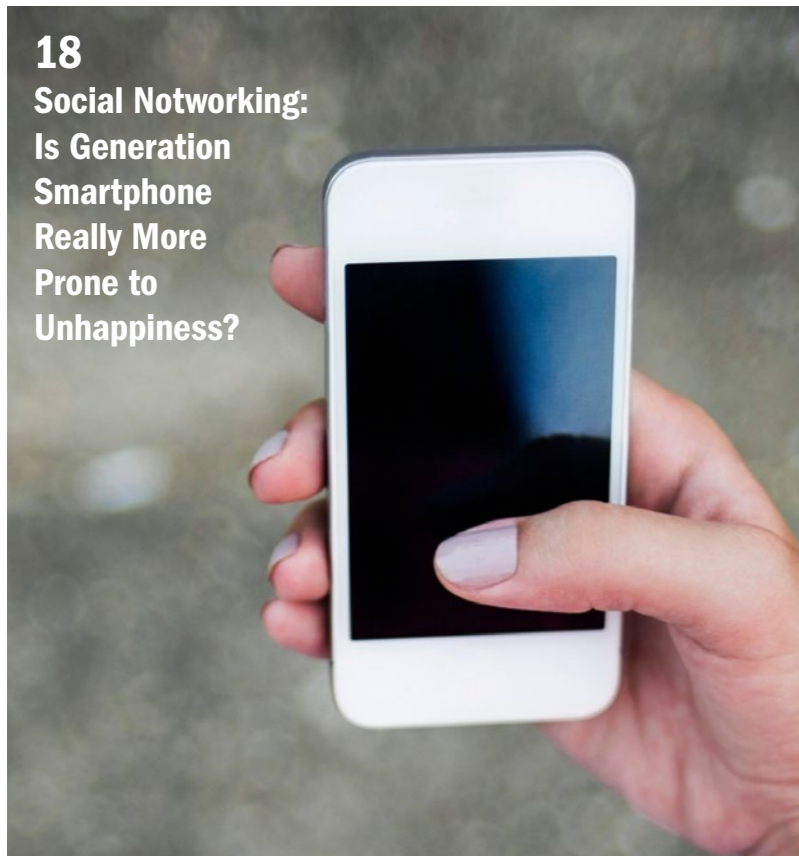
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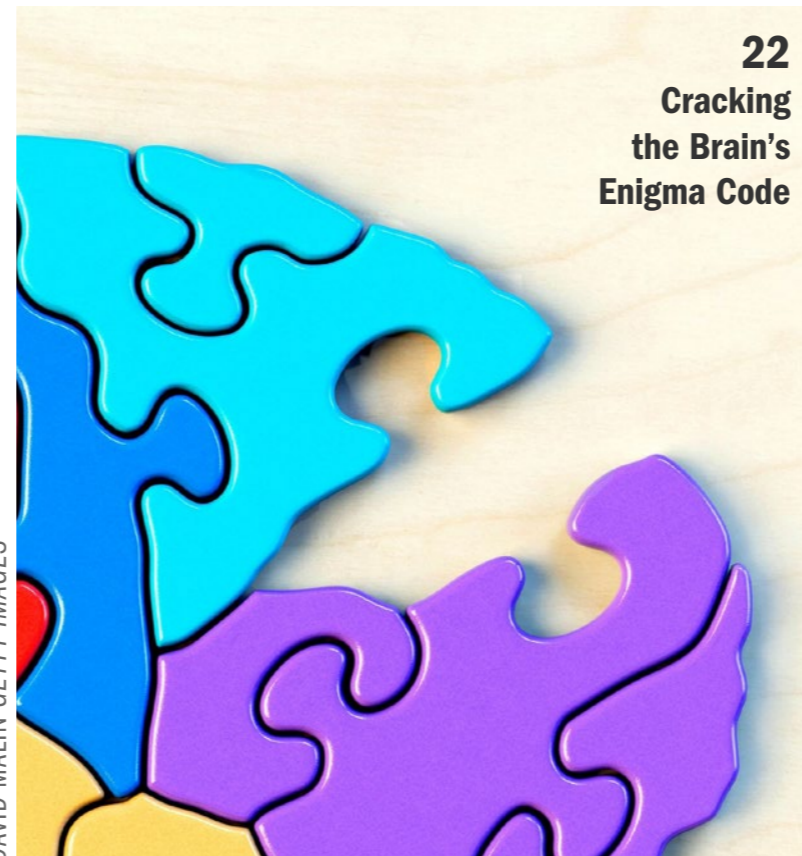
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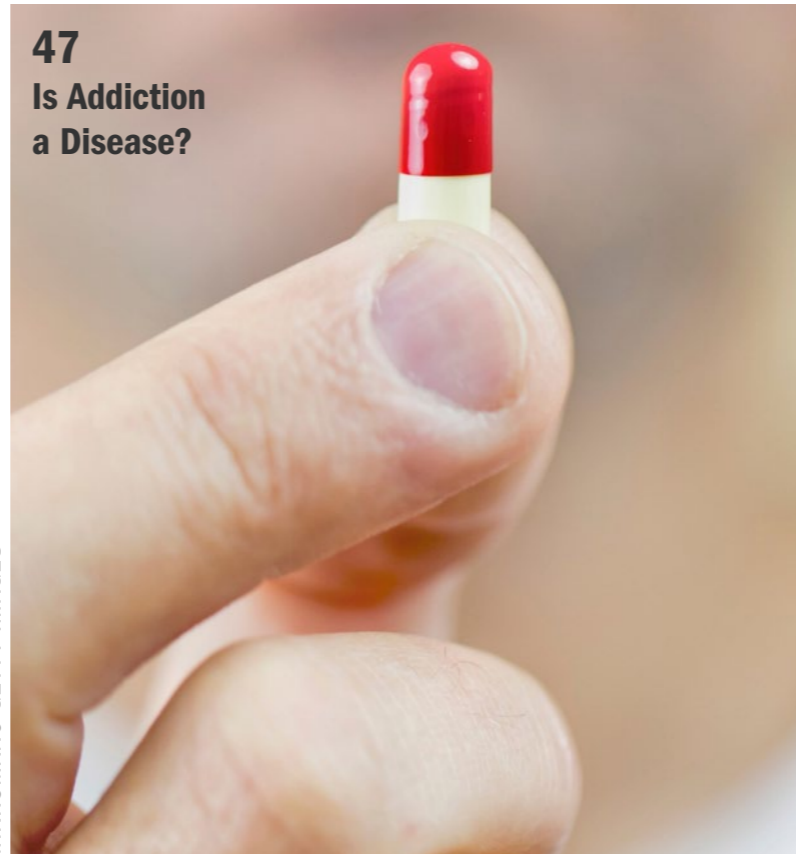
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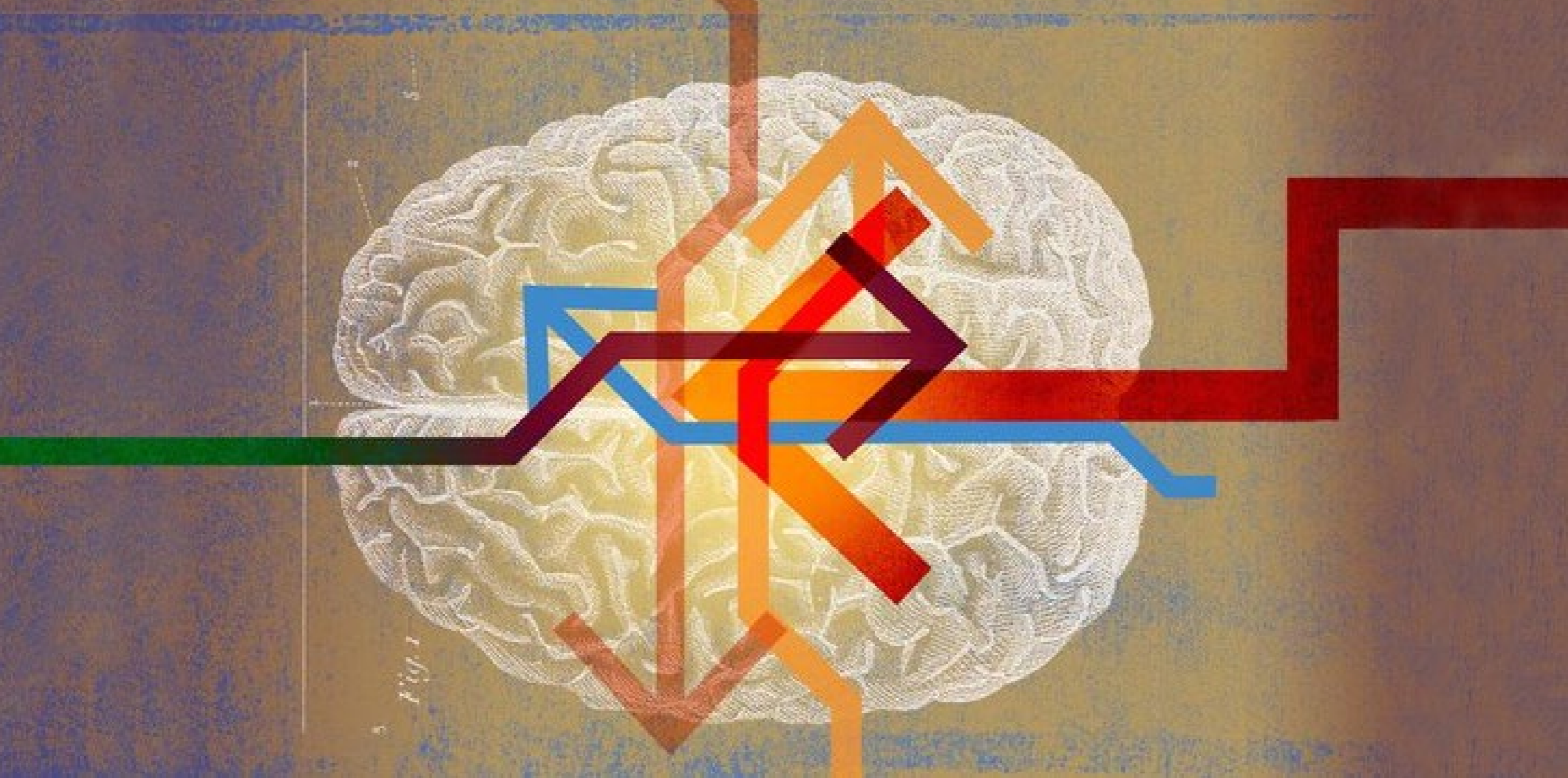
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NEWS

# The Neuroscience of Changing Your Mind

New findings suggest it is more complicated than scientists thought

Every day our brains grapple with various last-minute decisions. We adjust our gait to avoid a patch of ice; we exit to hit the rest stop; we switch to our backhand before thwacking a tennis ball.

Scientists have long accepted that our ability to abruptly stop or modify a planned behavior is controlled via a single region within the brain's prefrontal cortex, an area involved in planning and other higher mental functions. By studying other parts of the brain in both humans and monkeys, however, a team from Johns Hopkins University has now concluded that last-minute decision-making is a lot more complicated than previously known, involving complex neural coordination among multiple brain areas. The revelations may help scientists unravel certain aspects of addictive behaviors and understand why accidents like falls grow increasingly common as we age, according to the Johns Hopkins team.

The findings, published recently in *Neuron*, reveal renegeing on an intended behavior involves coordinated cross talk between several brain regions. As a result, changing our minds even mere milliseconds after making a decision is often too late to alter a movement or behavior. Using functional

magnetic resonance imaging—a technique that monitors brain activity in real time—the Johns Hopkins group found reversing a decision requires ultrafast communication between two specific zones within the prefrontal cortex and another nearby structure called the frontal eye field, an area involved in controlling eye movements and visual awareness.

Lead author Kitty Xu, formerly a Johns Hopkins graduate student and now a researcher at the social media site Pinterest, explains that when it comes to split-second decisions, the longer a decision has to take hold in the brain, the harder it is to reverse. “Stopping a planned behavior requires extremely fast choreography between several distinct areas of the brain, our research found,” she says. “If we change our mind about pressing the gas pedal even a few milliseconds after the original “go” message has been sent to our muscles, we simply can’t stop.” Xu adds that if we change our minds within roughly 100 milliseconds of making a decision, we can successfully revise our plans. If we wait more than 200 milliseconds, however, we may be unable to make the desired change—in other words we may land a speeding ticket or a tumble

down the stairs. As we age, our neural communication slows, and that likely contributes to more of these glitches, Xu says.

To identify the brain regions involved in canceling a decision, the new study recruited 21 subjects for a modified “stop signal task,” a commonly used neuroscientific behavioral test that involves canceling a planned movement. Participants undergoing functional MRI were instructed to watch a screen and to immediately stare at a black dot when it appeared. But just after they focused on the black dot a colored dot would appear, prompting their gaze to shift to the new stimulus—essentially causing them to abandon their initial plan to fix their eyes on the black dot. The researchers watched what areas of the brain lit up during those decision-making steps, and after the volunteers terminated their plan. To confirm their findings, the authors then ran the same experiment on a single macaque. Using an implanted electrode, they saw activation in monkey brain regions analogous to those reported on in humans when the monkey stopped looking at the black circle in favor of the colored dots.

Tracking these eye movements and neural action let the researchers resolve the

very confusing question of what brain areas are involved in these split-second decisions, says Vanderbilt University neuroscientist Jeffrey Schall, who was not involved in the research. “By combining human functional brain imaging with nonhuman primate neurophysiology, [the investigators] weave together threads of research that have too long been separate strands,” he says. “If we can understand how the brain stops or prevents an action, we may gain ability to enhance that stopping process to afford individuals more control over their choices.”

Xu hopes these insights into how difficult it is for the brain to amend its plans—a task that only gets harder as we age and neural communication slows—can eventually help researchers devise ways to intervene and help us make faster, safer decisions. In the short term she hopes key targets will include helping seniors avoid falls and modifying last-minute impulses in people with addictions.

“The sooner I can turn off the plan to drink or use the drug,” she says, “the less likely I am to carry out that plan.”

—BRET STETKA



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NEWS

# Do Brain-Wiring Differences Make Women More Vulnerable to Concussions?

Female axons—brain cells' output cables—are shown to have a thinner structure



Researchers have known for some time that female athletes experience higher rates of concussion than their male counterparts, and also often suffer harsher symptoms and take longer to recover. But why women seem more vulnerable to such injuries has long remained a puzzle.

Concussion symptoms range from headache, dizziness and confusion to memory loss, noise or light sensitivity, and irritability. Most people recover quickly but some develop problems lasting a year or more. A 2010 study led by neurologist Jeffrey Bazarian of the University of Rochester found that women—especially those of child-bearing age—had worse symptoms measured three months after injury.

Several explanations have been proposed including sex hormones, neck structure and cerebral blood flow, but no one really knows what is to blame. Now, however, a study led by Douglas Smith, director of the Center for Brain Injury and Repair at the University of Pennsylvania, adds a new candidate: differences in axons—the output “wires” of neurons.

Smith and his colleagues discovered differences in the size and structure of male

and female axons and found the female structure was more susceptible to damage. “The findings are intriguing,” says neuropsychologist Donna Broshek of the University of Virginia, who was not involved in the study. “Many theories have been put forth, including that—because of differences in cultural socialization—women are more likely to endorse symptoms.” But the new results, published recently, “suggest that women report more symptoms because they are ... experiencing more symptoms,” Broshek says.

Each neuron has many inputs, called dendrites, but generally only one output: its axon. Along with transmitting the electrical signals underlying cognition, axons transport cargo of various kinds—including proteins that are used mainly for repair and maintenance. Other specialized proteins haul this cargo via the axons along train track-like structures called microtubules. A major sign of concussion is damaged axons. “There’s an emerging consensus that one underlying issue with concussion is diffuse axonal injury,” Smith says. This led him to wonder if the sex differences in concussions might have something to do with axons. “Is there something different about

brain architecture,” he says, “that given the same mechanical forces, a female brain may be more injured than a male brain?”

To test this idea, the team first used a cell-culture model in which two populations of neurons are separated by tiny channels, along which axons grow. The researchers then used pulses of air to rapidly stretch the axons, mimicking sudden head trauma. “We found a dramatic difference,” Smith says. “The female axons had many more undulations, which were bigger, suggesting more structural damage.” Undulations occur when microtubules break. Their cargo then spills and builds up in the axon, causing swelling. Sodium, which is needed for normal transmission of electrical signals, then rushes in—but too much of it actually disrupts this signaling. “In concussion you have an immediate change in mental status, because the electric grid has been taken out,” Smith says. “It’s like a blackout or browning out of the city.” The excess sodium also causes calcium to flood in, activating enzymes that destroy structures inside axons. Twenty-four hours after being hit with air pulses, the female axons had more swellings and signaling loss. This was true for both neurons taken from rats and hu-



man neurons derived from stem cells that were genetically male or female.

The researchers next examined the axons with electron microscopy. They found the female axons were thinner, with fewer microtubules—a difference that has been hinted at previously but never directly demonstrated. They then used a computational model to compare how the different male and female structures responded to the same mechanical force. The female structure suffered more breaks. Microtubules are connected by proteins that become stiffer the faster they are stretched. And if axons are stretched too rapidly, these proteins pull on microtubules and break them, Smith says. Having more microtubules gives the whole structure more stability.

The relatively rapid recovery most people experience may reflect the time it takes to repair axons—but if the damage is too severe, axons may degenerate. “We think that’s the route that has persisting symptoms,” Smith says. “Up to 20 percent of individuals have persisting dysfunction; we’re really interested in those people, because we think they have permanent damage.” If he is right, recovery from long-term symptoms may reflect the time it takes

# Most important is the brain’s inflammatory response, which must be precisely controlled to clean out waste without doing damage.

brain plasticity to compensate for lost cells.

How much of the concussion sex differences might be explained by this discovery is not yet clear. “I’m almost certain this cannot be the only thing that contributes,” Smith says. “It’s probably one of several factors; time will tell how large a role it plays.” Differences in rates may be “primarily about axonal damage,” but recovery time is a different question, Bazarian says. “There’s a host of processes that take place, to clean up, that may also have sex differences.” Most important is the brain’s inflammatory response, which must be precisely controlled to clean out waste without doing damage. Hormones regulate this process, which could explain findings like worse outcomes in child-bearing years. How effective these processes are—plus injury severity—are likely what determine re-

covery times. “It’s a combination of the two,” Bazarian says.

A caveat is that cell cultures and models are a far cry from the immensely complex environment of a real brain. “This sets the stage for the next step, which is finding some way to verify these findings in living human brains,” Bazarian says. This will be challenging, as researchers cannot easily examine live human axons directly. There are ways around this, however. For example, researchers can look at less-direct evidence of the damage, such as changes in white matter. (Nerve fiber tracts appear white due to the coloring of the myelin sheaths that cover and insulate axons.) “This will open the door to looking at white matter with advanced neuroimaging,” Smith says. “Given the same head impacts, do females have more changes in white matter?”



Another promising approach is measuring levels of proteins in blood. “We’re realizing we see these axon proteins in the blood after injury, which are only there if the axon degenerates,” Smith says. “Hopefully in the next few years we’ll have a test to identify individuals who are going to have long-term problems.” This would be a boon not just for diagnosis but for testing treatments. One reason clinical trials fail is if the participants are too diverse, so the treatment is not appropriate for all. If a blood test could identify patients likely to develop persistent problems, they could be selected and enrolled in trials targeting the axon damage flagged by the test.

—SIMON MAKIN



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NEWS

## Bad News for the Highly Intelligent

Superior IQs are associated with mental and physical disorders, research suggests

There are advantages to being smart. People who do well on standardized tests of intelligence—IQ tests—tend to be more successful in the classroom and the workplace. Although the reasons are not fully understood, they also tend to live longer, healthier lives, and are less likely to experience negative life events such as bankruptcy.

Now there's some bad news for people in the right tail of the IQ bell curve. In a study just published in the journal *Intelligence*, Pitzer College researcher Ruth Karpinski and her colleagues emailed a survey with questions about psychological and physiological disorders to members of Mensa. A “high IQ society,” Mensa requires that its members have an IQ in the top 2 percent. For most intelligence tests, this corresponds to an IQ of about 132 or higher. (The average IQ of the general population is 100.) The survey of Mensa's highly intelligent members found that they were more likely to suffer from a range of serious disorders.

The survey covered mood disorders (depression, dysthymia and bipolar), anxiety disorders (generalized, social and obsessive-compulsive), attention-deficit hyper-

## The biggest differences between the Mensa group and the general population were seen for mood disorders and anxiety disorders.

activity disorder and autism. It also covered environmental allergies, asthma and autoimmune disorders. Respondents were asked to report whether they had ever been formally diagnosed with each disorder or suspected they suffered from it. With a return rate of nearly 75 percent, Karpinski and colleagues compared the percentage of the 3,715 respondents who reported each disorder to the national average.

The biggest differences between the Mensa group and the general population were seen for mood disorders and anxiety disorders. More than a quarter (26.7 percent) of the sample reported that they had been formally diagnosed with a mood disorder, while 20 percent reported an anxiety disorder—far higher than the national averages of around 10 percent for each. The differences were smaller, but still statisti-

cally significant and practically meaningful, for most of the other disorders. The prevalence of environmental allergies was triple the national average (33 percent vs. 11 percent).

To explain their findings, Karpinski and her colleagues propose the *hyper brain/hyper body theory*. This theory holds that, for all of its advantages, being highly intelligent is associated with psychological and physiological “overexcitabilities,” or OEs. A concept introduced by the Polish psychiatrist and psychologist Kazimierz Dąbrowski in the 1960s, an OE is an unusually intense reaction to an environmental threat or insult. This can include anything from a startling sound to confrontation with another person.

Psychological OEs include a heightened tendency to ruminate and worry, whereas



physiological OEs arise from the body's response to stress. According to the hyper brain/hyper body theory, these two types of OEs are more common in highly intelligent people and interact with each other in a "vicious cycle" to cause both psychological and physiological dysfunction. For example, a highly intelligent person may over-analyze a disapproving comment made by a boss, imagining negative outcomes that simply wouldn't occur to someone less intelligent. That may trigger the body's stress response, which may make the person even more anxious.

The results of this study must be interpreted cautiously because they are correlational. Showing that a disorder is more common in a sample of people with high IQs than in the general population doesn't prove that high intelligence is the cause of the disorder. It's also possible that people who join Mensa differ from other people in ways other than just IQ. For example, people preoccupied with intellectual pursuits may spend less time than the average person on physical exercise and social interaction, both of which have been shown to have broad benefits for psychological and physical health.

All the same, Karpinski and her colleagues' findings set the stage for research that promises to shed new light on the link between intelligence and health. One possibility is that associations between intelligence and health outcomes reflect *pleiotropy*, which occurs when a gene influences seemingly unrelated traits. There is already some evidence to suggest that this is the case. In a 2015 study, Rosalind Arden and her colleagues concluded that the association between IQ and longevity is mostly explained by genetic factors.

From a practical standpoint, this research may ultimately lead to insights about how to improve people's psychological and physical well-being. If overexcitabilities turn out to be the mechanism underlying the IQ-health relationship, then interventions aimed at curbing these sometimes maladaptive responses may help people lead happier, healthier lives.

—DAVID Z. HAMBRICK AND  
MADELINE MARQUARDT

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Baby sleeping in a hammock in the Tsimané settlement of Anachere, in the Amazon rainforest.

NEWS

# Parents in a Remote Amazon Village Barely Talk to Their Babies—and the Kids Are Fine

Ignoring a Western child-rearing practice does not seem to matter for the Tsimané of Bolivia



In 1995 a landmark study found that children whose families were on welfare heard 1,500 fewer words every hour—or eight million fewer per year—than children from professional backgrounds. Eight years later these same children performed significantly worse on vocabulary tests and language assessments than their higher-income peers did.

These findings have influenced child-rearing practices ever since, and it is now taken for granted that the more time a parent talks to an infant, the better. In subsequent studies infant-directed speech has consistently been linked to a child's language skills, which in turn influence IQ, executive function and emotion regulation.

Apparently, word of all this did not reach the Bolivian Amazon. A recent study published in *Child Development* revealed the Tsimané—members of a forager–farming society—speak to their young children for less than one minute every hour, roughly one tenth the amount of time U.S. mothers speak to their babies.

The Tsimané, a so-called “preindustrial society,” are a favorite among anthropologists and health scientists. They have changed how we think about heart disease,

color identification, sleep, music preferences, parasitic worms and genes for Alzheimer's disease—and now language development. Their unique health and behavioral patterns are precisely why researchers need to study cultures that fall outside of so-called WEIRD—Western educated industrialized rich democracy—societies, says Michael Gurven, a professor of anthropology at the University of California, Santa Barbara, and director of the Tsimané Health and Life History Project.

The researchers observed, anecdotally, that language development appears to be slightly delayed in the Tsimané—but this does not seem to matter. The children grow up to be fully functioning, communicative and productive members of the community. In fact, as interactions between Tsimané and other Bolivians increase, many of the children are becoming bilingual in Spanish as well at their native Tsimané language.

Previous research on the Tsimané showed family and child-rearing dynamics are very different. Parents do not give their babies as much attention as Westerners do, and there is little playing with or soothing young children. But the children also cry less. One reason may be that they are with their mothers

the vast majority of the time, so basic biological demands like breast-feeding can be taken care of immediately.

The Tsimané's distinctive child-rearing styles may stem from a sobering reason: a high infant mortality rate. Thirteen percent of infants do not make it through their first year of life, most dying from infectious diseases. As a result, Gurven says, mothers may not want to become too attached to their babies early on, beyond keeping them alive. Many children are not given names until after their first birthdays. “You can imagine that active speaking and conversing with an infant as if it were like any other member of your family—or even as a way of speaking to yourself—you could see why that might be not that common in the context of high infant mortality,” he says.

Dean Falk, an anthropologist at The Florida State University who was not involved in the study, says it is not only the quantity of speech that matters in language acquisition but the quality. “Motherese” is the universal simplistic language and sing-song tone associated with baby talk. Although it may seem like an annoying by-product of encountering chubby limbs, big eyes and soft cheeks, there is a strong developmental ben-

efit of speaking in baby talk. The accentuated vowels help children distinguish between words, while simplistic sentence structures emphasize teaching object labels.

Falk says when determining how the lack of direct speech impacts Tsimané children's ability to learn language, she would like to know about the acoustic features of the speech they do receive. "There's a good deal of cross-cultural variation in how people talk to babies," she says. "What would be interesting would be if they would start looking at the quality. You know: What is this infant-directed speech like? How is it different from adult-directed speech?"

Tsimané children do overhear conversations between adults for roughly seven minutes every hour. Laura Shneidman, who has conducted similar research on the Mayan population in Mexico, says that although directed speech contributes more to children's language acquisition, these overheard conversations could still be beneficial, particularly in non-Western societies. Preliminary data from Shneidman's research suggest that although U.S. children do a better job of retaining learning through directed speech, Mayan children remember new information from both directed and overheard speech.

"The importance of something being directed, per se, varies depending on your culture. Kids growing up in the U.S. get a lot of information that things you direct to them are important," Shneidman says. "Kids in other cultures where observational learning is more prevalent don't have those heavy cues that you should only attend and pay attention to things that are directed to you."

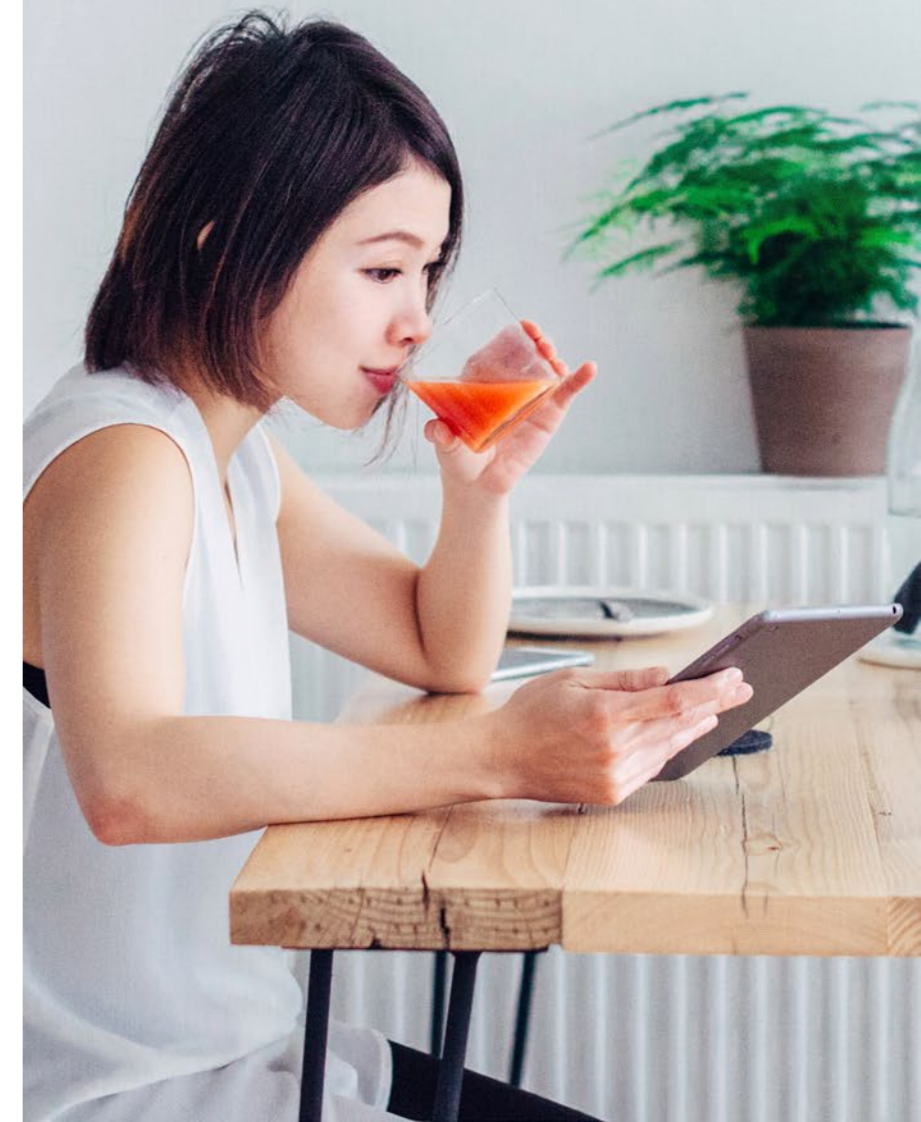
Before you stop talking to your children, however, Shneidman notes that for Westerners, speaking to infants is still critical—especially when considerations like school and competition with other children are taken into account. "In the United States there's a lot of evidence that talking to kids matters and has these effects on later acquisition," she says. "I think what's problematic is taking programs of intervention that have worked in the United States, and taking them wholesale to these other cultures."

—DANA G. SMITH

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NEWS

# Social Notworking: Is Generation Smartphone Really More Prone to Unhappiness?

A study closely correlates device use with depression and suicide, but the link is contentious

Mobile devices have become our alarm clocks and newspapers and, via platforms like Facebook and Instagram, portals to our social lives. With smartphones inhabiting the pockets of roughly three quarters of all Americans and tablets borne by half, a pale blue glow silhouettes modern life.

As screens have become ubiquitous, so has the phenomenon of depressed or suicidal teens, notes Jean Twenge, a psychologist at San Diego State University and the author of *iGen: Why Today's Super-Connected Kids Are Growing Up Less Rebellious, More Tolerant, Less Happy—and Completely Unprepared for Adulthood*.

In a study published in November in *Clinical Psychological Science*, Twenge correlates the increasing use of social media, gaming and Internet browsing with rising symptoms of depression and suicidal behaviors in teenagers. Importantly, however, other research has shown that some device use—on social media, in particular—might be positive for people struggling with depression or other serious mental illnesses.

The study led by Twenge collected data on more than half a million American teenagers' electronic device and online media

habits from two national surveys conducted annually since 1991 and involving people ages 13 to 18. When Twenge compared those same teens' reports of having thoughts of or a plan to commit suicide—or making actual attempts—a third of teens who used devices at least two hours a day acknowledged at least one of these behaviors. That number went up to nearly half among teens who used devices for five or more hours a day. Teenagers who used social media on a daily basis were 13 percent more likely to say they felt depressed than were peers who did not use it every day.

Twenge and other researchers had been seeing dramatically rising rates of depression, especially among teens, over the past five years. “I noticed this very pronounced spike in depressive symptoms around 2012,” she says. According to the data collected annually by the U.S. Centers for Disease Control and Prevention, the teen suicide rate has been climbing steadily since then, too.

One of the biggest things happening in society at exactly the time of the depression spike was a rapid proliferation of smartphones. “[It] was the year the percent of Americans who owned smartphones crossed 50 percent,” Twenge says. By 2015

about 85 percent of young adults had smartphones and were using their devices a lot more, according to a [Pew Research Center survey](#). “There was this turn where it wasn't just that people had smartphones,” Twenge says. “It became the primary way teens communicated with one another.”

For many teenagers, social media is not simply the primary medium of communication but the epicenter of social life itself. “If you don't have a Snapchat [account], you're not connected to anyone in school,” says Aashima, a 16-year-old U.S. high school student. (Her surname is withheld to protect her privacy.)

Not only do students hear about gossip or drama more quickly as pictures and messages blaze through virtual networks; Aashima says social media won't let ugly rumors fade. “I remember in like fourth grade, we didn't really have cell phones and [gossip] would just die in school that day,” she says. “But with texts and social media, you can discuss it when you're home, in the car—anytime.” She adds people will bash each other online over something that happened in school or the way somebody looked one day. “And it just drags on and on and on,” she says.

Social media also opens teens up to the



worldwide online community. Aashima says strange men follow her accounts frequently and, as a courtesy, she often returns the favor. “And then they [direct message] me, and then they’re like, ‘What’s up, girl?’ And they just say really gross things. This morning I was dealing with someone like that. Like why do you have to take time out of your day to ask me these kinds of questions?” she says. “I feel like, in their eyes, [I’m] another thing to use—to talk about. It’s just really degrading.” Despite her wariness, Aashima says she still wants to engage with people online. “Even if they’re like the worst person ever,” she says, “you just want everyone to like you and not think bad of you, so you try your best to do that. When that fails, you feel like giving up on yourself, and you just don’t want to live anymore.”

The uptick in teenage depression and suicidality has come almost entirely from young women, based on annual surveys of teenagers and young adults taken from 1991 to 2015 that are part of the University of Michigan’s Monitoring the Future Series, which Twenge also used for her study. Some researchers say they can intuitively see possible reasons for this, although they

# The uptick in teenage depression and suicidality has come almost entirely from young women.

are unsure of any definite factors. “Girls are very relational, so there’s lots of detailed interactions around their relationships and who is doing what, who is more popular,” says Holly Shakya, a psychologist at the University of California, San Diego, who did not work on Twenge’s study.

Twenge also suggests smartphones’ mere presence may affect physical and mental health. “There’s blue light shining into your eyes and preventing you from feeling tired,” she says. “They’re also psychologically stimulating, and that can lead to you turning your thoughts over and over. In many cases it’s ‘Why didn’t I get likes on that post?’ or ‘Is that other person doing something much more fun than me right now?’” These things can keep people up at night, and sleep-deprived people are more prone to depression, Twenge says.

But much of this is hard to prove, Shakya notes. For example, the new study did not address the question of whether gaming or social media use was more closely tied to depression. It merely correlated self-reported information on electronic device and social media use with suicidality and depression, which does not rule out the possibility that depressed people are likely to spend more time on social media.

Also, Twenge’s study did not delve into exactly what people might have been doing when they were using their devices, says Kelly Aschbrenner, a mental health services researcher at the Geisel School of Medicine at Dartmouth College, who was not involved with the work. The researchers “only ask how often they’re using social media or devices. We don’t know that people are scrolling through social media and

viewing content that's upsetting them or interacting with others in a way that makes them feel bad," Aschbrenner says.

There are also significant reasons to believe social media can be healthful. "Our studies have shown people with mental health problems can benefit when they connect with others like them [on social media] to share advice [and] ailments and feel that they're not alone," Aschbrenner notes. "It's not like you can go to the park and scream out, 'Is anyone else feeling anxious today?' There are really few opportunities for people to find others in life who have the same stigmatized illness."

Aschbrenner says that although it is important to consider the risks of new technologies, health care providers and researchers should be leveraging social media and smartphones as a way to help people. "There are people with mental illnesses who are experiencing debilitating symptoms and can't leave their home," she says. "Social media could be a safe platform to help people connect with others as a first step."

Facebook, for one, says it shares that hope. The social network has wellness researchers who pay close attention to these findings and work to redesign the Web site's interface

with healthiness in mind, according to a company representative. "We want people to be healthy users of social media and that includes connecting in a meaningful way with your friends and community on Facebook. This is something we think a lot about, and research is core to our efforts," Facebook's director of research, David Ginsberg, wrote in an e-mailed response to queries.

In some cases users should be mindful of ways technology might be hurting rather than helping them—but the crux of the matter is in how one uses it, Shakya says. Reaching out for support from friends on Facebook or even using the multitude of fitness or mental health apps may have significant benefits. "This isn't black and white," she says. "It's important to think about this stuff in nuance. It's not like social media is terrible and ruining the world."

Teenagers recognize this, too. "[The pros] are connecting to your friends immediately and being able to talk to them and share your ideas in a public way. If you want to say or advocate for something, it's easy to share to everyone, and people will see it," Aashima says. "It is very powerful. You can use it for good, and you can use it for bad."

—ANGUS CHEN



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# Cracking the Brain's Enigma Code

Neuroscientists are taking cues from cryptography to translate brain activity into movements

by Helen Shen



**B**rain-controlled prosthetic devices have the potential to dramatically improve the lives of people with limited mobility resulting from injury or disease. To drive such brain-computer interfaces, neuroscientists have developed a variety of algorithms to decode movement-related thoughts with increasing accuracy and precision. Now researchers are expanding their tool chest by borrowing from the world of cryptography to decode neural signals into movements.

During World War II, codebreakers cracked the German Enigma cipher by exploiting known language patterns in the encrypted messages. These included the typical frequencies and distributions of certain letters and words. Knowing something about what they expected to read helped British computer scientist Alan Turing and his colleagues find the key to translate gibberish into plain language.

Many human movements, such as walking or reaching, follow predictable patterns, too. Limb position, speed and several

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She has contributed to *Nature*, *Science* and the *Boston Globe*.

other movement features tend to play out in an orderly way. With this regularity in mind, [Eva Dyer](#), a neuroscientist at the Georgia Institute of Technology, decided to try a cryptography-inspired strategy for neural decoding. She and her colleagues published their results in a recent study in *Nature Biomedical Engineering*.

“I’ve heard of this approach before, but this is one of the first studies that’s come out and been published,” says [Nicholas Hatsopoulos](#), a neuroscientist at the University of Chicago, who was not involved in the work. “It’s pretty novel.”

Existing brain-computer interfaces typically use so-called ‘supervised decoders.’ These algorithms rely on detailed moment-by-moment movement information such as limb position and speed, which is collected simultaneously with recorded neural activity. Gathering these data can be a time-consuming, laborious process. This information is then used to train the decoder to translate neural patterns into their corresponding movements. (In cryptography terms, this would be like comparing a number of already decrypted messages to their encrypted versions to reverse-engineer the key.)

By contrast, Dyer’s team sought to predict movements using only the encrypted messages (the neural activity) and a general understanding of the patterns that pop up in certain movements. Her team trained three macaque monkeys to either reach their arm or bend their wrist to guide a cursor to a number of targets arranged about a central point. At the same time, the researchers used implanted electrode arrays to record the activity of about 100 neurons in each monkey’s motor cortex, a key brain region that controls movement.

Over the course of many experimental trials, researchers gathered statistics about each animal’s movements, such as the horizontal and vertical speed. A good decoder, Dyer says, should find corresponding patterns buried in the neural activity that map onto patterns seen in the movements. To find their decoding algorithm, the researchers performed an analysis on the neural activity to extract and pare down its core mathematical structure. Then they tested a slew of computational models to find the one that most closely aligned the neural patterns to the movement patterns.

When the researchers used their best



model to decode neural activity from individual trials, they were able to predict the animals' actual movements on those trials about as well as some basic supervised decoders. "It's a very cool result," says Jonathan Kao, a computational neuroscientist at the University of California, Los Angeles, who was not involved in the study. "My prior thought would have been that having the moment-by-moment information of the precise reach, knowing the velocity at every moment in time, would have allowed you to build a better decoder than if you just had the general statistics of reaching."

Because Dyer's decoder only required general statistics about movements, which tend to be similar across animals or across people, the researchers were also able to use movement patterns from one monkey to decipher reaches from the neural data of another monkey—something that is not feasible with traditional supervised decoders. In principle, this means that researchers could reduce the time and effort involved in collecting meticulously detailed movement data. Instead they could acquire the information once and reuse or distribute those data to train brain-computer interfaces in multiple animals or

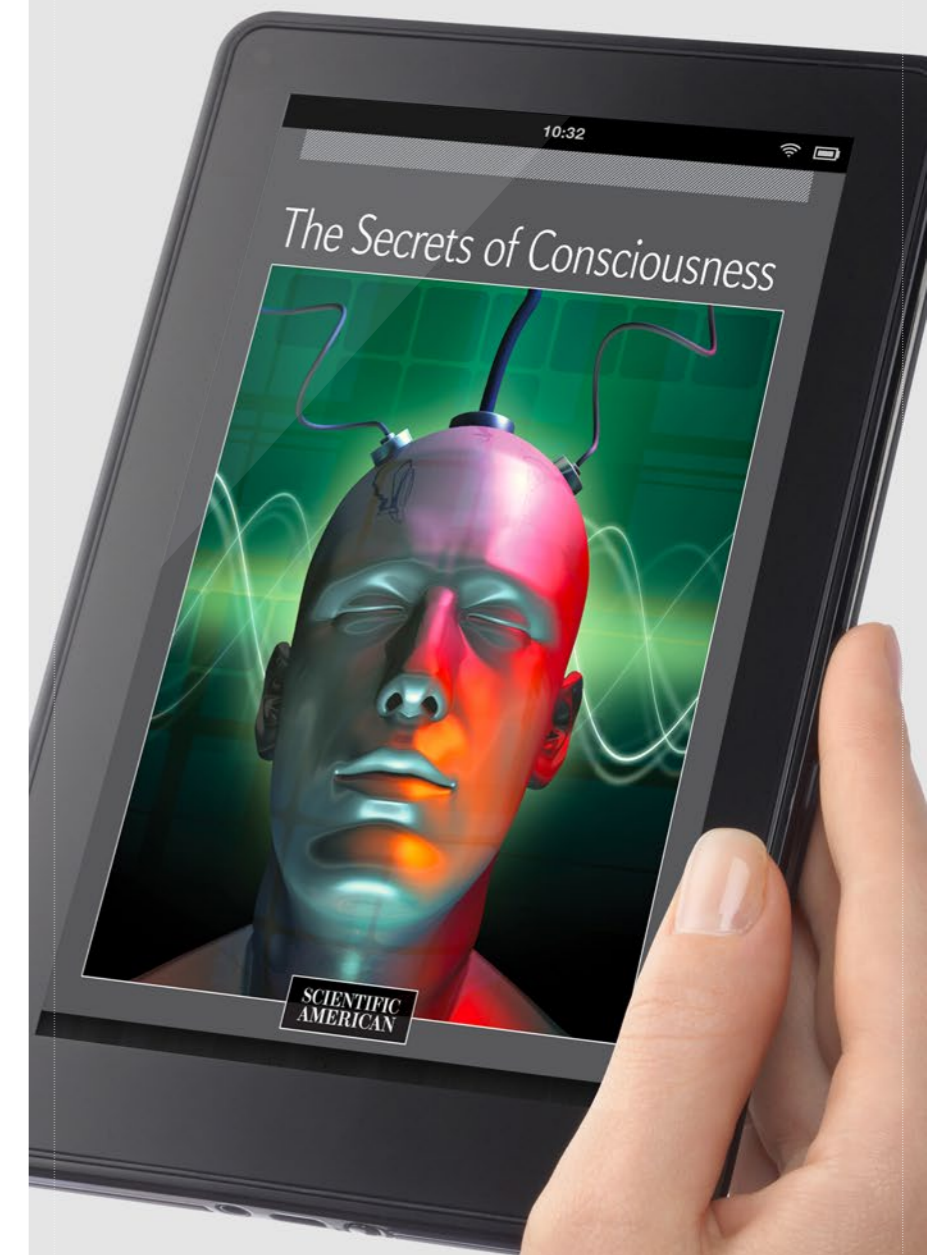
people. "It could be very useful to the scientific community and to the medical community," Hatsopoulos says.

Dyer calls her work a proof of concept for using cryptographic strategies to decode neural activity and notes that much more work must be done before the method can be used widely. "By comparison to state-of-the-art decoders, this is not yet a competitive method," she says. The algorithm could potentially be strengthened by feeding it signals from even more neurons or providing additional known features of movements, such as the tendency of animals to produce smooth motions. To be practical for guiding prosthetic devices, the approach would also have to be adapted to decode more complex, natural movements—a nontrivial task. "We've only kind of scratched the surface," Dyer says. **M**

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# The Secret to a Better Night's Sleep: A Sense of Purpose?

Intriguing new research suggests a positive sleep role for a meaningful life

by Daisy Grewal



**D**espite its importance for health and well-being, many American adults find it difficult to consistently get enough sleep. Approximately 50 million to 70 million Americans suffer from a sleep disorder, according to the Centers for Disease Control and Prevention. Sleep disturbances are particularly common in older adults and involve a variety of problems including difficulties falling or staying asleep, interrupted breathing and restless leg syndrome. A person's racial background can influence his or her likelihood of developing a sleep disorder, with a greater number of black Americans reporting sleep disturbances compared to white Americans.

Beyond its effects on health, not getting enough sleep can lead to car accidents, medical errors or other mistakes on the job. To encourage better sleep, the medical community encourages adults to engage in good “sleep hygiene” such as limiting or avoiding caffeine and nicotine, avoiding naps during

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Daisy Grewal holds a bachelor's degree in psychology from the University of California, Los Angeles, and a doctorate in social psychology from Yale University. She currently works at Stanford University as an applied researcher.

the day, turning off electronics an hour before bed, exercising and practicing relaxation before bedtime. It is also well-known that mental health is closely linked to sleep; insomnia is more common in people suffering from depression or anxiety.

A recent study now raises the possibility that sleep could be affected by the degree to which someone feels like his or her life is purposeful or meaningful. Arlener Turner, Christine Smith and Jason Ong of the Northwestern University School of Medicine found that people who reported having a greater sense of purpose in life also reported getting better sleep—even when taking into consideration age, gender, race and level of education.

To establish this link, the researchers recruited a sample of 825 older Americans to participate in a study where they reported on their sense of purpose in life along with the quality of their sleep. The majority of these participants were female (77 percent) and slightly more than half were African-American (54 percent). The participants were, on average, 79 years old. A sense of purpose in life was measured using a survey where participants rated how much they agreed with each of 10 statements, such as

“Some people wander aimlessly through life, but I am not one of them.” The results showed that participants who reported having a greater sense of purpose in life also reported higher quality sleep on a regular basis, as well as fewer symptoms of sleep disorders. Importantly, the researchers found that their findings held true for both the white Americans and black Americans who participated in the study.

It is important to emphasize that this study only looked at the *association* between a sense of purpose and better sleep—the findings cannot say for sure that having a greater sense of purpose causes one to sleep better. An alternative interpretation for the findings is that people who have a greater sense of purpose also tend to have better physical and mental health, which in turn explains their higher-quality sleep. Another important limitation of the study is that the findings rely entirely on people's self-reported sleep symptoms. The researchers did not bring participants into a lab and actually monitor the quality of their sleep. Therefore, it is possible that people with a higher sense of purpose simply remember getting better sleep compared to people who do not report experiencing a sense of purpose in life.

Despite these limitations, this study is the first to suggest any kind of strong link between purpose in life and sleep. Given how common sleep problems are, anything that may suggest new avenues for treatment is important to explore. Perhaps developing a sense of purpose in life could be as effective at improving sleep as following healthy habits, such as limiting coffee. In addition to promoting good sleep hygiene, doctors may end up recommending mindfulness practices or exploring one's values as ways of helping older adults sleep better. Given how elusive a good night's sleep has become for many, it's well worth exploring. The impact of poor sleep goes far beyond our own personal health, as the side effects have the potential to wreak havoc on other people's lives as well.

Developing a sense of purpose in life may simultaneously convey other benefits in addition to better sleep. Research has linked experiencing purpose in life to a variety of other positive outcomes including better brain functioning, reduced risk of heart attack and even a higher income. People with a greater sense of purpose in their life would surely be better off while also serving as a positive example in the lives of those they know. **M**

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A young boy with dark hair is shown in profile, looking down. An adult's hand is gently holding his hand, suggesting support and guidance. The background is a soft, light blue gradient.

# The Importance of Fostering Emotional Diversity in Boys

Boys grow up in a world inhabited by a narrower range of emotions

By June Gruber and Jessica L. Borelli

**Y**ou're given a choice: Would you rather spend your day feeling happy, versus happy interspersed with some moments of sadness, frustration and anxiety? Most of us would choose the first option in a heartbeat. Psychologists, too, long championed the importance of cultivating positive emotions as one path toward optimizing well-being, resilience to stressors and salutary physical health out-

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**June Gruber** is an assistant professor of psychology at the University of Colorado Boulder and director of the Positive Emotion and Psychopathology (PEP) Laboratory. She is a licensed clinical psychologist who uses experimental tools to address questions about happiness, psychopathology and emotion. She has a free online course in Human Emotion and is editing a forthcoming handbook on positive emotion and mental illness

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**Jessica Borelli** is an associate professor of psychology and social behavior at the University of California, Irvine, and director of The Health, Relationships, and Interventions (THRIVE) Laboratory. She is a licensed clinical psychologist specializing in parent-child relationships and emotion, with a particular focus on developing tools for preventing anxiety and depression in children. Borelli maintains a private psychotherapy practice where she specializes in children and families.

comes. Not surprisingly, when people are asked what emotions they want to feel, they place a heavy emphasis on wanting to feel primarily positive emotions.

However, research suggests the choice may no longer be a straightforward one. Recent work by psychologists reveals the once-hidden benefits of experiencing a *diversity* of emotions, both positive and negative. Just as physical environments flourish through a biodiversity of flora and fauna, this new work on “emodiversity” likens the human mind to an abstract and internal psychological ecosystem that may also benefit from experiencing a wide diversity of emotions. Although still a new idea, the yield of emodiversity is apparent: adults who report experiencing a greater diversity of both positive and negative emotions report fewer symptoms of depression and fewer days spent in a hospital. This is consistent with what we have long known about emotions: namely, that emotions serve as a guidepost on the map of human experience, drawing our attention to the important markers in our environments—the warning signs, or things that need to be noticed, changed, processed and understood. So the emotional ingredients underlying well-be-

ing might be more diverse than just feeling good or positive emotions. In addition, adults who experience a wider range of positive emotions—for example, calm, amused, excited and proud—exhibit lower markers of inflammation, suggesting that happiness isn't the *only* positive feeling that confers well-being benefits.

If having lots of different emotions is good for our health as adults, then shouldn't we be fostering the experience of a diverse range of emotions in young children as well? And yet the research suggests we are not fostering emotional diversity from a young age, especially when it comes to raising young boys. As early as infancy, boys' and girls' emotional landscape differs. One study reported that when watching an infant being startled by a jack-in-the-box toy, adults who were told the infant was a boy versus a girl were more likely to perceive the infant as experiencing anger, regardless of whether the infant was actually a boy. Gender differences in the diversity of emotion words parents use in conversations with young boys and girls also emerge. In another study examining conversations between mothers and young children, mothers interacting with daughters employed emotion vocabu-



lary of greater density and depth, whereas conversations with sons tended to focus primarily on a single emotion—you guessed it, anger. Regardless of whether gender differences in adult behavior arise from conscious or unconscious psychological processes, one thing is clear: boys grow up in a world inhabited by a narrower range of emotions, one in which their experiences of anger are noticed, inferred and potentially even cultivated. This leaves other emotions—particularly the more vulnerable emotions—sorely ignored or missing in their growing minds.

This is all the more concerning given that research from Harvard Medical School shows that boys are in fact *more* emotionally expressive than girls. This begins as early as infancy and lasts through early childhood. So it is possible that boys might actually begin with at least comparable, if not more, intensity and range of emotional expressions. This suggests that something is happening in these early years, when children are the most receptive to messages their parents give them about emotion displays, that might very well have a longer-term impact on their emotional development.

## As early as infancy, boys' and girls' emotional landscape differs.

Indeed, a lack of fostering emotional diversity in youth may have long-term problematic consequences. As early as elementary school, the avoidance of strong emotions (besides anger) results in academic underperformance in boys. Psychologists have found that children who deny emotional vulnerability are also more likely to become adolescents who engage in health-risk behaviors, such as substance use. Later in development, men suppress (i.e., do not openly express) their emotions more than women; and men in turn experience greater depressive symptoms and resort more often to physical violence. Scientists speculate that trouble regulating emotion may explain the link between restricted emotions and aggressive behavior toward others in men. This seems likely, given that the skills to regulate emotion are gained through practice, which boys may be less likely to have if they do not have permission to experience the full range of emotions.

Unfortunately, men's restriction in emotion expression extends to the home—men are also less likely to share their own vulnerable emotions with partners and are less open to these experiences in their partners, a point made clear by University of Houston social work professor Brené Brown in her qualitative research on shame. And emotion suppression can have consequences for physical, as well as psychological and relational, health—these men may be at greater risk for stress-related cardiovascular problems in the long run. A lack of emotional diversity is not just important for young boys but continues to be so as emotionally restricted young boys mature into adult men with more rigid emotional repertoires. Experiencing the full range of emotions may not only benefit young boys' psychological health but have far-reaching benefits for society at large. **M**

A person in a full white space suit, including a helmet with a dark visor, stands in a desert landscape. The background shows hazy, orange-tinted mountains under a bright sky. The person is wearing a complex suit with various straps and equipment.

# My Year on “Mars”

Physicist Christiane Heinicke spent 365 days sequestered with five others in a geodesic dome on the side of a Hawaiian volcano to test what isolation might do to the psyches of the crew on a Mars mission

By Christiane Heinicke



**T**he wind sweeps quietly across the barren, dry landscape. There is not a shrub in sight, not a tree, not a single blade of grass that the wind might disturb. Only barren grayish-red rocks.

The wind never touched us as we peered out of our only window, which was more of a porthole than a real window. We did hear it, though, as it swept across our white dome, perched on the slope of the volcano.

We lived and worked for an entire year halfway up Mauna Loa under conditions similar to those that explorers on Mars will encounter. We called the 1,200-square-foot space that we lived in our “habitat,” and whenever we left it, we had to wear space suits. We each had our own tiny room outfitted with a bed, a small table, a stool and a chest of drawers.

Cut off from civilization, we were dependent on ourselves and on each other. We had to perform any work that needed

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**Christiane Heinicke** is a German physicist and engineer. Her main interests are things that can flow, like water, air or molten metal, but she has also studied auroras and done simulations of the Earth's mantle. At HI-SEAS she is working on extracting water from the ground, studying the crew's sleep patterns and doing experiments related to the toxicity of Martian soil.

# Our physical isolation from the Earth meant that we were isolated from its inhabitants as well.

doing and fix anything that broke. All we had was the material contained in the storage unit dubbed the “sea can.” The nearest supermarket was months away. We received news “from Earth” electronically—with a 20-minute delay. That is about how long it takes for signals to travel the maximum distance of 240 million miles between the two planets.

To be honest, it took weeks for me to realize just what I had gotten into. By that time, I was an integral part of the fourth and longest study conducted by the Hawaii Space Exploration Analog and Simulation, HI-SEAS for short. The project was conducted by a team under Kim Binsted at the University of Hawaii and financed by NASA.

The purpose of the experiment was to understand the effects that a Mars mission would have on the human psyche and to

simulate and understand these effects on performance and mood. Make no mistake, sending humans to Mars is much more than just a technical challenge.

## **The Right Mix Is Critical**

No simulation can possibly re-create the dangers actually encountered on such a voyage. These are well-known, however, as a result of experience with the International Space Station (ISS), but it is important to understand that physical dangers pose only one of many risks inherent in space travel. Thus far, astronauts have rarely spent more than six months on the ISS. A manned Mars mission, on the other hand, would take about two and a half to three years; the flight alone would take about six months. This is why finding candidates who are able to form a cohesive team capable of working togeth-

er at close quarters over time without getting on each others' nerves and who are able to deal with extraordinary stress is a prerequisite for such a mission. One of the questions posed by the experiment was how to give support from Earth to a crew on Mars in resolving problems, given the considerable time lag involved in communications.

The knowledge gained from this project will be useful to other groups working under what are called ICE conditions (isolated, confined, extreme). These include submarine crews and teams stationed in Antarctica. There have been more than a few incidents in which fights between crew members have scuttled or nearly wrecked an expedition. It has become something of a tradition for HI-SEAS crews to watch *Mutiny on the Bounty* together. A scientific mission to Mars might easily be doomed to failure if its members are unable to cooperate.

But how do you pick a team that remains cohesive over months and even years, while at the same time doing highly demanding research? It is obvious that the members of a Mars expedition have to be experts in their fields. Pilots are needed to navigate the shuttle or the rocket. The engineers and technicians must be able to maintain both



**The Twin Peaks are modest-size hills to the southwest of the Mars Pathfinder landing site. They were discovered on the first panoramas taken by the IMP camera on July 4, 1997, and subsequently identified in Viking Orbiter images taken more than 20 years ago.**

the rocket and the habitat; they along with the physicians charged with caring for crew members must be absolutely competent. The researchers and scientists involved must know what they're doing.

These were the considerations when our HI-SEAS-IV team was put together. An-

drzej Stewart, a pilot and flight controller from the U.S., was our engineer; Sheyna Gifford, also from the United States, was our physician. Cyprien Verseux, our astrobiologist, was from France, and I served on the team as geophysicist and chief scientist. Rounding out our group were Tristan



Bassingthwaighte, at the time working on a degree in architecture and specializing in next-generation space habitats, and Carmel Johnston, a soil scientist.

In an anonymous election, we selected Carmel to be our commander. In essence, in situations in which decisions had to be made quickly, she had the final say. In most cases, however, we made our decisions democratically. At 26, Carmel was the second-youngest team member; Sheyna, the oldest, was 37.

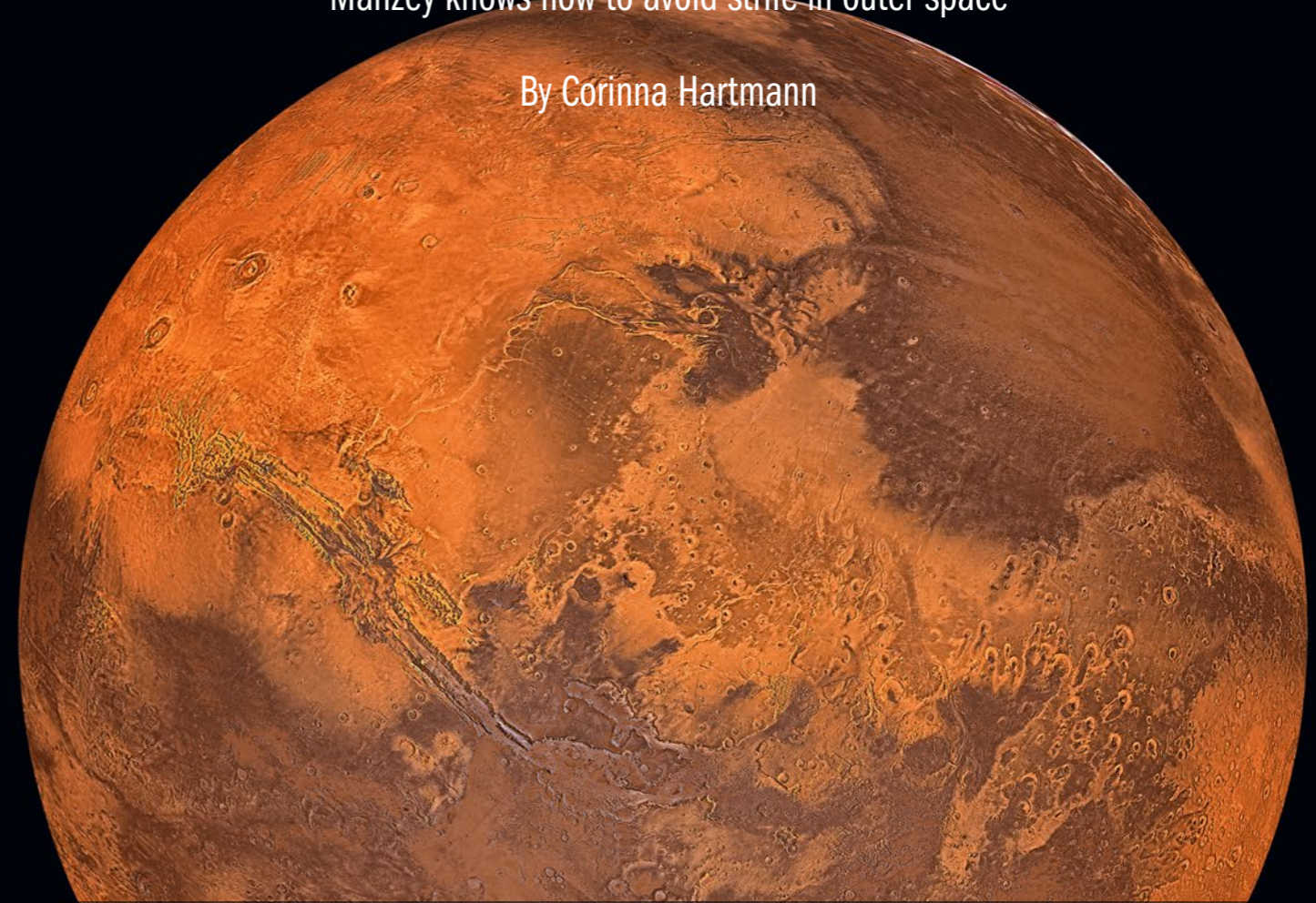
But professional qualifications tell only half the story. A team composed of the most brilliant scientists might be a disaster if they are all focused only on their own interests and can't get along with their colleagues. In a setting in which a moment's inattention can mean quick death, each individual is crucially dependent on his or her crewmates. This is why everyone has to be adaptable, empathetic, tolerant and, above all, make the needs of the team the top priority—even if that puts an individual at a personal disadvantage. That is the only way that the crew can pull itself together after working out serious differences and continue with its mission.

Conflicts, such as those that we experienced, are unavoidable on a Mars expedi-

## The Right Stuff in Space

A successful Mars mission requires that the crew can collaborate under severe stress. Psychologist Dietrich Manzey knows how to avoid strife in outer space

By Corinna Hartmann



FROM THE EDITORS: Getting to and from Mars is a challenging technical issue, but there's also the human factor. How will several people manage months together in isolation and close quarters? Psychologist Dietrich Manzey, professor of work, engineering and organizational psychology at the Berlin Institute of Technology, has spent much of his career focusing on this topic. He has been involved in research projects for a number of space missions, and he supervises astronauts for the European Space Agency during their stints on the International Space Station. Manzey discussed the challenges astronauts might face on a Martian expedition with Corinna Hartmann of *Gehirn&Geist*, the psychology and neuroscience specialty publication of *Spektrum der Wissenschaft* and the German sister publication of *Scientific American*. An edited transcript of the interview follows.



tion. Sometimes we argued over empty coffee cups left lying around, sometimes over how far we should venture onto dangerous terrain when we were deployed outside. No matter how carefully team members are vetted, it is impossible to prevent differences of opinion. But what distinguishes a good team from a bad one is that it quickly recovers from arguments and maintains a high level of performance over time.

### **A Trove of Outdoor Experience**

Each one of us brought to the project different personality traits, experiences, attitudes and work habits. Carmel, our commander, was a doer. Her motto might be summarized as, “Don’t put off for tomorrow what you can do today.” She was all business, solving problems and improvising as necessary. By her own admission, she would rather sleep outside in a sleeping bag under the stars than in a bed. As paradoxical as it may seem that she would voluntarily spend an entire year inside, her infinite trove of outdoors experience helped us immensely to endure life in our Mars habitat. We were cut off from civilization and forced to discover our internal resources and make do with the equipment we had brought along.

### **Professor Manzey, we’ve been sending humans into space for more than 50 years. Why would the voyage to Mars pose special challenges to astronauts?**

For one thing, the trip to Mars takes much, much longer than any expeditions to date — about six months. For the return trip, the crew would have to stay on Mars until the distance to Earth is optimally short — which can take as long as a year. In addition, communication with ground control is extremely limited. If the crew asks a question, it will take 40 minutes to get a reply. Under such circumstances it would be impossible to give the mission the sort of support that we are used to with missions closer to Earth.

### **When a small group of people lives at close quarters under difficult conditions for such a long time, friction is bound to occur, right?**

The 2010 Mars 500 study, in which six volunteers simulating a Mars expedition spent 520 days inside a container near Moscow, showed that people can

endure extreme situations and still get along with each other. A previous such study, in 1999, did not go so smoothly: during a New Year’s celebration, a few glasses of champagne helped trigger a brawl, and one participant was kissed against her will. This scandal has often been cited as an example of the risks inherent in long-term missions with small crews. But violence and abuses occur on Earth as well. My take on it is that the problems we see at home can just as easily occur in outer space. Of course, the consequences are more serious out there because there is no way to absent oneself from the scene. This is why it is so important to train the crew carefully to minimize the potential for chaos.

### **Do you look for particular social traits during the psychological vetting process?**

First of all, we look for the same kind of skill set that is relevant in the selection of pilots: attentiveness, memory, spatial orientation and reflexes. The candidate doesn’t have to be tops in all of



Her opposites, so to speak, were two team members who painstakingly analyzed each situation for potential weaknesses in our overall planning. They made every effort to ensure the safety of the crew – ironically, the majority of mishaps happened to them. But three other team members were perhaps the most important in terms of dealing with conflicts that arose. Two of them were born conciliators who argued rationally and posed probing questions whenever there were disagreements. And then there was Tristan, whose quick wit ensured that even tense confrontations were resolved with laughter.

The topics that we discussed changed over the course of the year. But the cause of conflicts always remained the same: differing motivations. Some had volunteered for the experiment because they saw it as an opportunity for personal challenge and enrichment. Whenever the HI-SEAS researchers made additional requests, they readily complied without grumbling. If they had free time, they worked on personal projects.

On the other hand, others had joined because they hoped to improve their chances of becoming astronauts. There's certainly nothing wrong with that. But it led two of

these areas, but he or she must not have glaring weaknesses in any of them. We're looking for "all-arounders." In a second set of tests we look at nontechnical characteristics such as the ability to cope with pressure, decision-making and teamwork. It is important that the candidates be able to communicate well with each other, cooperate and be able to put themselves in the other's shoes. These skills are necessary to resolve conflicts. This is why we give candidates a battery of questionnaires and observe them in group interactions.

### **What personality traits are especially advantageous?**

It's important to avoid extremes. Someone who is exceptionally extroverted can foul up the group dynamic as easily as someone who is withdrawn. Someone who is in constant need of conversation and social interaction probably won't do well on a long-term mission. By the same token, an introvert who needs a lot of time alone may get into trouble because

there's no place to escape to. The people need to be well balanced. Average does the trick—except in personality traits like agreeableness and conscientiousness, where we look for high scores.

### **There are people who just seem to get along in any group. Can this trait be measured?**

In fact, we are looking for candidates who are able to get along with lots of different people. But this is not so easy to measure. Some candidates seem to fit in with everyone and are a hit with the entire team. They bring with them a high degree of social adaptability, while maintaining their own integrity. They are very good at anticipating the needs of others and at intuiting how best to accommodate to their styles. This definitely fosters group harmony.

### **How is hierarchy within the crew established?**

Those decisions are mostly political, and the commander is named from outside the program. On missions like

the participants to try to get through the year with as little effort as possible. They resisted any work that had not been assigned to them from the beginning. In some cases, this led to arguments lasting hours about tasks that would have taken five minutes to complete.

It is doubtful that anyone seeking to travel to Mars would rather watch movies than explore the surface of the planet. But our experiences have shown that while astronauts on a real trip to Mars do not necessarily need similar character traits, they do have to be on the same wavelength when it comes to work.

### **Stress Test for Our Nerves**

Other factors frayed our nerves as well. For example, I found it hard not to be able to walk in a straight line for more than 36 feet or sleep with the window open. And I missed eating fresh raspberries. One thing that all six of us agreed on was that the endless stretch of volcanic rock made us miss the vibrant colors of living nature all the more. Even the city dwellers among us felt that way. Like the astronauts on the International Space Station or crews in a submarine, a Mars crew lives “inside” at all

the International Space Station, command has alternated between an American and a Russian. On its next mission in 2018, Alexander Gerst will be commander. He’s from Germany. Psychologically it is important to make sure that no crew member is extremely dominant and therefore unable to subordinate to the needs of the group. Too many crew members of this stripe, and the risk of conflict mushrooms. I would assume that the team selected for a Mars mission will have gotten to know each other very well by liftoff. During the training phase the astronauts will be closely observed, and if problems recur the necessary actions will be taken.

### **What does this training phase look like?**

At present it consists of survival training in which candidate astronauts solve problems together in extreme environments. The European Space Agency (ESA) offers a training course called CAVES (Cooperative Adventure for Valuing and Exercising human behavior

and performance Skills) in which a group spends two weeks in a cave system in Italy. NASA uses an undersea laboratory off of Key Largo called Aquarius to simulate a mission. Leadership roles alternate among crew members, so they all experience giving and taking orders and learn to work as a team. These crews probably won’t be sent into space together, as the training is mainly designed to further each individual’s skills.

### **As a psychologist, do you see other potential stumbling blocks for astronauts?**

Astronaut diaries show that they tend to be immersed in their work above all else. Many of them find it burdensome when there is nothing to do or they have to do simple tasks like housework or inventory. Boredom may pose a greater hazard for conflict. So on long-term missions it’s really important that the crew members be engaged in a constant regimen of meaningful work. The astronauts have to know that their sacrifices are actually worth it.



times—whether within the dome or “outside” in a space suit.

Because of this, we never felt the sun or wind on our skin. Likewise, although we saw our surroundings through the visor of our headgear, the real world was somehow beyond reach. The external wall of our habitat, the space suit, every stone: everything felt the same—mediated through the muffling bluntness of our gloves. Even if human beings land on Mars one day, we will unavoidably perceive it as outsiders.

Even in the habitat, after a few months everything felt the same. We knew every nook and cranny, every smell, every noise. A few of us had brought scented oils to give our noses a little olfactory vacation, but they didn't help much. Paradoxically, measures like these that we thought might remind us of our previous lives ended up making us feel even more isolated. Among other things, we brought along a virtual reality program with which we could pretend to sit on a beach or walk through the woods or along city streets. These pastimes were a welcome change. But at the same time they reminded us that we were surrounded by desolate lava rock.

Our physical isolation from the Earth

# The question of whether life exists or ever existed on the red planet is one of the key reasons for sending an expedition there.

meant that we were isolated from its inhabitants as well. We couldn't see them, smell them or touch them, but even worse was the fact that every word we transmitted or received was delayed by 20 minutes. No intimate or encouraging conversation can take place under those conditions. As a result, we tended to exchange only the most urgent messages. At the beginning, this arrangement functioned fairly well, but over time we lost our sense of connection to friends and family. And that loss was mutual. Although we “Martians” received selected news from home, we had only the barest inkling of what was really going on. At the same time, our families became increasingly unable to appreciate what we were going through. This process of disconnection is gradual and insidious. In my case it took almost nine months, toward the end of the

much-feared third quarter, before I began to feel really alone and forgotten. By that time some of the crew members were dealing with emotional lows.

Most of us developed strategies to counter the isolation. In my opinion, those who played sports and worked hard each day were the most successful. It gave them a sense of inner satisfaction to dedicate themselves to a personal project and experience a sense of growth.

It is hardly a secret that workouts help to decrease stress. But on a trip to Mars they would serve a second function as well. Weightlessness and the effects of reduced gravity have a harmful effect on health, and so astronauts will have to engage in intensive exercise to retain bone and muscle mass.

We turned our forays outside the habitat into a hybrid of sports and work. For

example, we experimented with extracting water from the extremely dry lava rocks, which are about as dry as those on Mars. We went “outside” in our space suits every two or three days. I think we can agree that walking on rocky, uneven terrain in a suit weighing up to 50 pounds at 8,200 feet qualifies as strenuous exercise. Toward the end of our mission our excursions lasted as long as six hours. We went on numerous research expeditions and explored about a hundred caves in the surroundings. After all, the point of flying to Mars is to unlock the planet’s secrets, not to stay in one’s little pod.

Exploration of this sort will be a major focus on Mars. For one thing, caves offer a certain degree of protection from cosmic radiation from which we on Earth are protected by our magnetic field and dense atmosphere. At the same time, they may harbor more moisture than the surface and even provide a refuge for living organisms. If such organisms ever existed on Mars, they would more likely have survived in caves.

The question of whether life exists or ever existed on the red planet is one of the key reasons for sending an expedition there. But even aside from that, human beings

have always endured hardships in the service of understanding our own planet. Non-government initiatives such as Mars One or the ambitious plans for SpaceX show that many people are ready to take on the rigors of the dangerous journey. Presumably, liftoff is only a matter of time.

Studies such as HI-SEAS are designed to increase the chances that the first Mars crew will survive and to create a setting in which its members can concentrate on seeking out signs of life rather than squandering their energies in conflicts and petty competition.

If it were possible for me to fly to Mars today, I wouldn’t hesitate—provided that I got along well with the crew and knew that I would get back in one piece. My year-long experience gave me a good understanding of the negative aspects of life away from Earth, and I know that I have what it takes. While my time on our Hawaiian Mars did not transform me into a completely new person, I have become much calmer in the face of enormous psychological stress. It now takes a lot to make me lose my equilibrium. For the privilege of delving into the secrets of an alien planet I would gladly forgo fresh raspberries for a few years. **M**

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OPINION

## Do Sexual Harassment Prevention Trainings Really Work?

Remarkably little research has been performed on the effectiveness of employers' efforts to raise awareness

By Vicki J. Magley and Joanna L. Grossman

Sexual harassment scandals abound. From media personalities to Hollywood directors to famous chefs, powerful men are getting called out for years if not decades of imposing themselves on women, and in some cases on men and children, with whom they work. These scandals are a sobering reminder that sexual harassment remains a persistent and pervasive problem in the American workplace. The incidents also prompt a return to old sociological and policy questions: What causes this behavior and what can be done about it?

On the latter question, the research

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points to a few areas ripe for change. For starters, nearly every employer nowadays has a policy prohibiting sexual harassment, and most also have internal grievance procedures in place designed to address such problems. U.S. law rewards these two measures by minimizing liability for employers who take them. But neither has much of an effect on the likelihood that sexual harassment will occur in the first place. Despite its ubiquity, the law offers no special reward for trainings to prevent and raise awareness of sexual harassment—and popular culture does nothing but mock the concept. But studies suggest that training can help, particularly if its goals reflect the knowledge gained from research.

Most training programs aim to educate employees about the employer's sexual harassment policies and procedures, as well as the conduct that is explicitly prohibited. A few studies of college students show that participants leave training more knowledgeable about the subject of harassment than when they began it. But in studies of working adults, in one sample, knowledge improved only among men, and in another, it improved only among white

employees. Moreover, in a study of managers, who are increasingly required to undergo mandatory training, trained managers were no more able to identify proper responses to harassment after training than untrained managers and, post-training, they tended to identify scenarios as sexual harassment that really were not.

Training about sexual harassment often is also geared to increase employees' attitudes about the seriousness of harassment and increase belief that the organization also takes it seriously. Unfortunately, research does not support these effects. Neither students nor working adults showed any change after training in their personal attitudes about harassment or in their perceptions of organizational tolerance for it. Indeed, at least one study showed that a brief training intervention produced a backlash such that men were more likely to blame a victim of sexual harassment than were those who did not receive the training.

Ultimately, the "gold standard" for sexual harassment training is to reduce sexual harassment. To date, however, only one research study has looked at this outcome. And it found that the training was ineffective.



Two recent studies have taken a more complex view of prevention training by examining how organizational culture also factors into training effectiveness. First, knowledge *and* personal attitudes were changed for employees who perceived that their work unit was ethical, regardless of their personal sense of cynicism about whether the training might be successful. However, employees who already believed that their employers tolerated sexual harassment took that cynicism into training sessions and were less motivated to learn from it. That sense of futility affected their belief about whether training would be useful, more even than their own personal beliefs about sexual harassment.

Workplace harassment is pervasive—four in 10 working women report experiencing harassment within any two-year period—and existing law emphasizes preventative measures. But the studies we describe here are basically the sum total of research about whether these trainings are effective. Considerably more legal and psychological studies could help us understand how best to protect employees from sexual harassment. We suggest three areas of improvement:

1. Institutional culture change is needed. If workplace environments are influencing employees' attitudes toward training and/or its actual effectiveness, then employers need to pay more attention to the cultural environment of their organization. The paucity of data on evaluating training effectiveness is a direct result of organizations lacking an incentive to conduct internal studies, or self-studies, of their prevention trainings. Specifically, if data reveal that training was ineffective, employers are concerned that these insights would enhance their liability—and, so, they just don't gather these data. Such head-in-the-sand thinking needs to change. Self-study, as noted in a 2016 report from the Equal Employment Opportunity Commission's Select Task Force on the Study of Harassment in the Workplace, should be encouraged and lauded as an important part of improving the organizational climate around sexual harassment.

2. Employers should institute training with clear goals in mind. Is training expected to change employee attitudes? In some ways, it is not surprising that training does not alter long-held beliefs about and be-

haviors toward women. But training should not be crafted around a goal that is unattainable—or its content should be changed to increase the likelihood of achieving it. Is training supposed to convey the employer's commitment to maintaining a non-discriminatory work environment? Or is it merely calculated to minimize the employer's exposure to liability? There is no reason to expect that all sexual harassment prevention training will produce the same results, nor that those results will necessarily lead to a reduction in discriminatory behavior. As the 2016 EEOC report suggests, perhaps it is time to completely reconsider such training and replace it with respect-based interventions. Such interventions will, naturally, still require validation in research studies. Most importantly, though, training should have clear, decisive goals so that employees do not leave feeling confused and overwhelmed. Not only can such confusion cause employees to ignore what they've learned, it can also lead to other kinds of discriminatory behavior such as men avoiding work of any kind with women to avoid transgressing some unclear boundary.

3. Sexual harassment awareness and prevention training must be evaluated. The legal regime governing employer liability for workplace harassment has placed far too much emphasis on the existence of preventative measures like training and not nearly enough on the effectiveness of these measures. Courts neither review the content of training programs nor ask employers to assess their validity internally (do they achieve what they are supposed to achieve?). They routinely allow employers to dodge liability despite clear evidence that preventative measures that were undertaken failed. Training programs, like anti-harassment policies and procedures, are symbolic evidence of legal compliance, and their potential role in actually reducing harassment is ignored. As a result, training programs are rarely evidence-based and often lack meaningful content. The law should create incentives for employers to conduct such evaluations, such as acknowledging that such evaluations are indicative of a sincere desire to truly change the way women are treated in the workplace. **M**

### Further Reading

**The Unexpected Effects of a Sexual Harassment Educational Program.** S. G. Bingham and L. L. Scherer in *Journal of Applied Behavioral Science*, Vol. 37, pages 125-153; 2001.

**Managing Workplace Sexual Harassment: The Role of Manager Training.** T. J. Buckner et al. in *Employee Responsibilities and Rights Journal*, Vol. 26, pages 257-278; 2014.

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EEOC report of the Select Task Force on the Study of Harassment in the Workplace, June 2016: [www.eeoc.gov/eeoc/task\\_force/harassment/report.cfm](http://www.eeoc.gov/eeoc/task_force/harassment/report.cfm)

**Some Effects of Brief Training Interventions on Perceptions of Sexual Harassment.** R. S. Moyer and A. Nath in *Journal of Applied Social Psychology*, Vol. 28, pages 333-356; 1998.

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**Individual and Contextual Inhibitors of Sexual Harassment Training Motivation.** B. M. Walsh et al. in *Human Resource Development Quarterly*, Vol. 24, pages 215-237; 2013.

**Preventing Sexual Harassment: The Effect of Multiple Training Methods.** K. M. York et al. in *Employee Responsibilities and Rights Journal*, Vol. 10, pages 277-289; 1997.



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OPINION

## How to Avoid “Purchase Regret”

Follow the millennial generation’s four golden rules of personal finance

By Conor Artman,  
Joseph Sherlock and  
Dan Ariely

**M**illennials are the largest living generation in the United States, providing them with a guiding influence over the economy. And fortunately, despite cultural misgivings from some critics, many financial experts applaud this generation for its strong personal financial habits. They point to millennials' tendency to save more than previous generations, value a work-life balance and spend more on experiences than objects—all while balancing massive student debt and historically low wages.

So what can we learn from these financial priorities? To understand what makes millennials tick financially, we set out to

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# How can we avoid falling victim to those spur-of-the-moment buys?

measure how satisfied they are with their purchases. Or, more precisely, to see which expenditures they regretted the most.

As behavioral economists, we know that regret is a negative reinforcement that spurs people to self-correct. It's infuriating to get your car towed, right? But it also means you'll become more vigilant about reading parking signs in the future. Similarly, regretting a purchase is often the most direct way to avoid making the same type of purchase again. As with a film negative, by knowing what millennials regret spending money on, we can also see what they consider good financial behavior.

To do this, we partnered with the personal finance app Qapital to build a tool that measured people's level of spending regret. Using that tool, we asked people 20–36 years old who had already voluntarily linked their bank accounts to Qapital to rate their expenditures.

So what did we find? Here are the four

golden rules of personal finance as practiced by millennials.

## **Spend on Enrichment and Others**

In the study, we measured what types of purchases were most pleasing to people and when they made the purchases they were most pleased with. For the former, five different types of purchases generated a satisfaction level of 75 percent or above (in order): community, health care, utilities (including rent), arts & entertainment, and education. Overwhelmingly, these all have to do with self-preservation or enriching oneself.

At the same time, millennials were much more content with purchases made midweek and in early December. From this, we can infer that purchases made for others (holiday season) bring more pleasure and that people tend to prefer those purchases made midweek (Wednesday had the highest satisfaction rating) over those made on the weekend,



when we might buy things more impulsively (this is explained more fully below).

While this doesn't mean we should buy everything on Wednesdays in early December, it does suggest that we can derive satisfaction most when buying for others, when enriching ourselves, or when making thoughtful and deliberate purchasing decisions.

### **Put the Essentials on Autopay**

Millennials in our survey were generally about 10 percent more satisfied with recurring transactions compared to non-recurring ones. This is particularly high for purchases like convenience, debt repayment and health care.

One reason for this is because humans are great adapters. Our first experience of something is novel and interesting, but after several similar experiences the novelty and our attentions wane until we no longer have the same response. In the same way, more noticeable transactions are more regretful.

By setting up automatic payments for recurring and relatively stable transactions like rent, insurance and auto payments we can discount the financial pain of those payments and become more satisfied with them

as regular occurrences. On the other hand, make the payments you're likely to regret—another round of drinks at the bar or a fast-food stopover—more obvious and novel by paying in cash.

### **Limit Impulse Buys**

Just as the expenses necessary for living—rent, health care, groceries—reside near the top of the satisfaction results, so do those more optional purchases fall to the bottom. Millennials rate bar purchases, digital subscriptions, convenience store buys, coffee shop expenses, restaurant visits and fast-food purchases as their least satisfying expenditures. Only bank fees rate lower.

These types of things can often be those purchased on weekends, and such purchases also showed a high degree of regret. We can begin to reason that millennials take far greater pleasure in making responsible, deliberate and necessary purchases over spontaneous, frivolous ones.

How can we avoid falling victim to those spur-of-the-moment buys? Make “cold state” decisions removed from the heat of the moment. Determine on Wednesday or Thursday how much you want to spend on the weekend, and then have cash on hand to pay for

it. This can limit your reactionary spending and ensure greater levels of satisfaction.

### **Second Guess the Small Stuff, Don't Rationalize the Big Buys**

Across all types of purchases, millennials were less satisfied with smaller purchases than larger ones. We found that the average person reported higher satisfaction for purchases taking up a larger portion of his or her monthly income.

Why do we regret smaller purchases more? People often look backwards to justify their decisions rather than making decisions based on sound reasoning and evidence. If we spent a lot of money on something that we didn't like, we rationalize ourselves into believing that we *must* have made a good purchase because it was an expensive purchase.

So the lesson is twofold: 1. Question the small purchases. Just because that latte only costs \$4 does not mean it's inconsequential or won't bother you later. 2. Research the big purchases. Instead of rationalizing them away after the fact to justify the expense, do your research and make an informed decision. Your happiness will thank you on both counts. **M**



OPINION

## Is Addiction a Disease?

The current medical  
consensus about addiction  
may very well be wrong

By Elly Vintiadis



The prevailing wisdom today is that addiction is a disease. This is the main line of the medical model of mental disorders with which the National Institute on Drug Abuse (NIDA) is aligned: addiction is a chronic and relapsing brain disease in which drug use becomes involuntary despite its negative consequences.

The idea here is, roughly, that addiction is a disease because drug use changes the brain and, as a result of these changes, drug use becomes compulsive, beyond the voluntary control of the user. In other words, the addict has no choice, and his behavior is resistant to long-term change.

This way of viewing addiction has its benefits: if addiction is a disease then addicts are not to blame for their plight, and this ought to help alleviate stigma and to open the way for better treatment and more funding for research on addiction. This is the main rationale of a [recent piece in the \*New York Times\*](#), which describes addiction as a disease that is plaguing the U.S. and stresses the importance of talking

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## In other words, the addict has no choice, and his behavior is resistant to long-term change.

openly about addiction in order to shift people's understanding of it. And it seems like a welcome change from the blame attributed by the moral model of addiction, according to which addiction is a choice and, thus, a moral failing—addicts are nothing more than weak people who make bad choices and stick with them.

Yet, though there are positive aspects to seeing addiction in this light, it seems unduly pessimistic and, though no one will deny that every behavior has neural correlates and that addiction changes the brain, this is not the same as saying that, therefore, addiction is pathological and irreversible.

And there are reasons to question whether this is, in fact, the case.

From everyday experience we know that not everyone who tries or uses drugs and alcohol gets addicted, that of those who do many quit their addictions and that people don't all quit with the same ease—some

manage on their first attempt and go cold turkey; for others it takes repeated attempts; and others still, so-called chippers, recalibrate their use of the substance and moderately use it without becoming re-addicted.

But there is also strong scientific evidence that most people recover from addiction on their own and that things are not as simple as the medical model implies.

In 1974 sociologist Lee Robins conducted [an extensive study](#) of U.S. servicemen addicted to heroin returning from Vietnam. While in Vietnam, 20 percent of servicemen became addicted to heroin, and one of the things Robins wanted to investigate was how many of them continued to use it upon their return to the U.S. and how many remained addicted. What she found was that the remission rate was surprisingly high: only around 7 percent used heroin after returning to the U.S., and only about 1-2 percent had a relapse, even briefly, into

addiction. The vast majority of addicted soldiers stopped using on their own.

Also in the 1970s, psychologists at Simon Fraser University in Canada conducted the famous “Rat Park” experiment in which caged isolated rats administered to themselves ever increasing—and often deadly—doses of morphine when no alternatives were available. Yet, when these rats were given a mate and alternatives to drugs they stopped taking them. And in 1982 Stanley Schachter, a Columbia University sociologist, provided evidence that most smokers and obese people overcame their addiction without any help.

Although these studies were met with resistance, lately there is more evidence to support their findings.

In *The Biology of Desire: Why Addiction Is Not a Disease*, Marc Lewis, a neuroscientist and former drug addict, argues that addiction is “uncannily normal,” and he offers what he calls the learning model of addiction, which he contrasts to both the idea that addiction is a simple choice and to the idea that addiction is a disease. Lewis acknowledges that there are undoubtedly brain changes as a result of addiction, but he argues that these are the typical results

# It is incredibly hard, and for some people, practically impossible to undo years of habit.

of neuroplasticity in learning and habit formation in the face of very attractive rewards.

In reviewing a number of case studies, Lewis argues that most addicts don’t think they are sick (and this is good for their recovery) and that the stories of people who have overcome their addiction, instead of impotence and disease, speak of a journey of empowerment and of rewriting one’s life narrative. That is, addicts need to come to know themselves in order to make sense of their addiction and to find an alternative narrative for their future. In turn, like all learning, this will also “re-wire” their brain.

Taking a different line, in his book *Addiction: A Disorder of Choice*, Harvard University psychologist Gene Heyman also argues that addiction is not a disease but sees it, unlike Lewis, as a disorder of choice. Heyman presents powerful evidence not only that just about 10 percent of people who use drugs get addicted and only

around 15 percent of regular alcohol drinkers become alcoholics but also that around 80 percent of addicts overcome their addiction on their own by the age of 30. They do so because the demands of their adult life, like keeping a job or being a parent, are incompatible with their drug use and are strong incentives for kicking a drug habit.

This might seem contrary to what we are used to thinking. And, it is true, there is substantial evidence that addicts often relapse. But most studies on addiction are conducted on patients in treatment, and this skews the population sample. Most addicts never go into treatment, and the ones who do are the ones, the minority, who have not managed to overcome their addiction on their own.

What becomes apparent is that addicts who can take advantage of alternative options do, and do so successfully, so there seems to be a choice, albeit not a simple one,



involved here as there is in Lewis's learning model—the addict chooses to rewrite his life narrative and overcomes his addiction.

However, saying that there is choice involved in addiction by no means implies that addicts are just weak people, nor does it imply that overcoming addiction is easy. It is incredibly hard, and for some people, practically impossible to undo years of habit.

The difference in these cases, between people who can and people who can't overcome their addiction, seems to be largely about determinants of choice. Because in order to kick substance addiction there must be viable alternatives to fall back on, and often these are not available. Many addicts suffer from more than just addiction to a particular substance, and this increases their distress; they come from underprivileged or minority backgrounds that limit their opportunities, they have histories of abuse, and so on. So although choices are *in principle* available, *viable* choices for people are largely dependent on determinants of choice beyond their control, and this can mitigate their responsibility.

This is important, for if choice is involved, so is responsibility, and that invites blame and the harm it does, both in terms

of stigma and shame but also for treatment and funding research for addiction.

It is for this reason that philosopher and mental health clinician Hanna Pickard of the University of Birmingham in England offers an alternative to the dilemma between the medical model that does away with blame at the expense of agency and the choice model that retains the addict's agency but carries the baggage of shame and stigma. Both these models, Pickard claims, place the responsibility away from us: it is either the addict's fault or the disease's. But if we are serious about the evidence, we must look at the determinants of choice, and we must address them, taking responsibility as a society for the factors that cause suffering and that limit the options available to addicts. To do this we need to distinguish responsibility from blame: we can hold addicts responsible, thus retaining their agency, without blaming them but, instead, approaching them with an attitude of compassion, respect and concern that is required for more effective engagement and treatment. And the two, responsibility and blame, can come apart if we realize that responsibility is about the person who makes choices, but blame is about

our choice of how to respond to them.

In this sense, the seriousness of addiction and the suffering it causes both to the addicts themselves but also to the people around them require that we take a hard look at all the existing evidence and at what this evidence says about choice and responsibility—both the addicts' but also our own, as a society. We can call addiction a disease because the concept of a disease is not clearly defined, but if by “disease” we mean that there are brain changes that lead to lack of choices, then there is ample evidence to dispute this view. In the end, we cannot understand addiction merely in terms of brain changes and loss of control; we must see it in the broader context of a life and a society that make some people make bad choices. **M**

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