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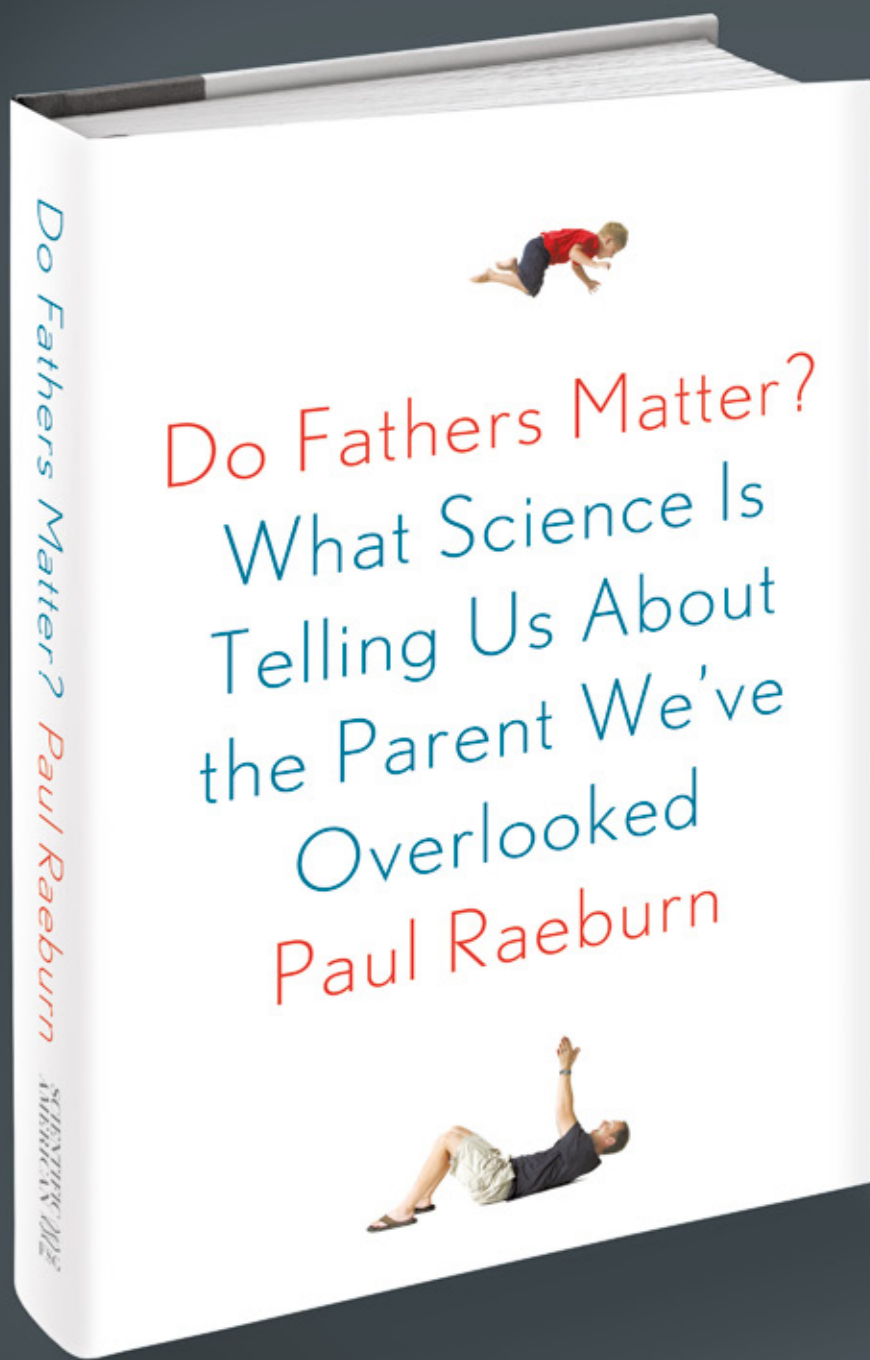
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Living a Purposeful Life

In a recent tête-à-tête with my boss, Mariette DiChristina, we mused over what motivates us in life and work. She shared a quote from George Bernard Shaw: “This is the true joy in life, the being used for a purpose recognized by yourself as a mighty one ... the being a force of Nature instead of a feverish selfish little clod of ailments and grievances complaining that the world will not devote itself to making you happy.”

The words lingered in my thoughts as I wrapped up our cover story, on burnout. We tend to associate burnout with exhaustion, yet a clash between one’s values and the demands of a job is equally burdensome. Psychologists Michael P. Leiter and Christina Maslach explore the causes of and remedies for workplace dissatisfaction in “Conquering Burnout.” To once again view a job as meaningful, the authors suggest trying to improve its social atmosphere, among other things. Turn to page 30.

Shaw’s words compelled me to articulate my own “mighty” purpose, which is to educate and inspire readers through powerful stories. Yet I can lose sight of that goal when life’s inevitable hurdles trip me up, triggering that “selfish little clod of ailments” known as frustration, anger and fear. Starting on page 48, psychologist and editor Steve Ayan offers advice for defusing negative sentiments early. He explains the five stages through which emotions escalate in “How to Control Your Feelings—and Live Happily Ever After.”

For young adults on the autism spectrum, learning to cope with anxiety is a key step toward entering the workforce. They often struggle to land jobs, yet extra training might be all they need to pursue a rewarding career. In “Autism Grows Up,” beginning on page 36, writer Jennifer Richler profiles a leading program that is helping some individuals gain employment.

The themes in this edition were timely for me, in that I recently faced a tough career decision myself. One of the joys of working here is that nearly every day I learn something relevant to my own life. Yet my path is now leading me elsewhere, so this is my final issue at the magazine’s helm. I will stay on as a contributing editor, but more important, I will remain *Scientific American Mind*’s biggest fan. I eagerly await whatever the team dreams up next.

Sandra Upson
 Managing Editor
editors@SciAmMind.com

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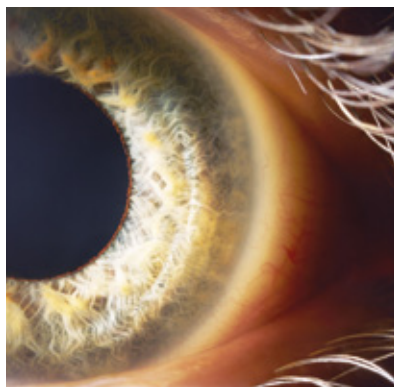
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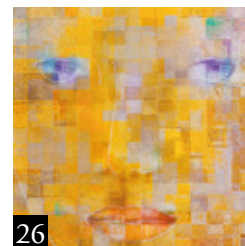
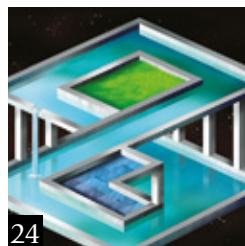
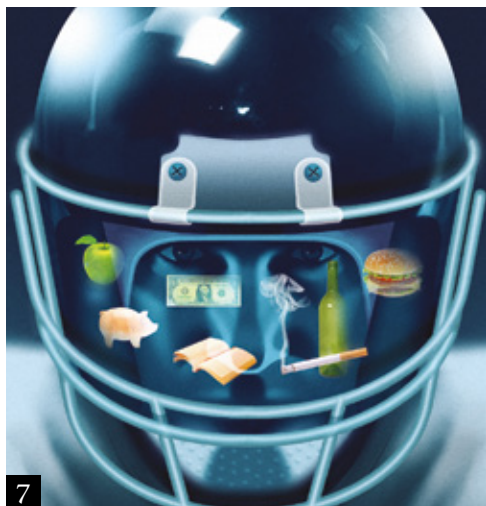


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THINKING ABOUT THINKING

Excellent article on metacognition [“The Power of Reflection,” by Stephen M. Fleming]. In reflecting on it, considering that metacognition is probably formed in large part with the help of external feedback, it occurs to me that for the past several decades, vast swaths of Americans have most likely had their metacognition impaired by unconditional positive reinforcement (for instance, unearned positive feedback or grade inflation), lack of punishment and drug abuse.

I have noticed that in mainstream American society many people have undue levels of confidence, which perhaps can be explained by impaired metacognition. This phenomenon is important because in matters such as hiring and mating we depend in no small part on one another’s metacognition. Overconfidence or underconfidence can have direct consequences in many contexts, such as the above, and indirect consequences in many others downstream, such as the economy, unemployment, social discord, health and evolution.

Jory Meltzer
via e-mail

Another very enjoyable issue. Fleming’s article was very well done. In his discussion of dysfunction, I noticed that all of the research that was cited concerned problems of reduced metacognitive function-

ing. I wonder whether dysfunction might also result from overactive metacognitive functioning. Some research suggests that rumination is a central feature of depression, at least in a subpopulation of depressed individuals. Rumination tends to be self-focused, including thoughts about one’s own depressive symptoms; as such, it could be characterized as overactive metacognition.

I have chronic depression. I tend to ruminate, and much of my rumination is metacognitive. In fact, I have often described it this way to therapists, complaining that I sometimes have two, or even three layers of metacognition running at the same time, making it extremely difficult to concentrate. I would be interested to find out whether any research has shown that people with depression exhibit hyperactivity of the regions involved in metacognition or hypoactivity in the regions that exert top-down executive control over metacognitive processes.

Aaron Konopasky
via e-mail

FLEMING RESPONDS: *Konopasky raises an intriguing link between metacognition and rumination, a key feature of depression. We currently do not understand how the neurobiology of depression relates to the work on metacognition outlined in the article. Early PET studies found that depressed individuals have reduced glucose metabolism in the lateral prefrontal cortex and increased metabolism in medial prefrontal regions, compared with controls. Functional MRI studies have shown abnormal increases in functional connectivity among the medial prefrontal cortex and other brain regions in depression, possibly consistent with an increased self-focus and rumination.*

Further experiments such as those suggested by Konopasky—examining brain activation and connectivity while depressed people engage in metacognition—would be needed to understand whether these tantalizing findings are related to changes in metacognitive thought.

MIGRAINE LINK?

Thank you for Stephani Sutherland’s interesting article on fibromyalgia, “An Unnerving Enigma.” Unfortunately, one

VIOLENCE AT HOME

Allison Bressler's article about domestic violence, "Love and Death," inspired many letters to the editor. Some were complimentary: "Kudos to your magazine for publishing this story on domestic violence," writes Kathryn Warren via e-mail. "All people need to be aware of the behavior signs of abusive persons so they can make better judgment calls before they invest in any relationship."

Yet a few readers felt we focused unfairly on male violence toward women. "I agree most abuse comes from men, but women can also be abusive," writes DeWayne Watts via e-mail. Research bears out this fact. Bressler responds, "That's true. Studies show that one out of seven men are battered in their relationship. It is important to note that number includes men in same-sex relationships. Men tend to experience verbal, emotional and financial abuse from their female partners; there are no specific studies that show at what rate women physically assault their partners."

Many of you were concerned about the effect of domestic violence on children. "Men who abuse their wives don't abuse only their wives," writes Michèle Gyselinck of Montreal. "Those who counsel women in abusive relationships might want to address the problem of how this abuse affects the kids, even if they aren't actually beaten themselves." Bressler agrees and reports that many agencies do provide much needed counseling for children.

A couple of readers wrote in to suggest advice or further resources for victims. Paul Carney of Towson, Md., cautions that the



article's recommendation to program the number for a shelter into a victim's phone could backfire: "Many abusers will check the victim's phone on a regular basis," he writes. "The consequence of finding an unknown phone number, or that of a shelter, could be catastrophic." Safety plans should indeed be tailored to each victim's circumstance, Bressler concurs. For a deeper discussion of abusive relationships and solutions, Citizens Advice Bureau counselor Michael Egan of St. Helens, England, suggests the highly regarded

Why Does He Do That? by Lundy Bancroft (Berkeley Books, 2003).

The big question on many of your minds is: How can we change our culture so that abuse happens less frequently? "As an educator and parent of a young child, I am wondering what we can do much earlier in life to foster the development of women who would reject a partner's complete control of her finances, behavior and physical appearance and, furthermore, would recognize it right away as abuse," writes Liz Swan via e-mail. Bressler reports that many schools in the U.S. have programs for middle school and high school children in which they learn about healthy and nonhealthy relationship behaviors. "I would also suggest that any parent engage their children about what they believe is healthy and not healthy in a partnership," Bressler says. "We must begin the conversation with young children, in an age-appropriate way, so that they understand they are equal in their intimate relationships."

—The Editors

fundamental view about the origin of the disorder was missing. Fibromyalgia is, like tension headaches and some other not so well defined pain disorders, only one symptom of central sensitization syndrome, also known as migraine syndrome. As mentioned in the article, patients do not have just pain but also fatigue, memory and mood problems, sleep disturbances, and a variety of symptoms of the dysregulation of the autonomic nervous system.

This symptomatology does not differ at all from that what we see in chronic migraine. The entire spectrum of symptoms does not always manifest at the same time, but over the years—if different epigenetic and stress factors generate more and more widespread neuronal dysfunction—we see one symptom after another

rising and fading, typically in a rhythm of three to four months. As a neurologist, I've seen hundreds (if not thousands) of migraine patients also diagnosed with fibromyalgia. After recognizing more than 10 years ago that fibromyalgia is just one variation of the sensorineural dysfunctions seen in migraine syndrome, I have had many more treatment options to offer to my patients.

Matti Ilmavirta
Jyväskylä, Finland

SUTHERLAND REPLIES: As Ilmavirta rightly points out, fibromyalgia involves many symptoms aside from bodily pain that are rooted in the brain. Many questions still surround this "central sensitization," which has been called by various other names as well, such as somatization syndrome. Fibromyalgia seems to

be only one trigger of this sensitization; other mysterious pain conditions can also culminate in the brain state. The changes in the nervous system that lead to central sensitization are still poorly understood. But the new findings discussed in the article suggest that—contrary to previous investigations of patients with fibromyalgia—ongoing peripheral nerve damage could be one such trigger. The hope is that if the nerve damage were to be halted or alleviated, the rest of the syndrome might also recede, but much work remains to be done to determine whether that will happen in people with fibromyalgia.

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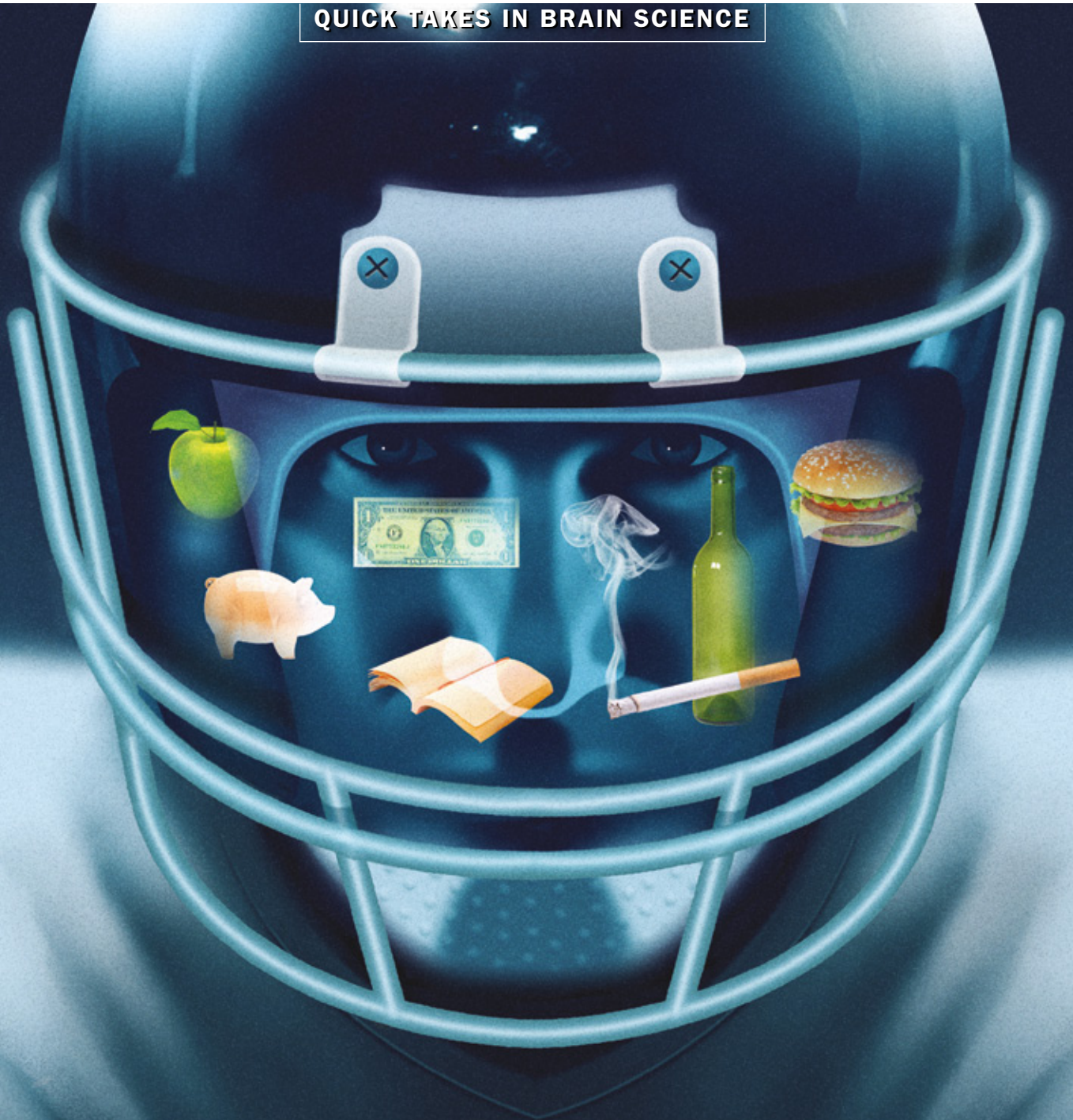
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Head Lines

QUICK TAKES IN BRAIN SCIENCE



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ILLUSTRATION BY STUART BRIERS



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» The Persistence Playbook

STRATEGIES FOR STICKING TO YOUR GOALS

Let's face it: changing our habits is really hard. Only about 10 percent of people accomplish their New Year's resolutions in the following year, according to studies of Americans and the British. The more we understand about how our brain works, however, the better we can help ourselves succeed—and adopting a different mind-set is often all it takes. Read on to learn how to beat your baser instincts and persevere.



See Setbacks in a New Light

Hiccups are inevitable—here's how to cope with them

Getting discouraged by setbacks is one of the most common reasons people fail to meet their goals. Recent research at Rutgers University reveals that people who felt a setback was within their control were more likely to persevere afterward, as were people who got more frustrated by adversity. The results jibe with a larger body of work suggesting that if you approach setbacks and your ensuing negative emotions with the right mind-set, you will be more likely to bounce back.

Increase your feelings of control

- Take a stance of actively learning about the process of reaching your goal. Every setback is educational and will help you learn how to succeed.
- See the journey to your goal as an adventure. Any setbacks are interesting twists in the plot rather than damning verdicts on your abilities.
- Reexamine your actions to find things you might have done differently.
- Look at the chance to try again as a gift.
- View persistence as a choice rather than a personality trait.
- Seek specific critical feedback. Detailed information can help you focus on what needs to change.

Make use of your frustration

- Let it fuel your focus. Use it to draw your attention to what can be done differently next time. Doing so will help you see setbacks as valuable information.
- Look at the frustration as a healthy sign of caring about your goal.
- Consider the flip side. If you are not frustrated, maybe you do not care enough about the goal or you are looking for an excuse not to reach it. Figure out what you really want.
- Do not beat yourself up. Blaming yourself and feeling inadequate may prevent you from figuring out what to change on your next attempt.
- Decrease stress in general. People have a harder time coping with emotions when they are stressed out. —Michele Solis

How Would a Psychologist Get in Shape?

We asked experts on behavior change how they recommend approaching three of the most common New Year's resolutions. The advice can be generalized to just about any goal, so read on even if you have a more unusual challenge ahead of you.

—Victoria Stern

Resolution #1: Eat healthier

"New Year's resolutions are often too general," says Philippa Lally, a research psychologist at University College London. She emphasizes identifying specific behaviors, deciding when to perform them and then doing so repeatedly. For instance, map out when you will eat your five servings of fruits and vegetables—one with each meal, one for your midday snack and one after dinner. At some point you will likely give into temptation, she says, but do not be deterred. Forming a new habit can take anywhere from 18 to 254 days, according to one study by Lally and her colleagues.



Resolution #2: Quit smoking

"We can improve self-control through practice," says Mark Muraven, associate professor of psychology at the University at Albany. In fact, Muraven notes, increasing our willpower is similar to strengthening a muscle. In a recent study, he found that smokers remained abstinent longer if they exerted self-control in other areas, such as cutting back on desserts, before attempting to quit. Don't overdo it, though—willpower can get depleted if you try to exercise it too much. Focus on your primary goal. If you keep slipping up, cut back on other attempts to use self-control.



Resolution #3: Spend less, save more

"If you're uptight and stressed while trying to modify a behavior, you actually inhibit yourself from changing, but if you're playful and flexible, you may become more open to figuring out a way to reach your goal," says B. J. Fogg, an expert on behavior change at Stanford University. Changing your behavior should not feel like drudgery. To save money, for example, be creative about how to cut back. Find a quirky vintage shop to purchase your winter coat or experiment with new recipes that make cooking more enticing than eating out.



THREE CHALLENGES OF HUMAN NATURE AND HOW TO OVERCOME THEM



Procrastination

Think about deadlines differently

What makes some tasks harder than others to tackle? It turns out the time allotted for the work matters less than how our mind perceives the deadline. When a deadline feels like it is part of the present—say, falling within the current calendar month—we are more likely to begin the task.

In one experiment, researchers asked 100 undergraduates when they would start a data-entry task that they had five days to complete. For some, the hypothetical assignment started April 24 or 25, whereas others got the job April 26 or 27. Although the groups had the same amount of time, the students with

a deadline in early May were less willing to begin the task right away, according to the study, which appeared in the *Journal of Consumer Research*.

An experiment involving 295 farmers in India had a similar outcome. At a finance lecture, the farmers learned they could earn a monetary benefit if they opened a bank account and saved a certain amount within six months. One group's six-month deadline landed in December, another group's in January. Farmers whose deadline came before year's end were more likely to open the account immediately and more likely to meet the six-month savings goal.

The findings illustrate how the brain divides time into discrete categories, with boundaries at the end of a month or the start of a new year, for instance. To motivate yourself to start a task you are putting off, try thinking about time boundaries differently. For a deadline next month, you might call it three weeks instead—or design a new calendar for yourself that does not break up the months. The researchers also suggest dividing a task into incremental steps with their own deadlines, which will feel more immediate.

—Esther Landhuis

Impulsiveness

Orient yourself to the future by looking at pictures of nature

Gazing at images of the great outdoors has been

linked with a range of benefits, including pain relief, stress recovery and mood improvement. Now a study published in May 2014 in *PLOS ONE* adds impulse control to that list. Researchers at Utah State University asked three groups of participants to complete a task that tests whether they could resist instant gratification for a better reward later on. Before and during the task, the nature group viewed images of mountains, whereas the other groups looked at pictures of buildings or triangles. Participants who viewed natural scenes made less impulsive decisions than the other groups.

Follow-up experiments revealed that seeing nature makes us think more about the future, says the study's lead author Meredith S. Berry, a psychologist now at the University of Montana. "When time is expanded, it is easier for people to imagine the future, and this effect appears to lessen the draw of immediate temptations." These findings mean that even when you're stuck at the office until sundown, you can still reap some cognitive benefits by looking at images of natural landscapes on your computer screen—and it may just keep you from raiding the office fridge.

—Tori Rodriguez



Performance Anxiety

Call it excitement and psych yourself up

Pounding heart, rapid breath, racing thoughts—is it anxiety or excitement? New studies at Harvard University found that by interpreting these sensations as excitement instead of anxiety, people performed better in three types of stressful situations: singing in front of strangers, speaking in public and solving difficult math problems.

In the experiments, some participants were told to either try to calm down or try to get excited before the task; others were given no such instructions. People who viewed their anxious arousal as excitement not only reported feeling more excited, they also performed better on all tasks than the other participants: their singing was about 30 percent more accurate, their scores on several dimensions of public speaking were approximately 20 percent higher, and their performance on a timed math test was about 15 percent better, according to the paper, which ran in the *Journal of Experimental Psychology* last June. Another Harvard study, published in *Emotion* in August 2014, also found performance-boosting effects for people with social anxiety who thought of their stress as being helpful during a public performance.

Most people try to calm down when facing high-stakes situations, but that approach backfires by increasing rumination about what could go wrong. Instead choose to focus on the potential high points of the scenario—for instance, look forward to making colleagues laugh during a presentation or knowing how to solve some problems on a test. "Getting excited about how things can go well will give you confidence and energy and increase the likelihood that the positive outcomes you imagine will actually happen," says Alison Wood Brooks, an assistant professor of business administration at Harvard Business School and author of the June paper.

—T.R.

Each of these experiences is complex enough that we could write an entire feature about them—and we have! Visit www.ScientificAmerican.com/Mind/goals-2015 to explore our in-depth coverage of procrastination, impulsiveness, performance anxiety, and more.

»» How Your Beverage Affects Your Mind

Coffee and Tea May Protect the Brain

Daily drinkers have lower rates of depression and cognitive decline

Coffee and tea may do more than just jolt you awake—they could also help keep your brain healthy, according to a slew of recent studies. Researchers have linked these beverages with protection from depression, Alzheimer's disease and Parkinson's disease.

One large study investigated the link between depression and the intake of coffee, tea and sweet drinks [*see box below*] by following more than a quarter of a million older adults for 10 years. Researchers at the National Institutes of Health recorded consumption of each type of beverage in 1995 and 1996 and then compared those figures with participants' self-reported diagnoses of depression after 2000. Results showed that coffee intake was associated with a slightly lower risk for depression, according to a paper published last April in *PLOS ONE*. The paper found little effect from tea, but other work has shown tea to be protective.

A study reported in November 2013 found older Chinese adults who regularly drank any kind of tea had a significantly smaller risk for depression: 21 percent for those who drank tea between one and five days a week and 41 percent for daily drinkers. The researchers also asked about the partici-



pants' leisure activities to ensure that the tea, and not teatime socializing, provided the protective effect.

Some studies suggest that coffee and tea drinkers have lower rates of cognitive decline, too, but the evidence is mixed. Research in rodents that has focused on specific compounds in coffee and tea supports the idea that some of these chemicals reduce the risk for Alzheimer's and Parkinson's. In one such study, published online last June in *Neurobiology of Aging*, supplementing rats' diets with a component of coffee called eicosanoyl-5-hydroxytryptamide shielded the animals'

brains against the pathological changes typical of Alzheimer's. In 2013 another experiment found the same compound to have protective effects against a mouse model of Parkinson's. Caffeine may not just defend the brain but help it, too—a paper in September in the same publication reports that spiking the mice's drinking water with caffeine reduced the protein tangles seen in Alzheimer's, and it also prevented spatial memory deficits.

It is still too soon to say whether coffee and tea truly protect the brain, but most researchers agree a daily habit couldn't hurt.

—Tori Rodriguez

Fact or Fiction?

Here's what the science says about some popular claims regarding the cognitive effects of certain drinks:



1. Pomegranate juice enhances memory: Probable. Many studies support the connection, including a recent brain-imaging study that showed that volunteers with age-related memory issues who consumed this antioxidant-rich drink performed better on memory tasks than those who drank a red placebo drink.



2. Red wine staves off cognitive decline: Possible. A growing body of research continues to support the health benefits of drinking wine. One study, which followed a group of men and women over seven years, found that those who consumed moderate quantities of red wine performed better on cognitive tests than those who tended to abstain from alcohol or who consumed beer or liquor.



3. Breast milk boosts cognitive development in childhood: Doubtful.

A 2013 comprehensive literature review concluded that although children who were breastfed as infants are generally more intelligent than those who do not, this benefit is most likely because of the parents' socioeconomic status and IQ, not mother's milk.

—Victoria Stern

Sweet and Sad



Soda and fruity drinks, whether sugary or artificially sweet, are associated with an increased risk of depression, according to the same NIH study that found coffee and tea to have a protective effect—the first investigation of this topic to follow a large cohort for many years. People who drank more than four soft drinks daily in 1995 and 1996 had a 30 percent higher risk of developing depression five to 10 years later. Artificially sweetened drinks seem to be the worst offenders: in all beverage categories, those who drank the diet versions had the highest depression risk. For example, participants with a daily intake of four or more cups or cans of a diet fruit-flavored drink had a 51 percent higher risk than abstainers, whereas a similar intake of diet soft drinks was linked with a 31 percent increase in risk. Experts caution that it is too early to conclude that the sugar or sweetener was causing the depression, though; it is possible people who were predisposed to depression chose to drink more sweet beverages.

—T.R.



A BAND-AID THAT MEASURES YOUR FEELINGS

Imagine communicating your deepest emotions without having to say a word. Researchers at the Korea Advanced Institute of Science and Technology (KAIST) are headed that way with their wearable goose-bump sensor, which they describe in a recent issue of *Applied Physics Letters*.

Goose bumps arise when the muscles at the base of hair follicles are flexed, which happens when we are cold or when we feel a strong emotion such as fear, pleasure or nostalgia.

The ultrathin goose-bump sensor is made of nine pin-head-sized capacitors sandwiched between two silicone rubber layers. Each capacitor is a flat spiral made from two charged wires. A goose bump pushes the coil upward, stretching apart the wires and reducing the charge between them. "It's comparable to wearing a thin Band-Aid," says Young-Ho Cho, senior author and director of the NanoSensuating Systems Laboratory at KAIST in South Korea.

The invention has sparked new collaboration. Cho is talking with researchers who study lie detection because goose bumps can be a telltale sign of deceit. Another



group of scientists are interested in identifying and monitoring individuals with antisocial tendencies or personality disorders. Anyone who is curious whether they touched an audience—say, politicians, performers or marketers—could potentially use the sensor to gauge emotional impact. Even people with autism might benefit: the sensor could help them recognize their emotions and communicate them to others.

And if nothing else, the device could detect when you are cold and turn up the heat.

—Esther Hsieh

» Bad Luck, Begone

Gestures to ward off ill fate help to drive unwanted thoughts out of mind

Even people who claim not to be superstitious engage in rituals intended to reverse a jinx after "tempting fate." Knocking on wood, spitting and throwing salt share a common thread: they involve avoidant actions that are directed away from the self. A new study finds that these actions help people feel better by making it harder to imagine the feared tragedy.

Investigators at the University of Chicago and the National University of Singapore first engaged participants in some small talk, then turned the conversation to a topic pertaining to a specific misfortune. In one experiment, for example, a researcher talked about car accidents and then asked, "Do you think that there is a possibility that you or someone close to you will get into a horrible car accident this winter?" Some subjects chose from one of three neutral answers; others chose from one of three

answers designed to be presumptuous, such as "No way. Nobody I know would get into a bad car accident. It's just not possible." A pretest had confirmed that these answers effectively triggered the sense that participants had tempted fate. The subjects were then instructed to try clearing their thoughts while either rapping their knuckles on a tabletop, knocking on the underside of the table or performing no action.

Results show that those who had tempted fate were more likely to be concerned about car accidents following the conversation. For participants who knocked down on the table, however, the perceived likelihood of an accident was reduced to a similar level as those who had not tempted fate. Those who performed no action or who tapped upward remained more worried. The researchers



also tested other movements that suggested either approach or avoidance. For example, tossing a ball—or even just pretending to—reversed the perceived jinx effect, whereas holding a ball did not. In all, five experiments published

last June in the *Journal of Experimental Psychology* found that avoidant actions of all types eased people's mind.

The power of avoidant actions may lie in their dampening effect on our imagination. Further questioning revealed that subjects who performed neutral or approaching actions, such as knocking on the underside of a table or holding a ball, had more vivid mental imagery of the negative outcome than people whose actions were avoidant. The researchers suggest that avoidant actions are common across cultures and comforting even to those who are not superstitious because they help obscure the mental picture of the feared event.

—Tori Rodriguez

» Neuroscience Update

NEW BRAIN DISCOVERIES IN DEPRESSION

The latest depression findings concern brain chemicals, neural connections and the shape of entire lobes. It is not yet clear how these puzzle pieces fit together, but experts are optimistic that such discoveries will eventually lead to a deeper understanding of the complex disorder and relief for people who suffer from it.

The Disappointment Circuit

A rare chemical balancing act may explain why people with depression attend more closely to negative information

People with depression process emotional information more negatively than healthy people. They show increased sensitivity to sad faces, for instance, or a weaker response to happy faces. What has been missing is a biological explanation for these biases. Now a study reveals a mechanism: an unusual balance of chemicals in a brain area crucial for the feeling of disappointment.

A team led by Roberto Malinow of the University of California, San Diego, studied the lateral habenula, a evolutionarily ancient region deep in the brain [see diagram on opposite page]. Neurons in this region are activated by unexpected negative events, such as a punishment out of the blue or the absence of an anticipated reward. For example, studies have shown that primates trained to expect a reward, such as juice, after a visual cue show heightened activity in the lateral habenula if the reward is withheld. Such findings have led to the idea that this area is a key part of a “disappointment circuit.”

Past studies have also shown that hyperactivity in the lateral habenula is linked with depressionlike behavior in rodents. In people with depression, low levels of serotonin, the brain chemical targeted by antidepressants, are linked with a rise in lateral habenula activity.

The region is unusual because it lacks the standard equipment the brain uses to reduce overactivity: opposing sets of neurons that either increase activity by secreting the chemical glutamate or decrease activity by secreting the chemical GABA. The lateral habenula has very few neurons that decrease activity, so Malinow and his colleagues set out to discover how the brain tamps down activity there.

now and his colleagues set out to discover how the brain tamps down activity there.

The team found that some nerve endings in the region secrete both glutamate and GABA. This rare mechanism has been seen in only two other regions and generally only in still developing brains. The researchers also showed that rats displaying depressive behaviors release less activity-dampening GABA and that rats treated with an antidepressant release more. This finding suggests that the balance of chemicals released controls the processing of negative events and that this balance can be shifted by drugs.

“These findings reveal a potential mechanism whereby antidepressants act



to correct negative bias in depression,” says Catherine Harmer, a neuroscientist at the University of Oxford, whose team has found that antidepressants shift these negative biases within hours, despite taking weeks to improve mood.

“The hope is that by studying pathways involved in processing reward and punishment, we can come up with drugs that act on these pathways more selectively than those we use now,” lead author Steven Shabel says. “And those might be better antidepressants.”

—Simon Makin

Depression’s Bad Wrap

Unusual bending in one brain structure may explain symptoms

Scientists have studied brain structure for decades, so most disease-related structural anomalies have been long known. New findings of this nature are rare—yet last summer one neuroscientist studying depression published just that. Over nine years of sorting through countless brain images, Jerome J. Maller of Monash University and Alfred Hospital in Melbourne noticed a particular type of brain abnormality that seemed to show up more often in depressed patients. Their occipital lobes were often wrapped around each other [see images on opposite page].

Maller and his colleagues investigated further and found that depressed patients are indeed three times as likely to have wraparound lobes. Occipital bending occurred in 35.3 percent of the depressed patients and 12.5 percent of the control

subjects, according to their paper, published in *Brain*. The effect was even more pronounced in women: 45.8 percent of female patients with major depressive disorder exhibited occipital bending versus only 5.9 percent of women without depression, possibly because women’s brains fit more snugly in their skulls than men’s do.

Previous studies have also found that occipital bending is more common in patients with schizophrenia. Maller suggests the lobes may wrap around each other when space for brain growth becomes constricted, perhaps because the brain is not doing enough neural pruning—the process by which the brain gets rid of neurons that are no longer needed. Indeed, many other studies have found that depressed brains are hyperconnect-

ISTOCKPHOTO

The Draining Brain of Depression

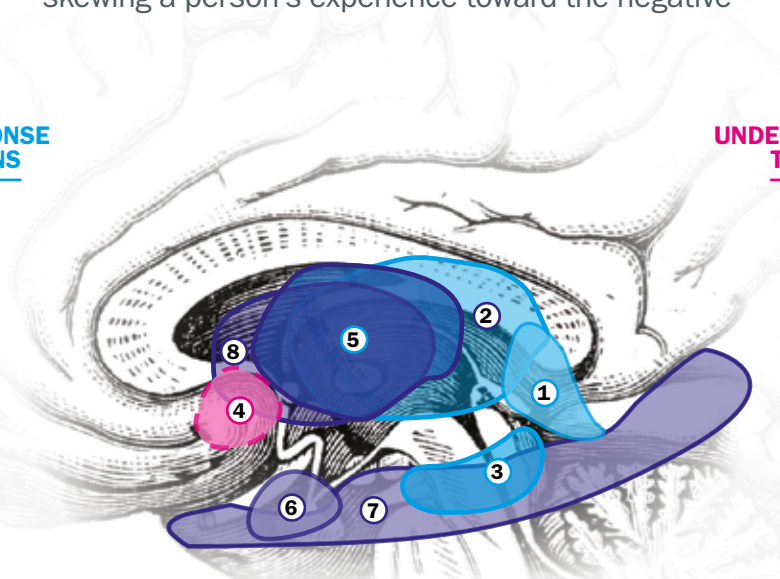
Many regions in the brain that process emotions and reward behave differently in depression, skewing a person's experience toward the negative

OVERACTIVE IN RESPONSE TO NEGATIVE EMOTIONS

- 1. Lateral habenula:**
Key player in the disappointment circuit
- 2. Thalamus:**
Processes emotions
- 3. Hippocampus:**
Involved in memory and mood

UNDERACTIVE IN RESPONSE TO POSITIVE EMOTIONS

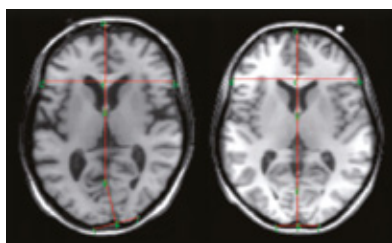
- 4. Ventral striatum:**
Part of the reward system



BOTH

- 5. Insula:**
Processes social emotions
- 6. Amygdala:**
Processes emotions
- 7. Fusiform gyrus:**
Important for visual memories
- 8. Putamen:**
Part of the reward system

ISTOCKPHOTO (brain diagram); SOURCE: "OCCIPITAL BENDING IN DEPRESSION," BY JEROME J. MALLER ET AL., IN *BRAIN*, VOL. 137, NO. 6, JUNE 2014 (brain scans)



MRI scans reveal higher rates of occipital bending (left) in people with depression.

ed. Maller does not know if the finding will have clinical implications beyond helping to diagnose depression, but experts hope that this avenue of research will eventually lead to a deeper understanding of the disorder. "It really suggests some significant biological basis for at least some forms of depression," says William Hopkins, a professor of neuroscience at Georgia State University, who was not involved in the study.

—Tori Rodriguez

A FIX FOR FAULTY WIRING

Magnetic stimulation may relieve depression by pruning connections

Many people with drug-resistant depression have found relief via transcranial magnetic stimulation (TMS). Yet the mechanism of this relief has been unknown. Now a study finds that TMS may work by correcting connectivity.

Researchers at Weill Cornell Medical College used functional MRI to scan the brains of 17 patients with depression and 35 healthy volunteers while they were not focusing on anything in particular. Previous research has shown that the regions active in this resting state, known as the default mode network, are hyperconnected in depression. Because these areas regulate internal focus, scientists believe the extra connectivity may be related to depression's repetitive ruminations.

The new study first confirmed these regions' hyperconnectivity in the people with depression. Then the patients received a standard five-week course of

TMS before their brains were scanned again. Not all patients benefited, but those who did revealed a pattern. Patients who improved no longer had too many connections; their scans were indistinguishable from those of healthy subjects. In addition, patients who initially had tighter links between resting-state regions were more likely to respond to TMS—further evidence that this finding explains how TMS treats depression.

The results suggest a way to eventually customize treatment. A patient could undergo a quick fMRI scan, for example, to learn whether his or her brain is hyperconnected—and if not, avoid a costly and time-consuming regimen of TMS. Study co-author Marc Dubin, a physician and neuroscientist at Weill Cornell, notes that targeting a person's specific abnormalities could help individuals find an effective treatment more quickly. —Nessa Bryce

with personal happiness? New research suggests so. | We can now create 3-D images of living brain tissue simply by shining a light on it.



How to Be a Better **shopper**

The other day an e-mail from Old Navy arrived in my in-box with the subject line “Buy one, get one 50 percent off all activewear. Two days only!” I get these sales e-mails from the store almost weekly, and even though I know exactly what the marketers are doing (trying to get me to spend money I wasn’t planning to spend), I usually click—and often end up purchasing—anyway. As a mortgage-owing, self-employed mom with two college funds and a retirement account to think about, I have got to become a smarter, better shopper. You, too? Here’s how consumer psychology and marketing researchers suggest we start.

#1 Know that scarcity can sway you—big time. That Old Navy e-mail used a really compelling tactic by highlighting the limited time parameters of the sale—it introduced the idea of scarcity into readers’ minds and implied that we could miss out. “Scarcity is very primal,” says Kelly Goldsmith, assistant professor of marketing at the Kellogg School of Management at Northwestern University. “When people see the world as running out of anything, the research shows it makes them crazy self-ish—it starts to explain things like Black Friday violence.” If something’s scarce, our minds tell us it is valuable and we need to snap it up. Even if we really, truly don’t.

#2 Prioritize before you shop around. The other week it took me three hours to decide which local hotel to book for an overnight staycation. There were just so many; what if I picked the wrong one and my husband and I ended up having a terrible time? This quandary illustrates one of the biggest problems facing shoppers these days, says Alexander Chernev, a consumer behavior researcher and marketing professor at the Kellogg School: too much choice. “It takes a lot of effort just to consider all the options available—to go out and find them and evaluate each one,” Chernev notes. He points out you don’t have to consider all the options, especially if you start with a good sense of

your priorities: “You always have to give up one thing for another. Do you prefer better coverage or lower price in health care? In buying a car, do you prefer performance, or comfort, or fuel efficiency?” If you figure out what’s most important to you ahead of time and consider only the options that match your priorities, you can keep from foundering in a sea of too many choices.

#3 Make a list—even online. Making a shopping list before hitting a store isn’t just about remembering necessary items, it can also help you tune out unwanted marketing messages. Studies on goal activation show that if you make a concrete action plan (such as a shopping list), you’re more likely to do what it is you actually set out to do. “Imagine your average trip to the grocery store,” Goldsmith says. “We go with good intentions, to get our bread and milk, then we’re bombarded by in-aisle displays and coupons that are meant to arouse us or change our minds about what we actually need.” Although carrying a list may seem like a no-brainer when heading to the store, Goldsmith points out that a shopping list can help just as much online, where banner ads and pop-ups try to entice you with complementary products to those in your cart. A shopping list can keep your

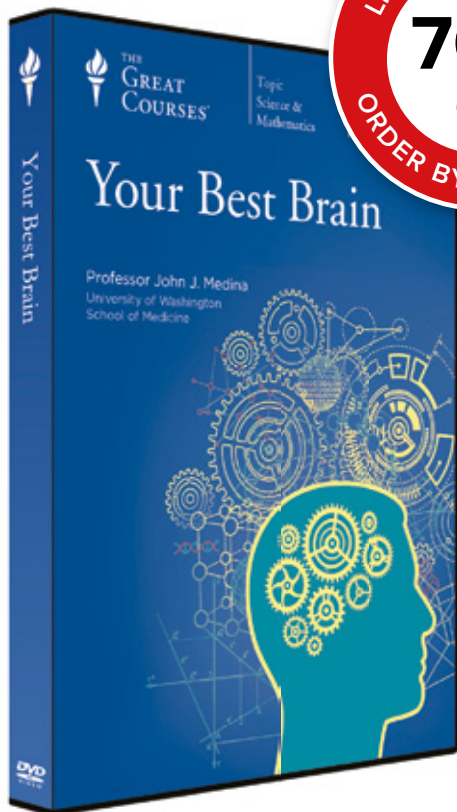
goal of shopping wisely at the top of your mind amid all these distractions.

#4 Try to think longer term. In the moment, it can be tough for shoppers to balance what consumer researchers call “vices and virtues.” A vice is anything that brings immediate gratification but costs you long term, whereas virtues may seem costlier now but are much better for you down the road. “In general, vices tend to prevail,” Chernev says. “If you think about how you’re going to experience and enjoy the chocolate bar sold near the cash register, you’re more likely to succumb.” One way to further boost your resistance to impulsive vice buys is to remind yourself of what you truly value in life. A series of studies in 2013 by psychologists Brandon Schmeichel of Texas A&M University and Kathleen Vohs of the University of Minnesota found that thinking and writing about your goals and values helped people exert more self-control when they were feeling run down or worn out. The next time I can’t sleep and I’m tempted to fire up my Amazon app and buy a bunch of adorable baby clothes (on sale!) in the middle of the night, perhaps I’ll grab a pen and paper instead and remind myself of what really matters.

—Sunny Sea Gold



PAUL PANTAZESCU (Stockphoto (globe icon)); MAGOZ (shopper)



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» Blood Type Matters for Brain Health

People with AB blood type are at higher risk for age-related cognitive decline

Blood type may affect brain function as we age, according to a new large, long-term study. People with the rare AB blood type, present in less than 10 percent of the population, have a higher than usual risk of cognitive problems as they age.

University of Vermont hematologist Mary Cushman and her colleagues used data from a national study called REGARDS, which has been following 30,239 African-American and Caucasian individuals older than 45 since 2007. The aim of the study is to understand the heavy stroke toll seen in the southeastern U.S., particularly among African-Americans. Cushman's team focused on information collected twice yearly via phone surveys that evaluate cognitive skills such as learning, short-term memory and executive function. The researchers zeroed in on 495 individuals who showed significant declines on at least two of the three phone survey tests.

When they compared that cognitively declining group with 587 participants whose mental muster remained robust, researchers found that impairment in thinking was roughly 82 percent more likely in individuals with AB blood type than in those with A, B or O blood types, even after tak-

ing their race, sex and geography into account. The finding was published online last September in *Neurology*.

The seemingly surprising result has some precedent: past studies suggest non-O blood types are linked to elevated incidence of heart disease, stroke and blood clots—vascular conditions that could affect brain function. Yet these cardiovascular consequences are believed to be linked to the way non-

O blood types coagulate, which did not seem to contribute to the cognitive effects described in the new study. The researchers speculate that other blood-group differences, such as how likely cells are to stick to one another or to blood vessel walls, might affect brain function.

Cushman emphasizes the need for follow-up studies not only to verify the blood type/brain function association but also to untangle mechanisms for it. In the meantime, those with AB blood need not panic about their future cognitive wherewithal, she says, noting that all our brains are apt to benefit from a healthy diet, awareness of our risk factors for heart disease and stroke, and regular exercise for the body and brain.

—Andrea Anderson



From Blood to Brain

Blood type has been linked with a variety of mental disorders, but the associations are weak—many other factors are more important in determining who ends up with an illness. Still, the fact that a connection may exist intrigues some scientists, who hope one day to uncover the biological processes that link blood molecules to mental health, possibly improving our understanding and treatment of these illnesses.

- People with O blood type may be more likely to have depression and intense anxiety; children may be at a greater risk of attention-deficit disorder.
 - People with A blood type may be more prone to obsessive-compulsive disorder; children may be at a greater risk of attention-deficit disorder.
 - Children with B blood type may have a lower risk of attention-deficit disorder.
- Victoria Stern

GETTY IMAGES (circulatory system); ISTOCKPHOTO (blood drops)

Think Clearly.

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(PHARMA WATCH)

DIZZINESS

A Side Effect That Can Kill

Chronic dizziness increases falling injury risk by 12 times
Virtual-reality games can cause dizzying "cybersickness"

4 out of 10 people will experience a serious bout of dizziness in their life
The top 5 types of drugs given to seniors can cause dizziness

Dizziness—a deficit in spatial perception that leaves people feeling lightheaded, unbalanced or disoriented—is one of the most common side effects of prescription drugs. Some of the most popular medications, including those that control high blood pressure or alter the neurochemistry of the brain, can intensify or cause dizziness in up to 30 percent of patients who take them, experts estimate.

"As we age, we are already dealing with changes to our physiology and our brain that make us more prone to dizziness," says Ann Tucker Gleason, director of the Vestibular and Balance Center at the University of Virginia. "To add to this, many of us also take drugs that significantly exacerbate dizziness and make us more likely to injure ourselves falling." According to the U.S. Centers for Disease Control and Prevention, falls are the

leading cause of accidental injury and death in people older than 65.

Still, many people remain uninformed of the dangers of dizziness or unaware that one or more of their prescription drugs may leave them off-balance.

Experts estimate that dizziness affects up to 30 percent of the general population, most frequently caused by disorders of the inner ear or vestibular system but also caused by conditions or medications that affect our vision, brain function or nervous system.

"Dizziness, especially lightheadedness, is not only a global problem but also a near epidemic in the geriatric population, making it a serious health concern," says Christopher Zalewski, a researcher at the U.S. National Institute on Deafness and Other Communication Disorders. Below are the most common drugs that can cause dizziness and advice about how to treat it.

—Victoria Stern



COMMON DRUGS THAT MAY CAUSE DIZZINESS

Inner Ear Disablers

These drugs directly affect the sensory organs that control balance and spatial orientation in the inner ear.

Antibiotics

Fight infection; may damage inner ear

Vertigo medications

Treat nausea or motion sickness

Head-Rush Producers

These drugs affect blood pressure or blood levels of glucose or oxygen, all of which can cause lightheadedness and disorientation if they drop too low.

Analgesics

Relieve pain (prescription)

Antihypertensives

Reduce blood pressure

Chemotherapeutics

Kill cancer cells

Diabetes medications

Decrease glucose levels

Diuretics

Flush water and salts out of the body

Brain Chemistry Changers

These drugs alter brain chemistry. It is less clear how that leads to dizziness; perhaps the altered chemistry impedes signals traveling from the inner ear.

SSRI antidepressants

Increase levels of serotonin

Antipsychotics

Lower levels of dopamine

Antiseizure drugs

Impede neuron firing

Sedatives

Calm central nervous system responses

Get Balanced

If you experience dizziness, the best thing you can do is consult your doctor. If a medication is to blame, your doctor may be able to lower the dose or switch you to a different drug. If the problem has a different origin or your medication cannot be altered, many other treatment options exist:

Exercise. Experts have developed several exercise regimens that can restore balance for some people. So-called vestibular rehabilitation encompasses exercises for the eye and head that help to retrain the brain to cope with the skewed signals coming from the inner ear. Canalith repositioning procedure, which also involves performing a sequence of head movements, shifts the contents of the inner ear to ease some instances of vertigo. Consult a doctor before attempting these exercises. Maintaining general

fitness and doing exercises that strengthen balance, such as tai chi, may improve dizziness. Although the evidence is limited, playing Wii Fit on a Nintendo Wii could be a fun way to enhance your balance.

Change surroundings.

Determine where around your home or workplace you may be most prone to falls and make adjustments. For instance, wear secure footwear to prevent falling on wet or slippery surfaces, improve lighting, and put carpet or additional railings on stairs.

Modify your diet. Eating less sodium may reduce dizziness, as may cutting back on alcohol, caffeine and nicotine.

Try an antidizziness drug.

If all else fails, your doctor may prescribe medication such as an antiemetic that suppresses mixed signals from the inner ear and reduces motion sickness. Yet many drugs used to combat dizziness come with problems of their own, such as unpleasant side effects. Ironically, some of them can even increase dizziness.

ISTOCKPHOTO (spiral and pills); GETTY IMAGES (face)



» Asian Glow May Indicate Lower Pain Tolerance

One of the body's alcohol-busting enzymes may play a role in pain relief

More than half a billion people carry a genetic mutation that incapacitates the enzyme responsible for clearing alcohol from the body. The deficiency is responsible for an alcohol flush reaction, colloquially known as the "Asian glow" because the vast majority of carriers are descendants of the Han Chinese. Now research published last September in *Science Translational Medicine* suggests that the mutation might

also compromise carriers' pain tolerance. The finding points to a new target for pharmaceutical pain relief and implies that drinking alcohol might exacerbate inflammatory conditions such as arthritis.

When people consume alcohol, the body breaks it down into several by-products, including chemicals called aldehydes. These compounds are noxious if they remain in the system too long, causing flushing, nausea, dizziness and other symptoms of the alcohol flush reaction. In most people, aldehydes are immediately broken down by the enzyme aldehyde dehydrogenase (ALDH2), but in those with the genetic mutation, the enzyme is incapacitated.

Researchers led by Daria Mochly-Rosen of Stanford University genetically modified some mice to carry the mutation seen in humans that disables ALDH2. When they injected those mice and normal mice in the paw with an inflammatory compound that turned it

red and swollen, mice carrying the mutation showed increased sensitivity to a poke compared with those with functioning ALDH2. When the researchers treated all the rodents with a novel drug called Alda-1 that boosts ALDH2 activity, the pain symptoms were reduced regardless of whether they carried the gene mutation.

The investigators were surprised to find aldehydes at the site of inflammation because the mice had not been exposed to alcohol. The discovery suggests that natural aldehydes produced by the body contribute significantly to pain and that they are kept in check by ALDH2.

What the research will mean for people remains to be seen. Mochly-Rosen next hopes to determine whether people with the mutation experience pain differently than those without it. Anecdotally, some descendants of the Han Chinese seem to have a lower pain threshold, but so far that has been blamed on cultural factors. If ALDH2 does affect pain in humans and if Alda-1 activates the enzyme in humans as it does in rodents, then the agent could potentially boost aldehyde metabolism and lower pain in people with or without the mutation.

A new pharmaceutical target for pain relief would be incredible news to people who do not respond well to opioid drugs, which have been the only option for decades. Much more work is needed before new drugs might materialize, but the finding that aldehydes play a role in inflammatory pain might be useful now—especially for people with conditions such as arthritis because it suggests they might reduce symptoms by avoiding alcohol. —Stephani Sutherland

» Join a Club, Stay Sharp

Group social activity beats one-on-one encounters for preventing cognitive decline

Social activity is well known to influence mental health, particularly as people age—but the details behind this phenomenon are unclear. Different types of social interactions may be more or less important, depending on the circumstances. One-on-one relationships, such as those between spouses, may yield specific emotional benefits. When it comes to slowing cognitive decline, however, group interactions have more power, according to a recent study published in *Social Science & Medicine*.

The study analyzed data from more than 3,400 adults aged 50 and older. Subjects who reported high engagement with social groups such as book clubs and community organizations performed better on tests measuring cognitive skills such as working memory. Individual relationships such as friendships, meanwhile, appeared to have no effect on cognitive ability. The mental boost from group activity was also more pronounced with age: group-connected subjects closer to age 50 had the cognitive capacities of someone about five years younger, whereas those near 80 years old were rejuvenated by about



10 years, putting them mentally closer to a 70-year-old.

Group relationships require effort to maintain, and they reinforce self-identity, both of which may sharpen thinking skills, says Catherine Haslam, a clinical psychology professor at the University of Queensland in Australia and lead author of the study. Conversely, the ease of interactions with spouses or family members may make them less stimulating. "The difference in terms of keeping mentally active is those group relationships," Haslam says. —Erica Westly

ISTOCKPHOTO (woman); A BELLO/Getty Images (seniors in pool)

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Pay Attention

Concentration affects how we detect and perceive objects and scenes

To a neuroscientist, the trouble with cocktail parties is not that we do not love cocktails or parties (many neuroscientists do). Instead what we call “the cocktail party problem” is the mystery of how anyone can have a conversation at a cocktail party at all.

Consider a typical scene: You have a dozen or more lubricated and temporarily uninhibited adults telling loud, improbable stories at increasing volumes. Interlocutors guffaw and slap backs. Given the decibel level, it is a minor neural miracle that any one of these revelers can hear and parse one word from any other.



BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE



Stephen L. Macknik and Susana Martinez-Conde are professors of ophthalmology at SUNY Downstate Medical Center in Brooklyn, N.Y. They serve on *Scientific American Mind*'s board of advisers and are authors of *Sleights of Mind*, with Sandra Blakeslee (<http://sleightsofmind.com>), which recently won the Prisma Prize for best science book of the year. Their forthcoming book, *Champions of Illusion*, will be published by Scientific American/Farrar, Straus and Giroux.

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The alcohol does not help, but it is not the main source of difficulties. The cocktail party problem is that there is just too much going on at once: How can our brain filter out the noise to focus on the wanted information?

This problem is a central one for perceptual neuroscience—and not just during cocktail parties. The entire world we live in is quite literally too much to take in. Yet the brain does gather all of this information somehow and sorts it in real time, usually seamlessly and correctly. Whereas the physical reality consists of comparable amounts of signal and noise for many of the sounds and sights around you, your perception is that the conversation or object that interests you remains in clear focus.

So how does the brain accomplish

Because your attentional system cannot absorb an entire image at once, it is easy to miss the differences between these pictures, a phenomenon known as change blindness.

this feat? One critical component is that our neural circuits simplify the problem by actively ignoring—suppressing—anything that is not task-relevant. Our brain picks its battles. It stomps out irrelevant information so that the good stuff has a better chance of rising to awareness. This process, colloquially called attention, is how the brain sorts the wheat from the chaff.

In collaboration with the laboratories of neuroscientists Jose-Manuel Alonso of the SUNY College of Optometry and Harvey Swadlow of the University of Connecticut, we discovered the initial circuits that mediate attention in

SPOT THE DIFFERENCE SOLUTION:
From left: mountain peak, red shoes, blue scarf, missing glass

GALLERY STOCK; SEAN MCCABE (Macknik and Martinez-Conde)

the primary visual cortex of the brain. To do this, we observed neurons in this area, some of which encourage activity in their fellow brain cells, so-called excitatory neurons, and others that tamp down activity, known as inhibitory neurons. We compared the activity in brain cells that process specific areas of visual space with that of other visual cells that are unaffected by changes in our gaze and attention. This comparison revealed that when someone attends to a specific spatial location, the inhibitory neurons take action, suppressing the activity in the brain cells that process other visual regions. In short, the brain depends on these inhibitory neurons to enable focus.

Even more interesting, the harder you concentrate, the greater the suppression. One fundamental role of cognition is to select what your brain goes on to process. It does that, at least in part, by blocking irrelevant information.

But that is not attention's only role. As the neural activity associated with attention travels down throughout our visual system's circuits, it can also affect how we perceive and interpret the shapes of objects. The illusions in this article illustrate some of the numerous perceptual consequences of our brain's attentional circuits. **M**



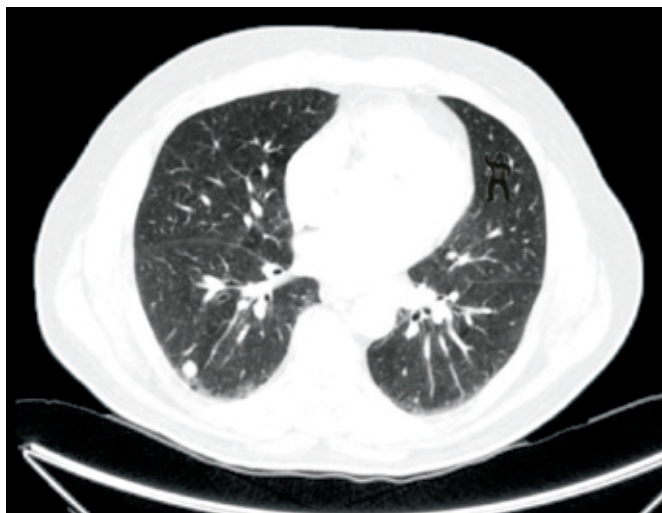
ALTERED STATES

In the illustration at the left, does the image depict a white octopus hugging a gray rock or a gray octopus hugging a white rock? You can see it either way. In 2013 neuroscientist Peter U. Tse of Dartmouth College and his colleagues included this example in a collection of illusions shaped by attention. The researchers hypothesized that our attentional systems influence the way our perceptual systems parse ambiguous objects to help us determine the interpretation most adequate for the task at hand.

PICK AND CHOOSE

Imagine you could pick one of the two apples at the right. Let's say you snatched that green Granny Smith—would you believe that someone might dupe you into thinking you had picked the red Honeycrisp? It may sound unlikely, but researchers at Lund University in Sweden have studied the phenomenon of choice blindness in-depth. Their work reveals that we can indeed be deceived into thinking we made a different choice—and even justify our nondecisions.

In 2013 they asked people to share their voting intentions in a survey. By using a secretly rigged survey tablet, they swapped their respondents' answers with people from the opposite political camp. Surprisingly, when the researchers showed participants their "answers," 92 percent of people endorsed and accepted the altered viewpoints. Many participants would then extensively confabulate on why they made their (swapped) choice, suggesting that much of the rationale we concoct for our everyday decisions may be rooted in self-deception.



THE RADIOLOGIST'S OVERSIGHT

One typical task for a radiologist is to count cancerous white nodules in a patient's lungs and differentiate them from similar (but elongated) white blood vessels. In 2012 neuroscientist Jeremy M. Wolfe and his colleagues at Brigham and Women's Hospital in Boston presented this image (left), along with many others, to specialists and untrained observers and asked each subject to tally up cancerous nodules in it. But their real question was whether participants would spot the 800-pound gorilla in the radiology suite. That's right—there is a gorilla in the image, although you may have missed it. All the untrained observers, and an astounding 83 percent of the trained radiologists, failed to see the gorilla during an experiment conducted with similar scans. Cognitive scientists call this a demonstration of inattention blindness. So were the radiologists unobservant? Did their brain fail them? Not at all. The specific task was to characterize white nodules in the images, not black gorillas. The attention system did what it was supposed to do and suppressed the irrelevant distractors.

FROM "HOW ATTENTION CAN ALTER APPEARANCES," BY PETER U. TSE ET AL., IN HANDBOOK OF EXPERIMENTAL PHENOMENOLOGY: VISUAL PERCEPTION OF SHAPE, SPACE AND APPEARANCE, EDITED BY LILLIANA ALBERTAZZI, WILEY, 2013 (©TAPUS); GETTY IMAGES (APPLES); FROM "THE INVISIBLE GORILLA STRIVES AGAIN: SUSTAINED INATTENTIONAL BLINDNESS IN EXPERT OBSERVERS," BY TRATTON DREW, MELISSA L.-H. VO AND JEREMY M. WOLFE, IN PSYCHOLOGICAL SCIENCE, VOL. 24, NO. 9, SEPTEMBER 2013 (SCAN)

ALARMINGLY, ONLY 35 PERCENT OF SUBJECTS NOTICED THE BEATINGS IN A NIGHTTIME EXPERIMENT BY CHABRIS AND SIMONS.

WOULD YOU IGNORE A BRUTAL ASSAULT?

One night in 1995 a group of Boston police officers brutally beat an undercover officer—a case of mistaken identity—during the chase of a suspect in a shooting. Another police officer, Kenny Conley, ran right by the violence while in pursuit of the real suspect. Conley later claimed that he never saw any of the beating, even though he had been just feet away. Prosecutors and jurors, assuming that Conley was lying to protect his guilty comrades, convicted him and sentenced him to jail for 34 months on charges of perjury and obstruction of justice. But could Conley have been telling the truth?

To find out, cognitive scientists Christopher Chabris of Union College, Daniel Simons of the University of Illinois at Urbana-Champaign and their colleagues conducted staged street beatings to determine if naive volunteers could miss them (as shown in image at right). But first they gave the experimental subjects a different task: to pursue a runner and count the number of times that he touched his head. Alarmingly, only 35 percent of subjects noticed the beatings when Chabris and Simons tested their subjects at night. Deeper study revealed that the more closely subjects attended to the runner, the



more likely they were to miss the beating. This was also a case of inattention blindness. So Conley might indeed have missed the beating of his fellow officer, despite having been in the midst of the attack.



THE HAND IS MORE ATTENTION GRABBING THAN THE EYE

Illusions of attention are central to magic performance, which we have discussed in our book *Sleights of Mind*. After all, sleight of hand often depends on the magician's ability to manipulate where and for how long we focus our attention. But are a magician's hands or eyes more likely to draw the attention of the spectator? We tested this by showing videos to participants of magic tricks by famous Las Vegas magicians Mac King, a headliner at Harrah's, and Teller, of Penn and Teller fame. The magicians' gaze did not affect the observers' behavior strongly—although it might in other routines. Instead spectators usually directed their attention to the magicians' hands. This is not altogether surprising from a neurophysiological perspective: our visual system contains some neurons that respond preferentially to hands, and hand motions can be an important part of social communication.

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UNEXPECTED UPSIDES

The Advantages of Dyslexia

With reading difficulties can come other cognitive strengths

By Matthew H. Schneps

Many of the etchings by artist M. C. Escher appeal because they depict scenes that defy logic. His famous “Waterfall” shows a waterwheel powered by a cascade pouring down from a brick flume. Water turns the wheel and is redirected uphill back to the mouth of the flume, where it can once again pour over the wheel in an endless cycle. The drawing shows us an impossible situation that violates nearly every law of physics.

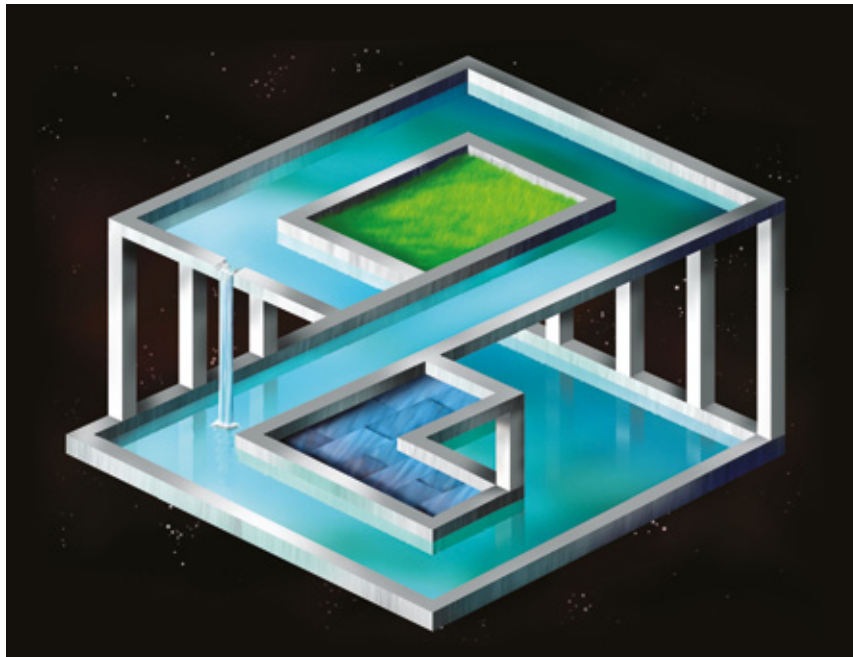
In 2003 a team of psychologists led by Catya von Károlyi of the University of Wisconsin–Eau Claire made a discovery using such images. When the researchers asked people to pick out impossible figures from similarly drawn illustrations, they found that participants with dyslexia were among the fastest at this task.

Dyslexia is often called a learning disability. And it can indeed present learning challenges. Although its effects vary widely, some children with dyslexia read

MATTHEW H. SCHNEPS is an astrophysicist with dyslexia who founded the Laboratory for Visual Learning at the Harvard-Smithsonian Center for Astrophysics (now at the University of Massachusetts Boston). Currently he is writing a book on e-reading technologies and dyslexia.



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Dyslexic individuals may be better than nondyslexic peers at spotting an impossible figure, such as this image in the vein of M. C. Escher's etchings.

so slowly that it would typically take them months to read the same number of words that their peers read in a day. Therefore, the fact that people with this difficulty were so adept at rapidly picking out the impossible figures puzzled von Károlyi.

The researchers had stumbled on a potential upside to dyslexia, one that investigators have just begun to understand. Scientists had long suspected dyslexia might be linked to creativity, but laboratory evidence for this was rare. In the years to follow, sociologist Julie Logan of Cass Business School in London showed that there is a higher incidence of dyslexia among entrepreneurs than in the general population. Meanwhile cognitive scientist Gadi Geiger of the Massachusetts Institute of Technology found that people with dyslexia could attend to multiple auditory inputs at once.

These findings raise the intriguing possibility that dyslexia involves certain advantages. The research hints that people with dyslexia exhibit strengths for seeing the big picture (both literally and figuratively) that others tend to miss.

And if this is true, the work reinforces the larger idea that differences that people might perceive as a source of difficulty in some domains can become a source of strength in other contexts.

Weeds among the Flowers

In our lab at the Harvard-Smithsonian Center for Astrophysics, we have studied various scientific talents among people with dyslexia. Biochemist Christopher Tonkin of the biotechnical company Biogen Idec, for example, has long noticed a sensitivity to “things out of place,” which he ascribes to his dyslexia. Tonkin is easily bothered by the weeds among the flowers in his garden, and his awareness of visual anomalies has aided his research.

Our studies hint that dyslexia may be an asset to many scientists. For example, in 2012 we asked 15 college students to search for specific objects in busy photographs of natural scenes. Some of these scenes appeared repeatedly, which allowed us to measure how well students could learn the layout of such images. Dyslexic individuals needed fewer repetitions to master these

searches than their nondyslexic peers, but only for blurred images. Such skills could translate well in medicine, for example, where physicians compare multiple diagnostic x-rays over time to identify tumors or growths.

Further evidence comes from studies by neuroscientist Martina Hedenius of Uppsala University in Sweden. In 2014 her team reported that among 28 children, those with dyslexia were more accurate in recognizing whether they had previously seen a given image.

Although we do not know precisely what would cause these advantages, we do have an understanding of how literacy changes the brain. An avid reader might read for an hour or more daily, for years on end. This specialized repetitive training, requiring split-second control over eye movements and perception, can shape the visual system to make some pathways more efficient than others.

Collège de France cognitive neuroscientist Stanislas Dehaene and his colleagues have identified some of these changes. In a study published in 2014 they asked 63 adults with varying degrees of literacy to rapidly identify whether pairs of letters and pictures oriented in various ways were the same or different. Curiously, when the pairings depicted mirror reversals of one another, people with greater literacy struggled to recognize the similarity more than their less literate counterparts.

Dehaene has concluded that the ability to carry out certain types of visual processing may be lost as reading is acquired. Visual strengths in dyslexia might thus be an artifact of differences in the brain created by reading.

Rethinking Dyslexia

My colleagues and I have offered an alternative explanation. One reason people with dyslexia may exhibit visual talents could be that they have difficulty managing visual attention, the ability to rapidly orient to changes in the environment. Visual attention is critical in perceiving letters within words and in guiding eye movement during reading.

Strong readers are necessarily skilled at focusing visual attention. But a trade-off is involved: when focusing on detail, the brain suppresses awareness of its surroundings. Poor readers may be unable to focus attention in this way. They would therefore be more globally aware, which could lead to advantages for performing tasks, such as discriminating impossible figures.

This theory is encouraged by ongoing studies by Italian psychologist Andrea Facoetti of the University of Padua. In 2012 Facoetti's team asked 82 children in

PEOPLE WITH DYSLEXIA MAY EXHIBIT STRENGTHS FOR SEEING THE BIG PICTURE THAT OTHERS MISS.

preschool to do a variety of tasks, such as a visual search, characterizing their individual strengths for visual attention. The children were then taught to read in first and second grades. When their reading proficiency was evaluated at the end of this period, Facoetti found that those who showed difficulties with visual attention in preschool tended to also express difficulties with reading in second grade. These findings raise the possibility that visual attention deficits, present from a very early age, are at least in part responsible for the challenges characteristic of dyslexia.

Facoetti's work also suggests that the observed advantages are not an incidental by-product of limited reading experience. Instead both the benefits and challenges of dyslexia might emerge from differences in the brain that were most likely present from birth. Further evidence of this paradox comes from longitudinal neuroimaging research by neurologists at the University of Southern California. Children in preschool, who later developed dyslexia, were found to have thinner gray matter in parts of the cortex linked to audition, vision and attention than their nondyslexic peers did. More important, these differences were evident before reading was taught.

Given the fact that attention affects perception in many ways, lifelong differences in this area might spur any number of abilities. These might include the ability to notice subtle undulations in complex mathematical graphs or to remember the spatial layout in a graphical organizer, such as the periodic table of elements.

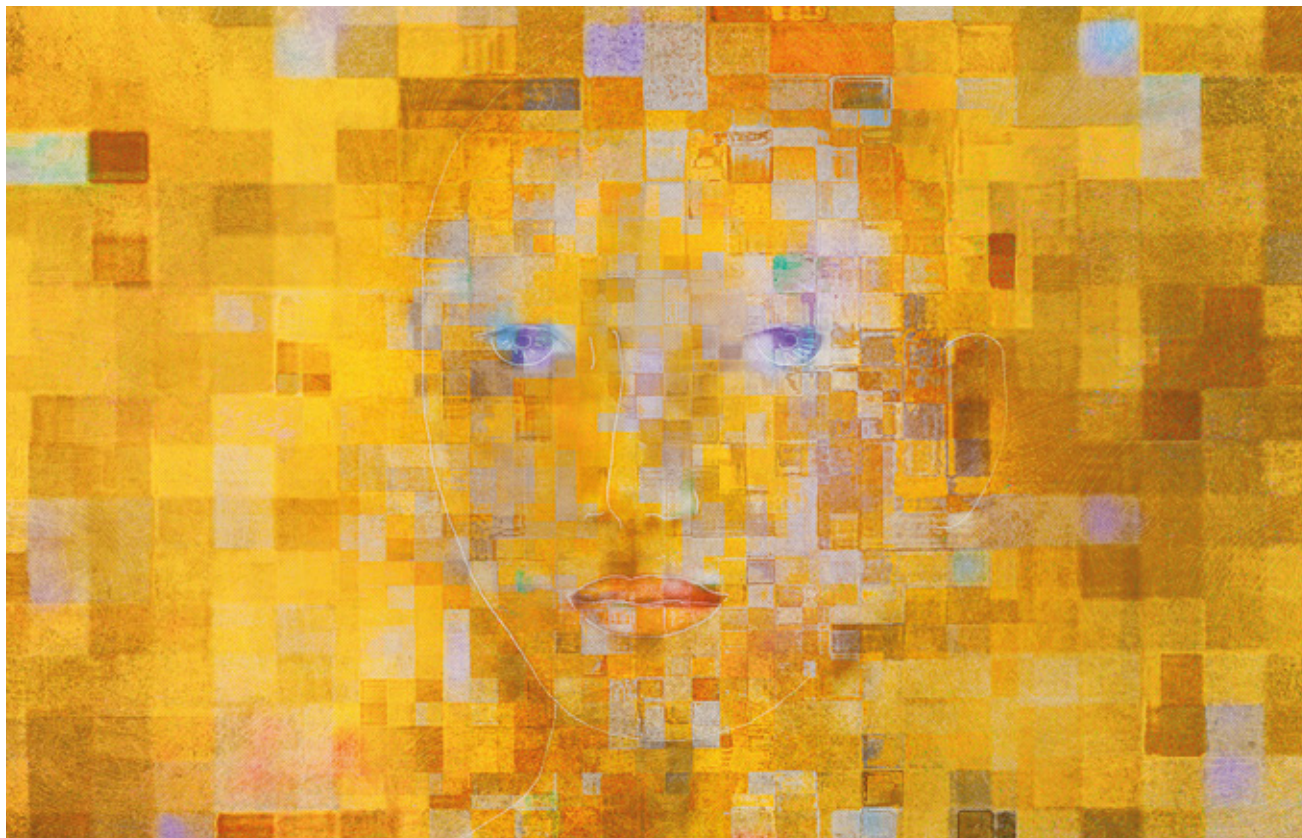
Whether observations of such advantages in the lab apply to real-life talents remains an open question. But the evidence makes it clear we need to broaden our views on dyslexia to include not only

the struggles but also the benefits that come from different kinds of thinking. After all, our conceptions of “advantage” and “disadvantage” have meaning only in the context of the task that needs to be performed.

In physics we know that heat engines, such as those in automobiles or power systems, can only transform energy into mechanical work by making use of differences in temperature, hot versus cold. Nothing productive takes place when everything is the same. Neurological differences similarly drive the engine of society and create the contrasts between hot and cold that generate new ideas. Impairments in one area can lead to advantages in others, and it is these differences that drive progress. **M**

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The Face as Entryway to the Self

What happens in the brain when you see—really “see”—a friend’s smile or scowl



BY CHRISTOF KOCH

Christof Koch is chief scientific officer at the Allen Institute for Brain Science in Seattle. He serves on *Scientific American Mind*’s board of advisers.



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The serial number of a human specimen is the face, that accidental and unrepeatable combination of features.

—Milan Kundera, *Immortality*, 1988

Faces are the glue that holds us together and that gives us our identity. All of us but the visually impaired and blind are experts at recognizing people’s identity, gender, age and ethnicity from looking at their faces. First impressions of attractiveness or competence take but a brief glimpse of somebody’s face. Newly born infants already tend to fixate on faces. This bias also turns up in art. Paintings and movies are filled with faces staring at the viewer. Who can forget the endless close-ups of the feuding husband and wife in Ingmar Bergman’s Cimmerian masterpiece *Scenes from a Marriage*?

Because recognizing a face is so vital to our social lives, it comes as no surprise that a lot of real estate in the cerebral cor-

tex—the highly convoluted region that makes up the bulk of our brain—is devoted to a task crucial to processing faces and their identity. We note whether someone looks our way or not. We discern emotional expressions, whether they register joy, fear or anger. Indeed, functional brain imaging has identified a set of adjacent regions, referred to as the fusiform face area (FFA), that are situated on the left and the right sides of the brain, at the bottom of the temporal lobe of the cerebral cortex. The FFA turns up its activity when subjects look at portraits or close-ups of faces or even when they just think about these images.

Two just published studies of the brain’s visual networks, including the

RECOGNIZING FACES IS CRITICAL TO OUR SOCIAL LIVES, AND THE BRAIN DEVOTES ENORMOUS ENERGY TO THIS TASK.

FFA, enlarge what we know about the physical basis of face perception. Both explore the unique access to the brain afforded by patients whose epileptic seizures have proved resistant to drugs. A surgical treatment finds the locations in the brain where the hypersynchronized activity that characterizes a seizure begins before spreading from its point of origin to engulf one or sometimes both hemispheres. If a single point—a focus where the seizure begins—can be found, it can be removed. After this procedure, a patient usually has significantly fewer seizures—and some remain seizure-free. To triangulate the location of the focus, neurosurgeons insert electrodes into the brain to monitor electrical activity that occurs during a seizure.

This clinical setup is the starting point for these two related but quite different studies that provide fascinating new details about whether the brain, like a camera, captures a literal rendition of a face or whether that image is synthesized in the brain by neurons in the cortex.

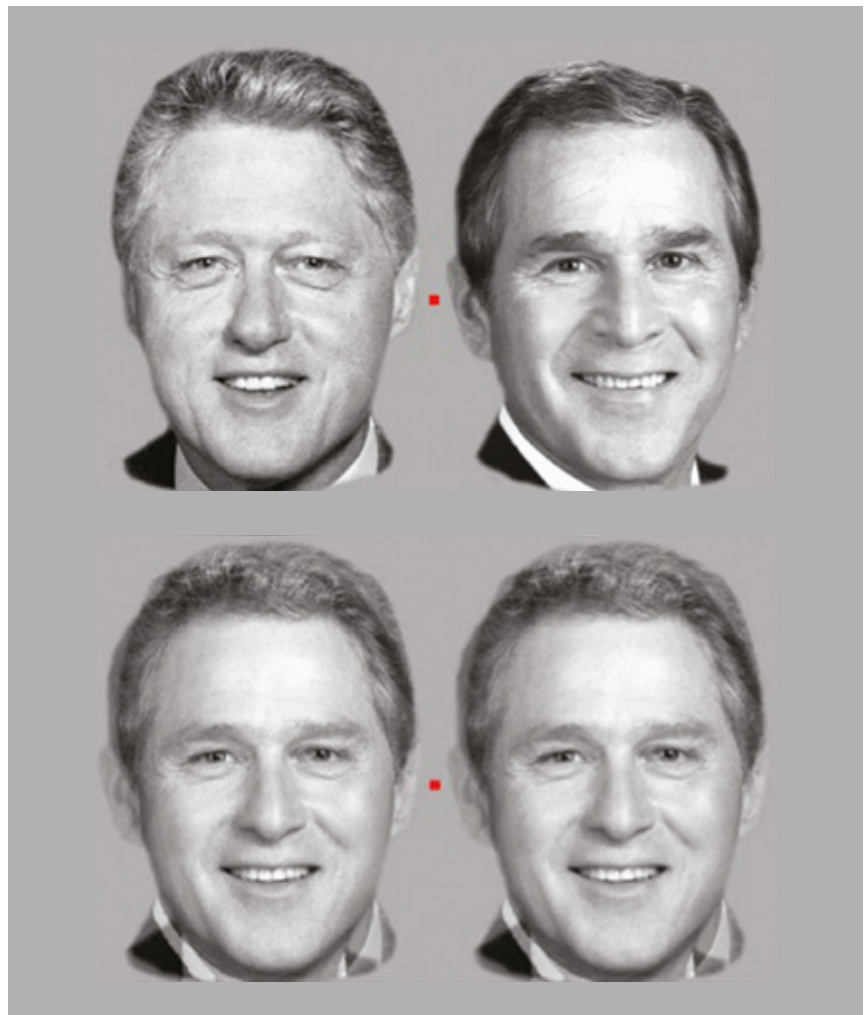
Prez 42 Morphs into Prez 43

To describe the first experiment, it is best to re-create what happened to the subjects. Keep your eyes steady on the red square in the top panel of the figure at the right for a fraction of a minute. Out of the corner of your eyes, you will see Bill Clinton on the left and his successor on the right. Now quickly shift your gaze to the bottom red square and note what you see. Don't hesitate. Just go for it! Most people see George W. Bush in the image on the left and his predecessor on the right. Yet when you compare the two photographs, you will realize that they are the same, a morphed image of the two presidents. Call this hybrid Clin-

tush, the 42nd and a half president. This illusion is an instance of a general class of phenomena, called sensory adaptations, that are a hallmark of the mind. As you stare at the face, the neuronal mechanisms supporting its perception undergo a process of recalibration. The longer you stare at the same image, the

more it changes. So when you look for a while at Clinton and then quickly glance at Clintush, you will perceive Bush, although this illusory perception quickly dies away, and the picture becomes ambiguous again.

How do the myriad nerve cells that make up the visual brain respond to such images? Neurons early on, say, in the eye, will respond to the chiaroscuro patterns of the photographs no matter what the brain the eye is attached to sees. That is, they register an image of the outside world. But somewhere in the upper reaches of the brain, there must be neurons that



Meet President Clintush, who emerges from an optical illusion. First, fixate on the top red dot for half a minute or longer. Without moving your eyes, who do you see on the left and on the right? Now shift your gaze to the bottom red dot. Who do you see now?

actively construct what the mind's eye sees when looking at Clintush. And depending on circumstances, that can be a picture of Bush or of Clinton.

The study was carried out by Rodrigo Quiñan Quiroga of the University of Leicester in England and Alexander Kraskov and Florian Mormann, all then members of my laboratory at the California Institute of Technology, where I was a professor. The project was supervised by neurosurgeon and neuroscientist Itzhak Fried of the University of California, Los Angeles, and myself. Fried implanted hair-thin wires in the brains

of patients at the David Geffen School of Medicine at U.C.L.A. The wires enabled the researchers to monitor the electrical activity of individual nerve cells in the medial temporal lobe and to detect neurons that would respond more to the perception of one person than to that of another.

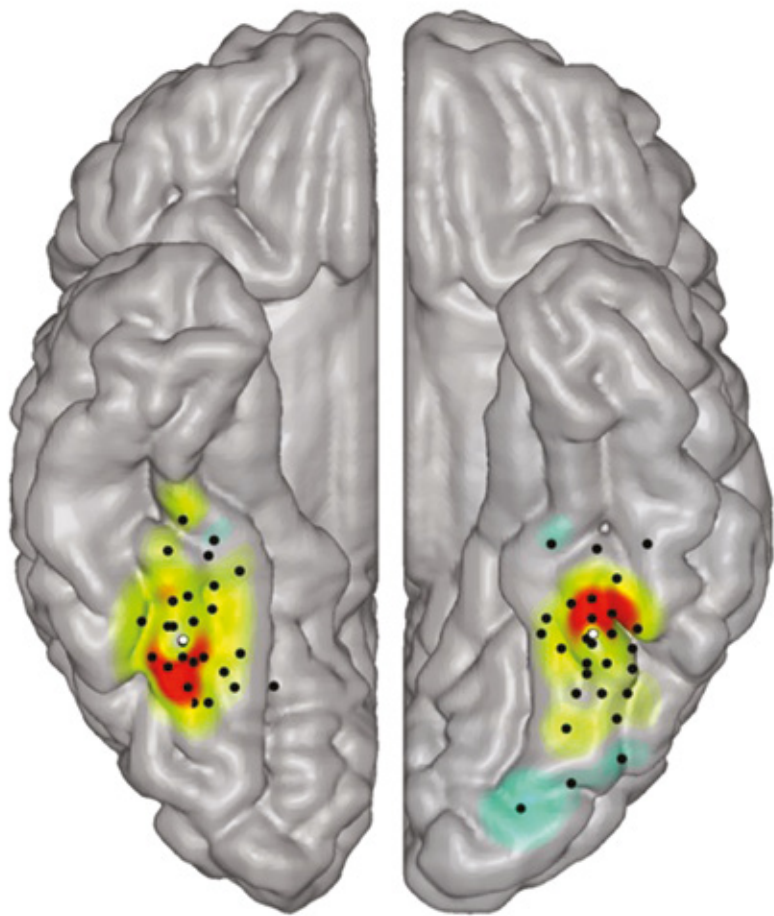
Years earlier, while using this very setup, we had discovered individual neurons that responded only to various pictures or drawings of specific people that the patient was familiar with—politicians, celebrities or family members. One of the first such neurons to be char-

acterized in this manner fired only when the patient saw images or cartoons of Clinton. Another cell became excited by photographs of Hollywood actor Jennifer Aniston, no matter what her dress or hairstyle was. Indeed, this class of neurons now bears her name. Some neurons not only respond to pictures of a particular, familiar individual but also to his or her written or spoken name.

For the present experiment, the investigators recorded from a cell that fired selectively to a picture of Clinton. When they next asked the patient to look for four seconds at a photograph of Bush, the cell remained nearly silent. That is, the cell preferred the sight of Clinton over that of Bush. Immediately afterward, a blended picture of Clintush was flashed on the screen, and the patient had to push one of two buttons: either “I saw Clinton” or “I saw Bush.” As probably happened when you performed this experiment earlier, the scientists found that the patient was more likely to see Clinton when previously exposed to four seconds of Bush, and vice versa.

How do the recorded neurons act? Do they care only about what is in front of the eyes out in the world, or do they tap into the image consciously formed in the patient's mind? If the former is true, they should fire equally strongly to the ambiguous, blended picture, no matter whether the patient perceives Clinton or Bush. But if these cells follow the patient's perception—whether looking at the defined images on top or Clintush on the bottom—they should respond only when their preferred stimulus is actually experienced in the mind's eye. That is, a Clinton cell should not fire when the morphed picture is perceived as Bush but should be active when the identical morph is seen as Clinton. And this is what happened.

In 62 neurons from 10 patients, the response to the morphed picture was significantly stronger when the patient recognized the neuron's preferred face, compared with when the patient reported the face that the neuron did not care



Regions of a brain area, the fusiform gyrus, become illuminated when viewing faces. Hot colors (red) indicate face selectivity, whereas cooler colors indicate locations that are less discerning about faces. The black and white dots indicate where researchers placed electrodes to measure brain activity in 10 patients who participated in the study. The perspective has the viewer looking up at the brain from underneath, with the back of the brain at the bottom.

FROM "ELECTRICAL STIMULATION OF THE LEFT AND RIGHT HUMAN FUSIFORM GYRUS CAUSES DIFFERENT EFFECTS IN CONSCIOUS FACE PERCEPTION," BY VINITHA RANGARAJAN ET AL., IN *JOURNAL OF NEUROSCIENCE*, VOL. 34, NO. 38, SEPTEMBER 17, 2014

about. Indeed, statistically, the strength of the neuron's response to a pure Clinton could not be distinguished from the response to Clintush, as long as the subject reported seeing Clinton (and the reverse for the other image—here Bush). That is, these neurons, located in a part of the brain that received input from the FFA, either directly participated in the mental decision “Clinton” or “Bush” or actually generated the conscious experience of the face.

To distinguish between these two possibilities, it would be necessary to entice these neurons to fire by some artificial means—remember the technology used in *The Matrix*—and then to ask the subjects if they saw something. Another approach would interfere with the neuronal firing activity to determine whether this perturbation would affect the patient's experience of faces.

Moving from Correlation to Causation

This second option inspired neurologist Josef Parvizi, psychologist Kalanit Grill-Spector and their colleagues at Stanford University to conduct a study of 10 epileptic patients. One of those patients, Ron Blackwell, came to Parvizi's clinic at Stanford when the drugs he had been taking since childhood could not control his seizures anymore. To localize the source of his seizure and identify which nearby tissue could be surgically removed without major loss of function, Parvizi's team implanted so-called subdural intracranial electrodes into Blackwell's brain that would not only monitor neuronal activity but could also apply electric current and so stimulate the adjacent part of the brain.

Both electrical mapping with the implanted electrodes and the more conventional functional whole-brain imaging in a magnetic scanner identified a cluster of regions in the FFA in both cortical hemispheres of Blackwell's brain that responded strongly to faces. Knowing the location of these face-selective regions

gave the clinicians a unique opportunity to test what Blackwell would experience when the current from the electrode interfered with normal electrical activity connecting these face-selective networks of neurons in his brain.

Parvizi can be heard in a video, talking to the patient, “Look at my face and tell me what happens when I do this.” On

such as twinkling and sparkling, traveling blue and white balls, flashes of light—so-called phosphenes—but no change in the character of the perceived face.

The faces retained their identity even though functional brain imaging and electrical recordings had pinpointed both left and right FFA circuits as responding more to faces over nonfaces.

FINDING WHAT IS REAL AND WHAT IS ILLUSIVE IS ONE OF THE CHALLENGES OF CROSSING THE BRAIN-MIND DIVIDE.

the first trial, the physician pretends to inject current, and Blackwell just shakes his head and mutters, “Nothing.” But when a four-milliamper current is sent through the electrodes, he says, “You just turned into someone else. Your face metamorphosed. Your nose got saggy and went to the left. You almost looked like somebody I'd seen before but somebody different. That was a trip.” (Go to www.jneurosci.org/content/32/43/14915.full to watch the video of Blackwell and Parvizi.)

These perceived facial distortions occurred in all seven real trials but not in the four sham trials. They were specific for faces and did not happen when Blackwell was told to look at a television screen. Also, not much happened when electrodes in a neighboring region were stimulated. “Only your face changed. Everything else was the same,” Blackwell emphasizes. Repeating this procedure in nine other patients revealed the same result.

Yet something else became more and more apparent—a striking left-right asymmetry was operating. Only stimulation of electrodes underneath the right fusiform gyrus—never its left counterpart—induced distortions in face perception. Electrical stimulation of the left fusiform gyrus caused either no perceptual change or more low-level changes

Thus, the second lesson this beautiful experiment teaches involves the potential pitfalls and perils of homing in on a brain region or a nerve cell and inferring that because it correlates with seeing faces or with recalling bad experiences or with making decisions, it must therefore be involved in face perception, in memory or in decision making. There is a reason scientists constantly preach that “correlation is not causation.”

Untangling the tightly woven neuronal tapestry to discover what is real is one of the challenges scientists confront when crossing the brain-mind divide, linking the physics of excitable matter to ephemeral subjective, conscious experience, the most real thing there is. **M**

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Conquering

BURN

JOB SATISFACTION IS A SURPRISINGLY
FRAGILE STATE. HERE'S HOW TO PROTECT
YOURSELF AGAINST THE TOP CONTRIBUTORS
TO BURNOUT

By Michael P. Leiter and Christina Maslach



You lie in bed in the morning, reluctant to swing your legs out from under the warm embrace of your blanket. After several bleary minutes, you finally rouse yourself, throw on some clothes and head to the office. Having arrived at your desk, you stare blankly as e-mail loads on your screen. When you first started this job, you derived deep satisfaction from addressing the day's challenges efficiently and artfully. Yet the optimism that used to buoy you is long gone. Now your morning coffee gives you the only jolt of energy you'll feel all day.

The details differ by profession, but this state of being is the essence of burnout. It undoes a person's ability to pursue a happy, healthy and



productive professional life. Given that many of us spend the bulk of our waking hours at work, burnout can pose a real threat to overall well-being.

Often it begins with pure exhaustion. When you are worn out, you invest less in your job. As a result, you accomplish fewer things and feel less effective than you did before. Because work has ceased to offer the same psychological rewards, you start to feel cynical about your role. This set of emotions—exhaustion, feelings of inefficacy and cynicism—feed off one another, producing a vicious cycle of deepening burnout.

So do you just quit? Quitting is probably not the answer, al-

FAST FACTS

WISDOM FOR THE WORKPLACE

- 1 The emotional and physical toll of burnout poses a threat to overall well-being.
- 2 Research shows that the syndrome has three main components: exhaustion, cynicism and inefficacy.
- 3 Several strategies, including improving the social environment of a workplace, can buffer against burnout.

though you might want to look for a different job. To recover a professional *joie de vivre*, it helps to understand the basics of burnout from a psychological perspective. Decades of research have revealed several core truths about the syndrome. First, banish the idea that it arises from a personal failing. People who face burnout do not lack some essential quality, such as work ethic, resilience or self-confidence. When all goes well, we naturally tend to bring dedication and pride to our work. Burnout represents the erosion of these noble qualities. Research has consistently pointed to management practices and poor job designs as the leading causes. The ways supervisors lead, and the structure of employees' workdays, fail to bring out the best in people.

If you suffer from burnout, your relationship with your job has gone sour. Just as a fight with a partner or close friend can exhaust you and cause you to pull away from that person, so can a soured relationship with your job sap your enthusiasm and alienate you. Relationships are complicated things, however, so there is no single solution, no magic bullet, no "one size fits all" approach. Yet with patience and optimism, anyone can find a path back to engagement.

The Rise of Burnout

The use of the term "burnout" began gaining popularity in the 1970s, especially among people working in human services. Herbert Freudenberger, a psychologist at an alternative mental health agency, and one of us (Maslach) wrote early articles describing idealistic young professionals in health care and social work who were overextending themselves. They felt discouraged because they did not

have sufficient resources to do their jobs well. Instead of building a better world, they felt they were marking time in a dysfunctional system.

Psychologists' understanding of burnout has since broadened to include any job and a wide range of causes. The most familiar reason for burnout is exhaustion from working too hard with insufficient rest. Yet that condition alone does not cause burnout, nor is it the only route. New entrants to the workforce can find their hopes dashed on entering jobs incompatible with the values they have been taught. Midcareer employees can feel disappointed that they have not advanced as they had hoped. People in service jobs are susceptible because of the high tedium and inflexibility of their workdays. Any environment where conflict or incivility is rampant can also produce burnout.

Dozens of studies support the idea that burnout has three main components: exhaustion, cynicism and inefficacy. Experiencing one of these dimensions alone is a risk factor, but qualities of the workplace can conspire to produce the other two facets, pushing a person into true burnout. The three feelings

tend to be related—for example, you would not stay in a purely cynical state over the long term. Either you would start to feel exhausted and ineffective, or something breaks the trend and you find a way to reengage with your work.

Ultimately the true culprit is a mismatch between a person and a job. You might not have the resources you need, or your bosses might expect you to complete a task in a way that clashes with your principles. For example, health care providers in our surveys often cite tensions between their professional ideals—to be emotionally supportive to their patients—and the constraints that undermine that goal, namely insufficient staffing and outsized workloads. The quantity of work is important, but the real trouble arises from an employee's perception of his or her performance.

Another type of mismatch stems from lack of control. Letting people make decisions about how they spend their days is vital to a healthy work arrangement, but a sense of control can be easily eroded. Managers who set unrealistic expectations for an employee contribute to its loss. So do colleagues who do not communicate well. We all rely on others while doing our jobs, and poor communication can make our workdays more difficult and unpredictable than they need to be. When people feel they lack control over their own work, they are particularly prone to feeling cynical and ineffectual.

Bosses who fail to express their appreciation also contribute to workers' feelings of inefficacy. Indeed, we have found in our research that negative interactions with a supervisor incline a person toward burnout. Yet not all praise is created equal. We worked with one organization in which employees resented an employee-of-the-year award. The rank and file perceived the accolade as an indicator of who was in the good graces of company leaders and little else. Seemingly inequitable promotions can similarly harm engagement. In a 2014 survey that one of us (Leiter) conducted of people's feelings of burnout, one respondent wrote, "It is difficult to watch the randomness of why some are promoted and others are ignored. It drains the spirit from you." That interviewee directly linked a feeling of being unappreciated with a loss of energy—a strong indication of burnout.

Early Warning Signs

The emotional distress of this syndrome can persist for years. Because it can become chronic, we grew interested in discovering whether we might predict—and thus potentially ward off—the emergence of burnout. In a study published in 2008, we surveyed 446 employees of an administrative department at a large university, first at the beginning of our in-

vestigation and again a year later. We probed numerous areas of their work life to assess burnout. We were curious to see how people who scored high on only one of the three dimensions—say, only high cynicism or only high exhaustion—would rate a year later. If they became more burned out, we wanted to know what tipping point might send them in that direction.

As it turned out, we found one such indicator: workplace fairness. People who perceived favoritism, cheating or other inequities were more likely to be burned out by the end of our study. Conversely, employees who viewed the workplace as a just environment tilted back toward engagement. A fluke event during the year of our study brought the issue of fairness into stark relief. Investigators uncovered members of the department who were stealing from it. Our final survey occurred soon after a few employees were apprehended and dismissed, so we could assess how disruptive this event had been. The thefts undermined trust among colleagues, weakened employees' sense of job security and, as a result, deepened burnout.

In a follow-up study of more than 4,000 forestry workers, published in 2013, one of us (Leiter) and colleagues at the Finnish Institute of Occupational Health found that other factors could also be triggers for burnout. In this case, employees experiencing cynicism (but who retained high energy and efficacy) were more likely to reengage if they felt their organizations communicated with them well, keeping them in the loop on important developments. Those without this belief slid into exhaustion and solidified their incipient burnout. For workers whose early-warning sign was feeling ineffective, the key factors were whether they could exercise diverse abilities and whether the job was predictable. What these results tell us is that there is not just one recipe for burnout. The context or culture of a workplace plays a major role.

The data further suggest that we should take symptoms of burnout seriously. As part of the Finnish study, we also gathered data on participants' purchase of psychotropic drugs, mainly antidepressants, between 2000 and 2008. The people who experienced increasing burnout were more likely than others to use these drugs in the subsequent decade. So if you notice yourself feeling chronically cynical, exhausted or ineffective at work, take a careful look at the characteristics of your job. It might be time to take some preventive action.

THE TRUE CULPRIT IS A MISMATCH BETWEEN A PERSON AND A JOB. FOR EXAMPLE, A BOSS MIGHT EXPECT YOU TO WORK IN A WAY THAT CLASHES WITH YOUR PRINCIPLES.

THE AUTHORS

MICHAEL P. LEITER is a professor of psychology at Acadia University in Nova Scotia. **CHRISTINA MASLACH** is a professor of psychology at the University of California, Berkeley.

The Social Solution

Because burnout depends heavily on the specific relationship between a person and job, broad guidelines for recovery are hard to come by. Nevertheless, we now believe that improving the quality of workplace relationships may be one general way to intervene. Social exchanges between colleagues play a role in many facets of burnout.

First, your co-workers have the skills, information, materials and influence needed to get things done. As you might expect, people share more readily with individuals they admire and trust. Conversely, hostile workplaces eat away at a person's ability to focus on his or her work. Consider, for example, this anecdote, also from Leiter's 2014 survey, in which one person articulates the energy tax of negative interactions: "I love my work. I am an avid learner and a very positive person. But I work in a toxic workplace. This is a highly political environment that encourages competition between colleagues, backstabbing, gossiping and hiding information. I find going to work very difficult and come home exhausted." Other participants in our studies have similarly cited the emotional toll of unpleasant interactions. They describe feeling upset for days following a few rude words from a colleague and losing sleep over the incident—both factors that make it difficult to engage in what otherwise might be pleasurable tasks.

An opportunity to try to alleviate burnout arose in a meeting with the leaders of a hospital in 2008. These executives had taken reasonable action to strengthen the sense of community in struggling work groups, including changing team leaders and reassigning or dismissing identified troublemakers. Managers had brought in inspirational speakers and conducted team-building exercises, with minimal success.

To tackle this problem, Leiter and his research team made use of a promising approach already in place within the Veterans Health Administration (VHA). In response to similar problems throughout the VHA's hospitals, a team led by Sue Dyrenforth, then director of the agency's National Center for Organization Development, devised an intervention called CREW, which stands for *civility, respect and engagement in the workplace*. Knowing that burnout has a social angle, we decided to deploy a version of CREW in several units of the hospital. Some of these units had a long history of problems, others were uncommunicative, and some functioned well but aspired to collaborate more.

Employees were divided into groups of 10 to 15 people from their same unit, and one person agreed to be the head facilitator. Because every team had its own sources of tension, we provided a collection of activities for the groups to choose

from rather than instructing them to follow a single script. Before we began, we surveyed all our participants on their perceptions of civility in their unit as well as their own conduct, so that we could compare their impressions at the beginning and the end of the program.

Over six months the teams met about once a week. The facilitator might kick off a session by asking a question such as "How do we show respect (or disrespect) for one another here?" Then attendees might do an exercise to help settle a dispute between two people. The meetings gave employees an opportunity to work through strained relationships and practice more productive ways of defusing emotions.

During the rest of the week, participants were encouraged to practice specific civility behaviors and log any acts of kindness they witnessed.


In 2011 we published our results from applying CREW to a group of Canadian hospitals. We confirmed that improving workplace civility decreases burnout. Even more encouraging, we have since found that these gains remained when we followed up one year later. The results suggest that CREW had established new, self-sustaining patterns of social interaction.

Yet the reviews were not all glowing. The hospitals found the personnel cost of implementing CREW to be a burden. Participants had to go out of their way to fit the sessions into their workdays. Applying the lessons to their day-to-day work life also required sustained effort. Given the occasionally irksome nature of the program, it is actually pretty impressive that CREW can be effective.

Finding Engagement

Given that not every company is about to start implementing CREW, what is an individual worker to do? Many corporations may see squeezing every bit out of employees to be to their advantage. Organizations by and large do not expect to retain their employees forever, so they are unlikely to serve their workers' long-term interests. Employees thus must shoulder the responsibility of maintaining a sustainable work environment.

The "company of one" perspective encourages individuals to think of themselves as independent contractors even when they are in an employment situation. Employees' primary focus should remain on preparing themselves for the next career opportunity that may arise. Doing so will require establishing work habits that depart from an employer's vision. In short, thriving in today's work world—where cost cutting is a prime objective and employees are routinely stretched too thin—requires serious self-management. You will need to stick to a routine, even when pressured to behave otherwise.



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Because burnout is a relationship issue, the individual has some, but not complete, control over circumstances. What follows are a few basic strategies for improving your contribution to the relationship. The good news is that many of these suggestions happen to be good for life in general, so you will benefit in many ways from developing these habits.

First up is fitness. A healthy way of life increases your resilience. A combination of sufficient exercise, nutrition and sleep will reduce your vulnerability to exhaustion. Although the job will not change, you will increase your endurance—and may even learn to thrive.

Closely related to fitness is a habit of integrating recovery cycles into your life. Demanding work depletes your physical, emotional and cognitive resources. As the saying goes, there is a reason it is called work. Your personal life should afford opportunities to enjoy relationships, catch up on sleep and take time for reflection. To reverse a trend toward burnout, a key step is to establish a firm structure for recovery activities. Lacking a structure, you will not make time for recovery in the course of a busy life.

You can incorporate small amounts of exercise and recovery into the workday, too. The strategy here is simple: get off your butt. Set an alarm every 30 minutes as a signal to get up and walk around. You can devise some activities that would convince an observer that this meandering is a necessary part of your work.

Now let us incorporate the social angle. As we demonstrated with CREW, improving the quality of day-to-day exchanges among colleagues reduces burnout. You do not need your entire team to join you on this journey, but if you can recruit a friend or two to share a burnout-reduction project (a short midday walk, perhaps) the mutual support can be powerful.

Receiving good vibes from others is an uplifting experience, but so, too, is expressing them to others. Keep a tally of your own acts of kindness toward colleagues. To whom did you express appreciation today? Collaborating with a companion will, again, help you get the most out of this project.

Last, consider job crafting. You very likely have more latitude in your work than you think. Job crafting is an analytic approach that involves identifying the duties you find tedious and the aspects you find fulfilling. You should develop a plan to spend a bit more of your day on the good parts. Those increments can add up over time. Just ensure that the additional time you are spending on the fulfilling tasks makes a meaningful contribution, so as to keep your colleagues and supervisor onboard.

These ideas may sound like a big investment, but the truth is that burnout can be hard to shake. Once the syndrome has set in, you must commit to a deliberate practice to find your way back to a healthy, fulfilling relationship with work. Yet it can be done, so let's get started. **M**

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AUTISM GROWS UP

New programs are helping ease the transition to adulthood for people on the spectrum

By Jennifer Richler

Ondine has autism. Even though she had always struggled with making friends, she did well in high school, earning good grades. Her school district offered support services for students with developmental disorders, and with that assistance she successfully enrolled in a local college. Yet when those supports disappeared after graduation, “she basically fell apart,” says her mother, Amira.* A month into her freshman year of college, Ondine stopped going to classes and completing assignments; eventually she stopped leaving her dorm room altogether. Forced to drop out and move back home, Amira says that her daughter “didn’t leave her room for 23 hours a day.”

Ondine’s story is not unusual. Many parents lik-

en the experience of their child with autism leaving high school to “falling off a cliff.” In many states, young adults with special needs are entitled to school-related support services until age 21 or 22, but after that it is up to them and their parents to find and qualify for services to help them navigate adult life. Until recently, those services barely existed for a growing segment of the population: high-functioning adults with autism. Studies show this group is underemployed compared with people with more severe cognitive disabilities, and surveys find they are often unhappy and lonely. Their unique combination of normal or high intelligence and deficits in social understanding puts these young adults in a frustrating position: many have the same goals as their typically developing peers but struggle to achieve them.

Illustrations by **GRACIA LAM**

**Surnames withheld to protect the privacy of patients and their families.*



SELF-AWARENESS Programs for adults with autism help their clients better understand themselves so they can communicate their emotions and needs to others.

thing in common: difficulty with social interaction. For the young adults served by programs such as Aspire, this deficit manifests in a variety of ways. They may have trouble identifying other people's emotions, discerning appropriate conversation topics and public behavior, and recognizing or understanding their own feelings and needs.

These impediments often make it tough for adults on the spectrum to get jobs and keep them. A study published in 2012 found that only 55 percent of adults with autism had held any kind of paid employment in the six years since graduating from high school. Adults with other kinds of difficulties, including speech or language disorders, learning disabilities and even intellectual disability, had much higher rates of employment, suggesting that the low rates among adults with autism cannot be explained solely by the fact that they have a disabling disorder. The researchers concluded that young adults with autism are "uniquely at high risk for a period of struggling to find ways to participate in work and school after leaving high school."

According to Paul Shattuck, now a psychology professor at Drexel University and lead author on the study, this situation exists partly because support services were set up around the needs of people with intellectual deficits and have not evolved much over time. "If you have an IQ [in the average range] and you're quirky and have difficulty with social interactions, it's very hard to get help," he says. This description fits many of the adults whom Aspire serves. Although the label "Asperger's syndrome" is no longer included in the *DSM-5*, psychiatry's manual of mental disorders, many of Aspire's clients have this label or identify as such; others say that they have "high-functioning autism" or "PDD," which refers to pervasive developmental disorder, another term that is no longer in the *DSM* but connotes a relatively high level of ability.

Even when these adults can find work, it is often on a volunteer or part-time basis. A different study found that only 27 of the 48 young adults in their sample had ever been employed in the years since high school, and of those only one was able to support himself.

Clinicians, researchers and educators have recognized the problem, and in the past few years programs have sprung up around the country to serve this neglected group. Ondine is currently enrolled in an internship program at one of the most well-established of these programs—Aspire, based at Massachusetts General Hospital (MGH)—and she now works part-time and enjoys socializing with her co-workers. "For her to be getting out, talking to people, taking public transit ... is such a huge transition," Amira says. As the prevalence of autism continues to rise and more and more people with the diagnosis enter adulthood, Aspire and other programs like it hope to ease that transition, bridging the gap as autism grows up.

Smart and Struggling

The autism spectrum covers a wide range of symptoms, but everyone with the diagnosis has one

FAST FACTS

EASING INTO ADULTHOOD

- ❶ Many people with autism struggle with the transition from high school to independent adulthood. Public support systems are often not available for those without intellectual disabilities.
- ❷ Private programs such as Boston-based Aspire are filling the gap, supporting adults with autism as they enter college or the workforce.
- ❸ These programs allow adults on the spectrum to socialize with peers while they practice social skills, learn to be more self-aware and develop techniques for managing stress.

Enter Aspire and other programs like it. Aspire launched about 12 years ago, when it split off from YouthCare, a larger program that serves children with a range of mental health issues. Aspire's executive director Scott McLeod, a clinical psychologist, explains that rates of autism diagnosis had soared, and YouthCare was inundated with children on the spectrum. The directors decided that they needed a program focused exclusively on autism.

Ultimately, says program director Dot Lucci, a school psychologist, the goal is to address what Aspire staff call the three Ss: self-awareness, social competency and stress management. Many of the people in Aspire's programs are very bright, she says, "but if you're not self-aware and socially competent and if you're unable to handle your stress, all your smarts in the world are not going to help you. You're not going to be able to get a job, keep a job or be in a relationship."

People Who Need People

A fair-skinned, dark-haired 19-year-old named Matt stands in the center of a circle, surrounded by his peers, who are seated in folding chairs. "I need to make some money quick. What should I do?" he asks.

"Steal all the gold from Fort Knox ... or rob a bank in Paris!" Dan exclaims.

"Work 24-hour shifts for the rest of your life," Nick suggests.

"Sell your arms and legs," Jae offers. He gets big laughs.

These young adults with autism are playing an improvisation game called Bad Advice. The person at the center of the circle presents a problem to be solved, and everyone else tries to come up with the worst possible suggestion. Aside from being a fun icebreaker, the game orients the group to the concept of social "dos and don'ts"; thinking about how *not* to behave in social situations implicitly reminds everyone how they *should* behave.

So begins another session of Aspire's Saturday Excursions group. For most clients, the gatherings provide a sorely needed social outlet. Although people with autism are often thought of as aloof and

uninterested in socializing, for many the opposite is true. A University of Missouri study of adults with autism published last April revealed that many suffer from loneliness and isolation, which often lead to depression and anxiety. The loneliness may be acute: a national study of teens with autism published in 2011 found that more than half had not gotten together with a friend in the previous year. And when another set of researchers asked parents of adults with autism about their children's unmet needs, they cited social interaction as a major area. Adults on the spectrum crave social interaction but do not know how to get it.

The excursions group gives these young adults the chance not only to enjoy one another's company but to practice skills they find difficult, including what people in the field call "activities of daily living"—tasks such as organizing an outing and managing time and money. After the improv game and before the group heads out into the windy early spring afternoon, Aspire staff members remind everyone that this week they will be seeing a movie downtown. They review the schedule for the day, check the subway route to the movie theater, and distribute wallets with preloaded debit cards and subway cards. On the way to and from the theater, there is plenty of time to practice another essential skill: conversation. Dan, a young man with closely cropped hair and sunglasses, asks for everyone's

SOCIAL SKILLS Many programs use group activities to give adults with autism practice navigating social situations. They can then generalize these skills to daily life.



birthday so he can read out their horoscopes from an app on his smartphone.

Today's outing goes smoothly, and afterward everyone gathers to discuss the "highs and lows" of the trip. (The consensus: seeing *The Lego Movie* was a high; walking against the wind was a low.) But there are occasional mishaps. On a trip to the Navy Yard with a different group, one of the members, tired from walking around, lay down to rest on a bed onboard a ship. These sticky situations are opportunities to discuss appropriate social behavior—for example, sometimes it is necessary to act differently in public than in private.

Aspire conducts most of its interventions in a group setting, rather than working individually with clients. "Working one-to-one with thoughtful, caring adults—those aren't challenging situations," McLeod observes. "We think that the group is a far more powerful place to learn skills." At the same time, the groups feel safer and more predictable than other social situations, he adds, so clients become less anxious, allowing them to practice skills they otherwise would not. "The reason a social skill may not be exhibited is usually far more complicated than the fact that they just don't have the skill," he says. Often other issues—anxiety, difficulty taking others' perspectives or simply not understanding the purpose of a certain social behavior—get in

the way. That is why Aspire avoids simply drilling skills into its clients, an approach that, according to McLeod, "has failed pretty miserably."

Studies on how to best help adults with autism learn and practice social skills are few and far between, so Aspire's programs draw from a number of evidence-based approaches in psychology. Advisers emphasize clients' strengths while giving positive and negative feedback, a technique based on principles from the field of positive psychology. They encourage clients to think about the thoughts and feelings underlying others' behavior as well as their own, a central tenet of cognitive-behavior therapy. "The premise is, you can learn social skills like turn taking, but if you have no idea why you're doing them, it's a veneer. If you get in an unfamiliar situation, it falls apart," Lucici explains. "It's about *why* we do what we do."

On the Job

Alex sits at a conference table next to his supervisor, Kevin Heffernan. He is nearing the end of his 14-week internship in the Corporate Real Estate division of Liberty Mutual, a position he got through Aspire's internship program, which places young adults with autism at sites around Boston and provides them with mentorship and support. Alex is thrilled with his experience. "It's given me a reason to wake up," he says. It has also taught him essential job skills, including how to make pivot tables in Excel, an accomplishment in which he takes considerable pride, judging from the shy smile that spreads across his face when he mentions it.

Heffernan says that once Alex finishes his internship, he can apply for positions at the company and has a good shot of getting one. "The sky's the limit for this kid," he says, beaming. It is not just Alex's work skills that have impressed him—it is also the way he interacts with his colleagues. Before Alex started, Heffernan was warned that he was shy and anxious in social situations. "My radar was on," Heffernan admits. But with time, Alex became comfortable with his co-workers. "He's fitting in just fine, thank you," Heffernan says.

The research on job-training programs for people with autism, though preliminary, suggests it should



STRESS MANAGEMENT Anxiety is a hurdle for many adults with autism. Programs teach a variety of calming strategies, such as meditation, yoga and exercise routines.

be possible to help more adults on the spectrum succeed as Alex has. For example, in a clinical trial of the Project SEARCH High School Transition Program, which serves adults with autism at dozens of sites across the U.S., participants completed a nine-month internship program embedded in a large community business, such as a hospital, rotating through different jobs and learning practical skills, such as using public transportation to get to work. They also received individualized support from autism specialists. The control group received standard services provided by the school district. The results were encouraging: of the 24 adults who had an internship, 21 acquired employment after the program, compared with only one of 16 in the control group, and the difference was sustained three months later. Perhaps even more important, those in internships gained independence over time—that is, they required fewer supports—which was not true of those in the control group.

Many other programs for adults with autism around the country also focus on employment or continuing education. For example, the College Internship Program, with sites in Indiana, California, Massachusetts and New York, is geared to college students on the autism spectrum who do not have an intellectual disability. It provides mentorship, group social activities and internship opportunities. Aspire also offers services for the college-bound, including a “boot camp” the summer before freshman year, in which students develop practical skills for life on campus. Once at college, they can enroll in Aspire’s mentoring program, in which they are paired with a typically developing student on campus, who helps them get acquainted with key services and resources and provides them with ongoing support.

For those who do have an intellectual disability, programs such as Next Steps at Vanderbilt University allow students to take classes alongside peers, learn vocational and social skills, and earn a certificate after two years. Project SEARCH also serves adults with significant intellectual or developmental disabilities. Given the enormous variability in functioning among those with autism, this specialization makes sense: it is hard to help everyone on the spectrum when there is so much heterogeneity within it. Specializing also helps programs secure funding—most are underwritten by private philanthropic donations, which allow them to offer financial aid to clients’ families. McLeod reports that nobody has ever been turned away from Aspire because of an inability to pay.

All these programs not only help adults with autism get jobs, they also support them so that they succeed at those jobs—which often requires navigating delicate situations. One of Aspire’s interns be-

came distressed, for example, after meeting a co-worker of a different ethnicity, loudly telling her supervisor that she could not work with that person because she had once had a negative experience with someone of that ethnicity.

These situations can be uncomfortable, but McLeod sees them as opportunities for adults with autism to learn in real time and in real life, where it matters most. In fact, “bringing interventions into



One of Aspire's clients, Dan, enjoys his internship at Safelite AutoGlass. He quickly got comfortable with his co-workers: “Everyone loves my playlist, so I just blast it,” he says.

the life space,” as he puts it, is key to Aspire’s approach. “One of the main challenges for folks on the spectrum is the transfer and generalization of skills,” he says. A concept such as taking another’s perspective can make sense in the therapist’s office, he explains, but can be incredibly challenging to implement in daily life.

Looking Forward

Ondine sits in a small group of young men and women at a table in a meeting room, waiting for the weekly internship seminar to begin. She chats with a brunette with an easy smile named Nicole as others busily check their smartphones. A bulletin board on the wall has a sign that reads, “I Aspire To ...” with construction paper stars affixed to it, on which clients have written goals that range from the fantastic to the mundane: “Be a Nascar driver”; “Show up to work 5 minutes before the scheduled time”; “Ask others about their interests.” Bretton Mulder, a clinical psychologist and director of Aspire’s teen and young adult services, starts today’s session by asking the interns how things have been going in their first couple of weeks on the job. Ondine laments that it took her two hours to get her security

THE AUTHOR

JENNIFER RICHLER received her Ph.D. in clinical psychology from the University of Michigan and is now a science writer living in Bloomington, Ind.



SOCIAL INTERACTION Leisure time with peers is a much needed benefit of many programs. Studies find adults with autism are often lonely and yearn to socialize.

perspective-taking deficit of autism is that sometimes it's hard to know who you are," he explains. To help uncover their identities, adults at Aspire and in other programs are encouraged to reflect on their strengths, weaknesses, thoughts and feelings. This process often leads them to important realizations: "I'm a bright person who's overreactive to certain sensory stimulation," McLeod gives as an example. Aspire's clients are encouraged to share these relevant aspects of their personalities with people they meet or work with; doing so usually allows them to be accepted and understood more quickly.

If self-awareness is the mental foundation and applied social skills are the practical component, the often overlooked but crucial third factor in helping adults on the spectrum succeed is stress management. Many programs, including Aspire, help their clients learn techniques such as mindfulness and yoga. So far the preliminary data indicate that with these three pillars of support, many adults with autism can join the workforce and eventually leave behind the programs that helped them get there. Autism's prevalence continues to increase, however; according to 2010 estimates from the Centers for Disease Control and Prevention, one in 68 children has autism, up 30 percent from figures reported in 2008. Recent research suggests that a major reason for this surge is more frequent diagnosis of precisely the people Aspire serves—those who are more cognitively able.

Although Aspire does not yet have outcome measures, survey data suggest clients and their families are highly satisfied. For some, such as Ondine, the programs have been a kind of life raft. Her internship at MGH might not be her dream job—"anyone can do it," she tells her peers matter-of-factly during the internship seminar—but she sees it as a major step toward her long-term goal of being a paramedic. Perhaps more important, Amira says the program staff make her daughter feel "respected and admired for who she is. These people see all the possibilities and potential she has."

As a result, Ondine's outlook has changed dramatically. "It used to be that she said she has no future," her mother says. "Now she's talking about a future." **M**

badge at MGH, where she is working in materials management. Others mention traffic troubles and connecting with co-workers over music. After checking in with everyone, Mulder leads the group in a discussion of how to distinguish between on- and off-topic comments when in a meeting and why it is important to avoid judging co-workers based on features such as appearance and level of education.

During the discussion, Nicole occasionally interrupts her peers but immediately catches herself. She clamps one hand over her mouth and gently waves the other in the speaker's direction, as if to say, "Oops ... go on." The self-awareness Nicole is demonstrating is often challenging for those with autism, McLeod says. "What goes along with the

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A black silhouette of a hand holding a syringe. The syringe is oriented vertically, with the needle pointing upwards. The hand is positioned as if holding the syringe. The title text is overlaid on the image. The word 'SHOT' is in a black box with white text. The word 'AT' is in white text. The word 'QUITTING' is in large black text. The word 'A' is in large black text above 'SHOT'.

A SHOT AT QUITTING

VACCINES
AGAINST COCAINE,
HEROIN AND OTHER
SUBSTANCES
MAY ONE DAY
HELP ADDICTS
STAY CLEAN

BY CARRIE ARNOLD

When neuroscientist George Koob proposed creating a vaccine for addiction 25 years ago, his colleagues thought he was wasting his time. The immune system evolved to prevent infections, not highs from illegal drugs. Prevailing wisdom holds that treating addiction requires months or years of psychotherapy to help addicts change their thought patterns, a difficult process that does not consistently work. But Koob, then at the Scripps Research Institute, wanted addicts to be able to see their doctor for a shot that could keep them from getting high when their motivation to stay clean waned.

His premise was simple. Vaccines against infectious diseases work by priming the body to produce antibodies that glom onto the invading pathogen, preventing it from causing illness. Koob, who now directs the National Institute on Alcohol Abuse and Alcoholism, believed that the body could be duped into producing antibodies to drugs of abuse. The antibodies would biochemically block these drugs from creating a high, thereby eliminating the incentive to use them. Unlike traditional vaccines, however, this approach would aim to treat, rather than prevent, drug abuse.

More than two decades after Koob proposed his idea, scientists are finally making headway on affordable vaccines against addictive drugs. A vaccine for cocaine has seen success in early human trials, and one against heroin is making its way toward the clinic. A potential vaccine to combat methamphetamine addiction has shown promise in rodents.

Yet the approach is not without its critics. No addiction vaccine has proved effective in a large-

scale investigation in people, and the first such vaccine (for nicotine addiction) to be put to that test did not fare well. Because environmental factors are instrumental in perpetuating addiction, many experts argue that the problem is unlikely to succumb to a strictly biochemical attack. Still, for a disease that often stubbornly persists despite available treatments, vaccines could be an important addition to the toolbox. “Drug users often say they desperately want to quit. Addiction vaccines are a new tool to help them do this,” says Ron Crystal, a physician at Weill Cornell Medical College who has also worked on this idea.

Scourge of Their Lives

Nearly one in 12 Americans is addicted to illegal drugs, according to the latest data from the Substance Abuse and Mental Health Services Administration. The National Institute on Drug Abuse estimates that abuse of alcohol, tobacco and illicit drugs together cost the economy more than \$600 billion a year.

Addictions remain difficult to treat. First a user generally heads to detox, during which addicts abstain from using a drug so that it is eliminated from the body. Patients in detox centers receive around-the-clock support to manage the often intense physical and psychiatric symptoms that accompany this process. After detox, some people spend weeks or months in rehabilitation at a live-in facility; others simply attend weekly outpatient psychotherapy either individually or in groups. They often have to rely on willpower and motivation to try to stay clean. The limits of this do-it-yourself approach to addiction treatment are reflected in abysmally high relapse rates, which range from 40 to 60 percent for cocaine, heroin and methamphetamines.

Most psychotherapies used to treat addiction help an addict reduce and resist his or her cravings by avoiding places and people linked to drug taking—their triggers—and developing support networks to help them kick the habit. In addition, doctors may prescribe medications such as methadone and buprenorphine for addiction to heroin and other opiates that reduce withdrawal symptoms and cravings and temper the high. But these medications do not completely eliminate cravings, and users may not remember to take them every day. Drugs that combat nicotine addiction are partially effective at best, and no medications exist for dependence on cocaine, methamphetamines or alcohol.

Thus, for many addicts, getting and staying clean seems like an impossible dream. “Sometimes I hear from heroin addicts themselves who have tried every-

FAST FACTS

IMMUNE TO ADDICTION

- 1 Scientists are making headway on affordable vaccines against illicit drugs such as cocaine and heroin.
- 2 The vaccines would dupe the body into producing antibodies against drugs of abuse. These antibodies would biochemically block addictive drugs from creating a high, thereby eliminating the incentive to use the drugs.
- 3 Because environmental factors are so central in perpetuating addiction, critics are dubious that focusing on biochemistry alone will solve the problem.



THE LIMITS OF A DO-IT-YOURSELF APPROACH ARE REFLECTED IN ABYSMALLY HIGH RELAPSE RATES.

thing and complain that none of it works. They're hooked on this drug, it's the scourge of their lives, and they want to get off, but they can't," Koob says.

Sleeping Rats

Koob wanted to help people overcome this frustration by interfering with the biochemistry of drug taking. After a user injects, inhales or ingests a drug, it travels through the bloodstream and crosses the blood-brain barrier, a sheath of cells that lines brain capillaries and protects the brain from many toxic substances and other molecules in the bloodstream. Once inside the brain, molecules of the drug (or its metabolized products) bind to specific targets, setting off a series of chemical events that produce feelings of euphoria. Methadone treats heroin withdrawal and cravings—and can block its high—by acting at opiate receptors much more slowly and mildly than heroin. Koob wanted to intervene sooner, before a drug crossed the blood-brain barrier. So he decided to push the idea of the addiction vaccine.

Like an infectious disease vaccine, an addiction vaccine mobilizes the immune system to fight a foreign substance. The vaccine trains the immune system to make antibodies that specifically target the "invader." These antibodies will then rapidly kill the pathogen or deactivate the drug whenever they encounter it in the bloodstream. Because they act by sticking to a drug molecule, antidrug antibodies have the added benefit of creating a compound that is too big to cross the blood-brain barrier.

For scientists, the goal of the vaccine was to coax the immune system into responding to something that does not ordinarily provoke a reaction. Koob and Scripps medicinal chemist Kim Janda de-



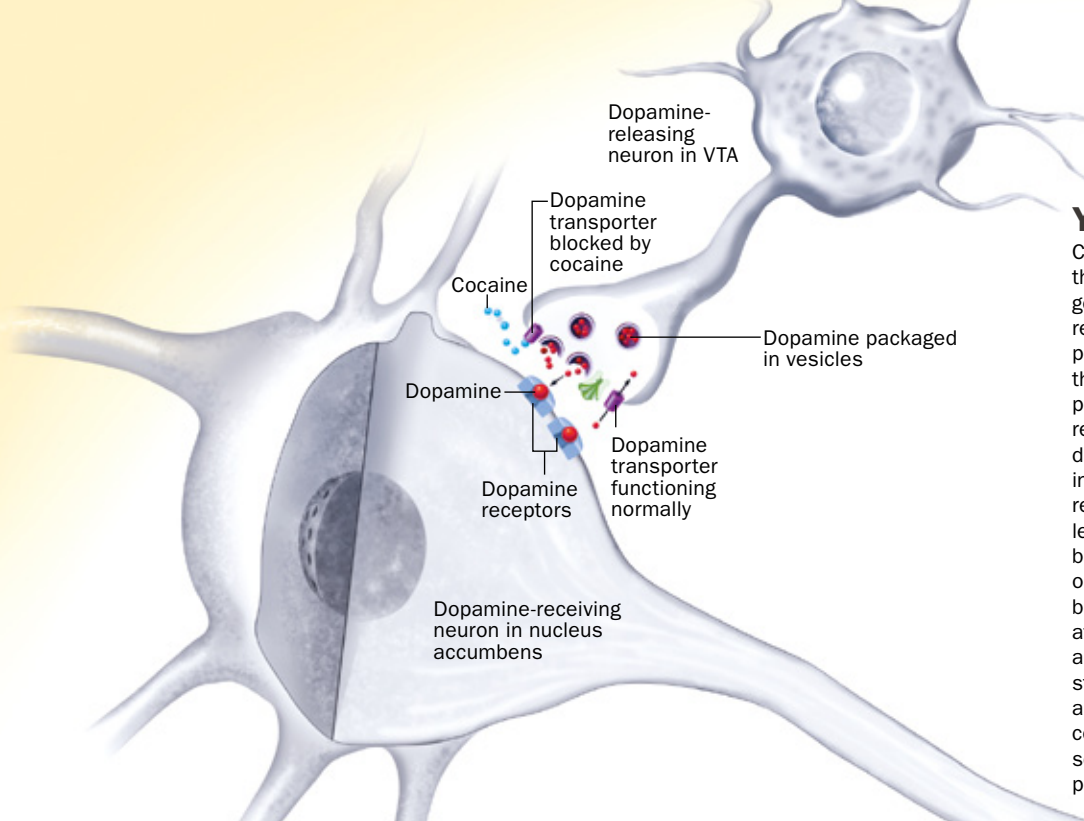
To help people addicted to cocaine (shown at far left in crack form) and heroin (left) kick their habits, scientists are working on vaccines that train the immune system to react to—and deactivate—these drugs when they enter the body. As the drugs lose potency, addicts may lose their motivation to use.

cidated to attach the drug molecule—cocaine in this case—to a protein from a virus that does incite an immune reaction. This technique causes the immune system to react to the combination molecule, creating antibodies that will bind to various parts of it. Many of these antibodies will then also attach to a cocaine molecule when it enters the body alone. The vaccine thus prompts a subset of immune cells to build an arsenal against cocaine.

Next Koob, Janda and their colleagues injected their vaccine into rats immediately after the animals were exposed to cocaine. Ordinarily, when rodents

THE AUTHOR

CARRIE ARNOLD is a freelance science writer living in Virginia. She is a frequent contributor to *Scientific American Mind*.



Your Brain on Cocaine

Cocaine hooks users by changing the chemistry of brain regions that govern feelings of pleasure and reward. When someone has a pleasurable experience, neurons in the ventral tegmental area (VTA), part of the brain's reward system, release the neurotransmitter dopamine at junctions with neurons in the nucleus accumbens. The responses of these recipient cells lead to feelings of delight. Cocaine binds to dopamine transporters on the endings of VTA neurons, blocking the reuptake of dopamine after its release. Dopamine thus accumulates and continues to stimulate reward neurons, creating a "high." A vaccine would prevent cocaine from entering the brain so that the drug could no longer produce feelings of euphoria.

get high for the first time on a stimulant such as cocaine, they become hyperactive and restless; they fail to eat and stay awake for extended periods. In contrast, after these rats took a huge hit of cocaine they were able to fall asleep. The rats had become immune to the effects of cocaine. "This was the paper that broke the field open and said you could immunize against drugs," Koob says, recalling the group's 1995 publication.

Several other laboratories, including that of neuroscientist Thomas Kosten of the Baylor College of Medicine, also developed cocaine vaccines that proved effective in animals. Instead of using a viral protein, Kosten and his colleagues attached cocaine to a toxin produced by the bacterium that causes cholera. In 2002 the researchers gave 24 former cocaine users their vaccine to test its safety and to see whether it would trigger the hoped-for antibody production in people similar to those who might eventually receive the vaccine therapy. Although the treatment proved benign, it failed to produce high levels of antibodies in 25 to 30 percent of patients.

Booster Shots

In a larger follow-up study published in 2009, Kosten's team injected 109 drug users either with the vaccine or with saline—and gave the participants four booster shots over the next 12 weeks to try to raise the percentage of those able to make adequate antibodies. The researchers also tested the addicts' urine three times a week for 24 weeks for

cocaine and other drugs and monitored the level of anticocaine antibodies in their bloodstream. Only 38 percent of the vaccine recipients had high levels of those antibodies, yet nearly all produced some antibodies, and as a group they were 22 percent less likely to have a cocaine-positive urine test than were those who received saline injections. In addition, those who produced large amounts of antibodies were significantly more likely to have cut their cocaine usage by half.

Still, Kosten's vaccine left a considerable number of cocaine addicts without adequate antibody protection. It also did not affect their desire to use, which means that they might not come back for booster shots. So Koob and his colleagues kept pursuing their virus-based vaccine and came up with a combination of chemicals that included a new viral protein. In a study published in 2013 Crystal, Koob, Janda and their colleagues injected their latest manipulation of the cocaine molecule into four female rhesus macaques (*Macaca mulatta*) that had become dependent on cocaine; a fifth received a saline injection.

The macaques that received the vaccine produced very high levels of antibodies to cocaine. When the monkeys were then injected with cocaine, positron-emission tomography brain scans showed that very little of the drug bound to its molecular target, the dopamine transporter in the brain [see illustration above]. What is more, the animals showed no behavioral signs of a drug high, such as restlessness or in-

somnia. Koob and Janda are currently planning a preliminary safety trial of their vaccine in humans.

The pair is also now putting the finishing touches on a heroin vaccine. A vaccine for heroin is trickier to make because heroin is rapidly metabolized into morphine and 6-monoacetylmorphine, both of which act on the brain's opioid receptors. An effective vaccine therefore has to spur the production of antibodies against heroin's breakdown products as well as the drug itself. So Koob and Janda made three vaccines in one: they separately attached the virus protein to heroin and its two major metabolites.

In 2013 Koob, Janda and their colleagues tested their compound vaccine in rats addicted to heroin. These animals spent many of their waking hours either searching for or taking heroin, delivered by intravenous infusion whenever the rats pressed a lever. The researchers then removed the heroin and injected half the rats with three doses of vaccine. After 30 days, the vaccinated rats were once again offered heroin. Although the animals tried to get high, they stopped pushing the lever after several minutes, presumably because they were not getting any reward. The rats that had not been vaccinated, in contrast, kept obsessively pressing the lever for heroin.

Whether the vaccine will work in humans is still an open question, however. Human addicts might be more determined than rats to get high, so if a vaccine thwarts that high, instead of giving up, people might wind up taking more of a substance, leading to a massive overdose, notes University of Queensland bioethicist Wayne Hall. In addition, humans have access to other addictive substances. "If you have an addict who seriously wants to use drugs and is vaccinated, then the next option is to use a different drug that the vaccine doesn't act against," Hall says.

The Other Half of Addiction

Even if vaccines do not produce such rebound effects, many addiction specialists believe the approach is too narrowly focused on biochemistry to be of much benefit in the real world. A complex interplay between individual psychology and environment is at least half the equation of addiction, says Angela Garcia, an anthropologist and addiction specialist at Stanford University. "Maybe the vaccine would help with the part of addiction that is biological, which I would embrace," Garcia says. "But what are we going to do with the other half?"

Garcia points to families in which addiction spans multiple generations. For some people, taking drugs is so familiar it seems normal. Of those who do seek treatment, most end up returning to the same setting in which they first started using, sur-

THE RATS STOPPED PUSHING THE LEVER FOR HEROIN, PROBABLY BECAUSE THEY WERE NOT GETTING A REWARD.

rounded by people taking drugs and object reminders that trigger cravings. A vaccine does not diminish any of those environmental incentives to use.

The nicotine vaccine NicVAX, produced by Nabi Biopharmaceuticals, provides a cautionary tale. In large-scale clinical trials conducted from 2009 to 2011, the vaccine (which is nicotine attached to a bacterial antigen) performed no better than placebo in getting people to quit smoking. Koob and other researchers believe, however, that the devil is in the details. They expect other combinations of pathogen proteins and drug molecules—whether nicotine, heroin or cocaine—to fare better.

Koob concedes that vaccines are only part of the solution to the addiction puzzle. "Vaccines aren't going to cure addiction by any stretch," he says. "But they will put up an enormous barrier." If vaccines can help even a fraction of addicts get off drugs, Koob and Janda believe their work will have been worth the effort. **M**

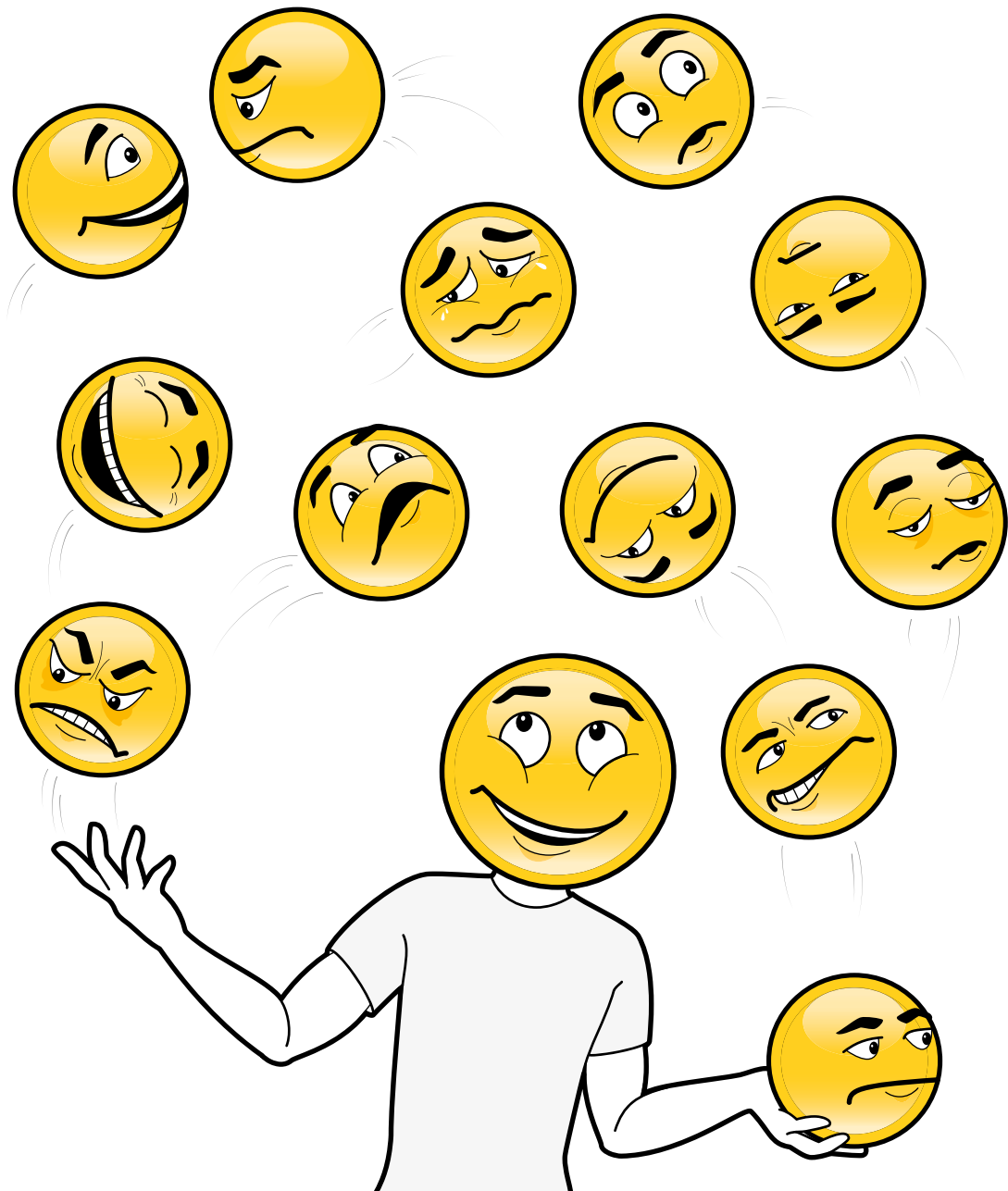
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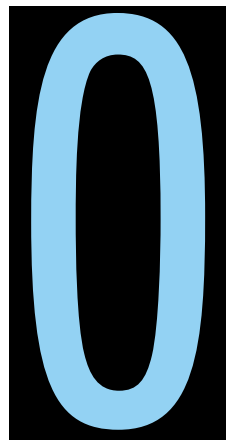
HOW TO CONTROL YOUR FEELINGS—



AND LIVE HAPPILY EVER AFTER

LEARNING TO REGULATE POWERFUL EMOTIONS
CAN ENHANCE PHYSICAL AND MENTAL WELL-BEING

BY STEVE AYAN



Once upon a time people firmly believed that thinking and feeling were two separate capacities, destined to often clash. As 17th-century Dutch philosopher Baruch de Spinoza put it, “When a man is prey to his emotions, he is not his own master, but lies at the mercy of fortune.” By this logic, the intensity of experiences such as sadness, anger or fear can trump our reasoning.

Yet modern research tells us otherwise. We are not slaves to our passing passions; rather we regulate emotions all of the time. You resist exploding at a client just because he is tardy, and you manage not to throw things at the house next door during their noisy barbecue. Controlling anger and frustration keeps our professional and private lives on track—and prevents irksome situations from escalating.

Regulating emotions goes beyond keeping them down. We also need to find healthy outlets for our feelings. These inner responses, after all, can be excellent guides, as when fear warns you off a risky choice. They enrich daily life as well, leading us to revel in the joy of a birthday party or hoot ecstatically when a favorite team wins a game.

How exactly we go about striking a balance with our emotions is a topic that psychologists have been plumbing for decades. Their work has underscored that there is no single perfect approach. A good option in one case could be cataclysmic in another scenario. Instead we rely on dozens of techniques.

To make sense of these disparate tactics, psychologist James Gross of Stanford University developed a model in 1998 that sought to explain

how emotions arise. Gross argued that any emotional experience follows a trajectory with five distinct stages in which a person can intervene to alter the outcome. At first we decide whether to seek out or avoid an emotional scenario. Then we may modify the situation itself. In the next two stages, we sideline unhelpful feelings by redirecting our attention or reappraising our response. Finally, we can deploy coping mechanisms to handle the physiological and behavioral consequences of an emotional event. The comprehensive scope and simplicity of Gross's model quickly made it the most influential framework for emotion regulation in the field.

The catch, however, is that most of our responses at each

stage are automatic. How we react in the face of calamity is often the result of habit or circumstance rather than deliberate choice. "The learned set of emotion regulation [behaviors] is powerful and not easy to modify," says University of California, Berkeley, psychologist Iris Mauss.

Yet we can learn complementary techniques to make the most of our knee-jerk responses. Current research has confirmed that with a little training and awareness, we can learn to avoid potential pitfalls and prevail over every part of this process. By heightening sensitivity to long-term goals, the broader context of an event and a feeling's intensity, we can make smart choices in even fraught situations. In short, we can master our emotions.

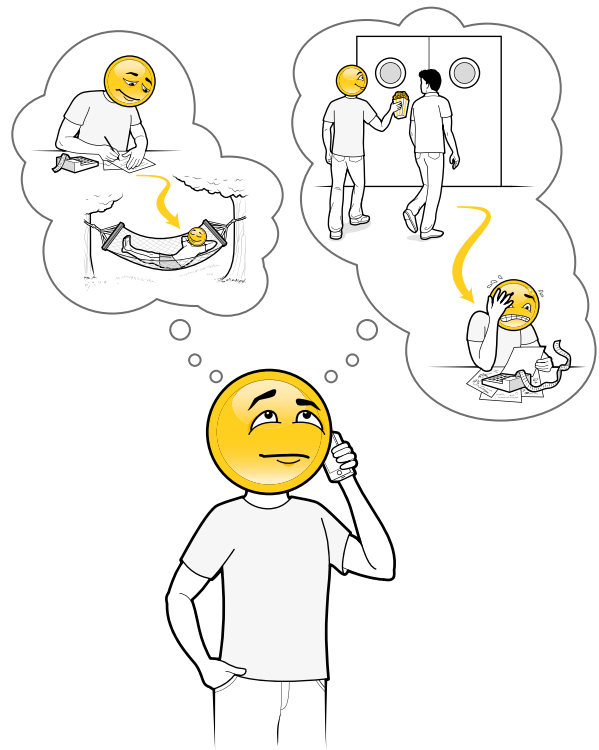
STAGE 1 PICK AND CHOOSE

It is a rainy Friday afternoon. You have had an exhausting week, and you want nothing more than to curl up on the couch and take a nap. You had planned to spend a long, lonely evening working on your taxes. Then a friend calls to ask if you want to see a movie instead.

You are facing the very first stage in Gross's model: "situation selection." You have the power to choose the path your evening will take and the emotional outcome of your day. Here you have to engage in some psychological fortune-telling. How might an evening of taxes make you feel in the future? If you see the movie instead, how will your Saturday shape up? This task can be challenging. Spending time with a friend may be restorative—or it might lead you to neglect necessary chores.

Before you plunge into a decision, bear in mind that people routinely overestimate the intensity of future emotions. Numerous studies have shown that negative outcomes are often not as bad as we expect, and sometimes pursuing a seemingly more positive option can inadvertently set us up for disappointment. For example, in findings published in 2011 Mauss and several colleagues asked 69 participants to read either an article extolling the value of happiness or an emotionally neutral story. Afterward the participants watched a feel-good film clip. Curiously, the people who had read about the benefits of happiness felt less cheery after the movie than the participants who had not read the article. Why the paradox? Mauss theorizes that a preoccupation with being happy can lead people to expect too much from everyday pleasures. Additionally, evaluating your level of bliss may heighten self-awareness, which could hinder the experience of pleasure when it comes your way.

Psychologist Maya Tamir of Boston College has found that rather



than make the pursuit of happiness a guiding principle in life, a person should think in terms of broader aims. In 2012 Tamir and Brett Q. Ford of U.C. Berkeley gave 136 people a battery of tests, including one designed to assess emotional intelligence, which is the ability to recognize, control and express emotions. The participants pondered situations and selected the emotion they would prefer to experience in that moment. For example, "If you need to reach a compromise, would you rather feel angry or happy?"

Tamir and Ford found that people with high emotional intelligence opted for whichever feeling had greatest utility—regardless of whether that emotion was pleasant. A little anger might help an otherwise easygoing person prepare for a difficult negotiation, and piquing anxiety could create extra incentive to study for an exam. A good policy, then, is to keep your long-term goals in mind when evaluating a decision such as how to spend your Friday evening.

FAST FACTS

MORE THAN A FEELING

- 1 Psychologists recognize five different stages during which people can regulate their emotional responses to an event.
- 2 The best way to manage one's feelings depends on many factors, including how malleable the situation is and the intensity of our reaction to it.
- 3 Certain therapies can help individuals better manage otherwise innate responses.



STAGE 2 TAKE ACTION

Often people face an emotional event with no way to change course. Perhaps they have to read a eulogy at a funeral or sit next to a particularly irksome aunt during a holiday meal. In these cases, the best options involve “situation modification,” or changing elements of the environment to make things easier.

The key is to anticipate the potential for stress and take proactive measures. These interventions can be as simple as carrying a lucky charm to make you feel more comfortable or asking a friend to sit nearby as a conversational buffer. Such strategies can also avert further annoyance. For example, if a neighbor is making a lot of noise, you may be better served asking him to quiet down now rather than waiting it out and becoming more frustrated.

Recent research suggests that people who do not take steps to ease difficult circumstances will only compound their troubles. In 2013 Franklin & Marshall College psychologist Allison S. Troy, along with Mauss and New York University mindfulness researcher Amanda Shallcross, recruited 170 volunteers who had experienced a challenging life event in the two months prior to the study. The experimenters first rated how controllable these events were—ranging from accidents and illnesses that no one could have foreseen to things caused directly by the individual’s actions, such as losing a job because of poor performance. Next, the volunteers watched a sad movie while consciously trying to view the film in a positive light.

Some people found this task more taxing than others did. Among the participants who were very successful in reframing the film, those whose recent history had included a stressful but controllable event, such as getting fired because of shoddy work, reported more symptoms of depression than counterparts whose experiences had been less controllable. Events that could have been averted left people more susceptible to depression, perhaps because their failure to prevent problems primed them for feelings of hopelessness. And people who could recast a negative event in a positive way may be most at risk because their flexible thinking allows them to recognize different outcomes to their earlier life events. Individuals in controllable scenarios, therefore, should identify and address sources of stress proactively rather than assuming they can manage the emotional fallout later.

Anticipate potential stress and take proactive measures, such as asking a friend to be an emotional buffer.

Five Tips for Emotional Health

Emotions are hard to control. But even without a fully fledged strategy for regulation, you can adopt some basic techniques to improve your well-being:

Be active. Physical exercise and intellectual engagement usually prevent people from focusing on negative emotions too much. Strain your body once in a while at the gym or enjoy good food, books and music. Such pastimes can make it easier to look at the bright side of life.

Try new habits. Disrupting your routine can help you focus on positive events and avoid boredom. For example, start a diary and take note of nice things that happen to you. Reserve a few minutes each day to remind yourself of happy times.

Meet people. Mingle with folks you like. An active social life is an effective means to overcome everyday worries and mild anxieties.

Be thankful. Being grateful for what you have received enhances satisfaction.

Don’t set the bar too high. It is possible to want happiness too much. Putting pressure on yourself to be merry all of the time may itself become a source of discontent. It is okay—and healthy—to experience a whole spectrum of emotions.

THE AUTHOR

STEVE AYAN is a psychologist based in Heidelberg, Germany, and is an editor at *Gehirn & Geist*.



STAGE 3
LOOK ELSEWHERE

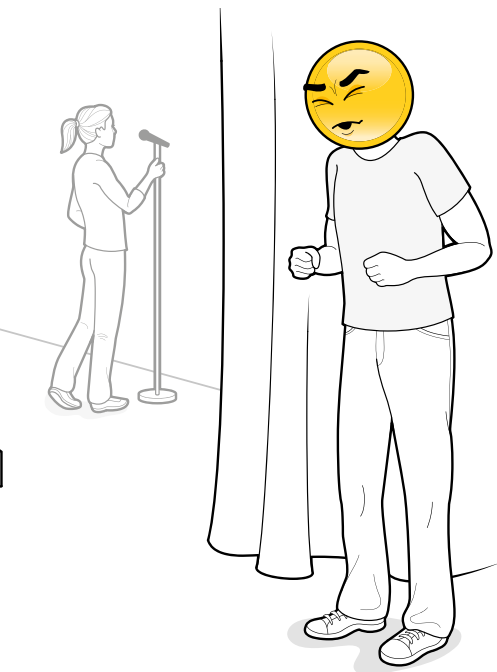
When it is too late to change any aspect of a situation, Gross proposed that people deploy their attention to their advantage, either through distraction or through focus on the matter at hand. For instance, if you need to keep a serious demeanor during an important professional meeting you might avoid

glancing at a colleague who enjoys clowning around during work hours. Whether you should concentrate your attention or divert it will depend in part on the situation's intensity. In a series of studies, psychologist Gal Sheppes of Tel Aviv University asked participants to either reinterpret a sad photograph in a way that made it less worrisome—seeing tears of joy as opposed to grief, for example—or think of something completely different. Although people who reimagined an image's meaning could alter their emotional response, participants often opted for avoidance. Sheppes found that the more unsettling an image

was, the more often people preferred to self-distract. This result suggests that attending to a powerful stimulus can be exhausting, making the opportunity to look away a welcome relief.

In 2014 Sheppes took these findings a step further. He asked 22 participants to look at photographs with varying emotional intensities. This time, however, he gave them additional information. He instructed some of the subjects to respond in a way that would minimize their immediate negative feelings and told other participants that they would have to confront this image later in the experiment. Once again, most people looked away when an image was especially distressing, but those who believed they would view the image in the future were more likely to study even the intense pictures. Distraction, therefore, is an easy option but not necessarily the best way to respond to a recurring concern.

Admittedly, controlling attention can be a challenge: our thoughts and gaze often wander despite our best efforts. Yet certain therapies might help. For example, working memory training, which bolsters the brain's ability to hold and manipulate multiple pieces of information, can boost many facets of emotion regulation, including attention. Typically this training involves learning memory strategies, such as mental rehearsal and mnemonic devices, and doing exercises that use working memory. In addition, mindfulness-based stress-reduction therapy can teach practitioners to observe and detach from inner reactions to strengthen emotional management. In 2010 Gross and Philippe Goldin of Stanford found that eight sessions of this therapy and a half-day meditation retreat could help people with social anxiety disorder learn to attend to their breathing to refocus during an unpleasant experience.



STAGE 4
THINK AGAIN

The people in Sheppes's 2014 study who did not look away from disturbing photographs engaged in a process that psychologists call "cognitive change" or reappraisal. This is when individuals tackle thoughts that lead to an emotional response. For example, a performer with stage fright might reframe nervous energy as "getting pumped" for his next show.

In its most extreme form, some people engage in this stage through prolonged pondering of their personal experiences and sensations. This practice, known as rumination, can intensify symptoms of depression and aggression. A better technique, according to psychologists Ethan Kross of the University of Michigan and Ozlem Ayduk of U.C. Berkeley, is "self-distancing," or imagining the situation as an impartial observer. Instead of asking "Why do I feel like that?" they recommend addressing the question in the third person: "Why does Steve feel like that?"

In 2012 Kross, working with colleagues at Ohio State University and VU University in the Netherlands, published findings from a study in which they examined how self-distancing strategies affect feelings and behaviors. In the first experiment they asked 94 volunteers to rapidly solve anagram puzzles and then announce their solutions aloud. The experimenters, meanwhile, stoked the students' ire by repeatedly demanding that the speaker raise his or her voice. After this activity the students had to visualize the events that had just taken place in one of three ways: as they themselves experienced them, as though they had been a mere witness to the events, or without any special instructions.

Kross and his colleagues found that the participants who imagined the events as though they had been bystanders harbored significantly fewer aggressive thoughts and feelings than their colleagues who had relived the preceding moments. In a follow-up experiment, students who used this fly-on-the-wall perspective for thinking about an emotional moment showed less aggressive behavior than their peers who had not employed self-distancing.

STAGE 5 LET IT OUT

But what if, despite your best efforts, you still find yourself walloped by an emotional blow? If someone unexpectedly shares an insulting opinion, for example, you might not be able to avoid feeling hurt, but you can still respond in many ways. Your jaw might drop in indignation, you could take a deep breath to calm your rising pulse, or you might smile and act unfazed. In the final stage of regulation your options are limited to managing your bodily response.

A person's immediate reaction may be dictated by personality, experience or culture. For example, many Western societies advocate venting, or the release of stress through conversation or exercise. Unfortunately, these techniques can sometimes fuel a person's fury further, revving up energy instead of releasing it.

The primary strategy that people employ at this stage is suppressing their physical reactions. This response results in part from parents raising their children to behave in this way. Not screaming, hitting or crying whenever you feel like it is an integral part of socialization—but holding back emotions can take a toll. In a classic experiment, psychologist Roy F. Baumeister of Florida State University found that when people restrained their emotions during either a comical or sad film clip they tended to give up earlier on a subsequent anagram puzzle than participants who could express their feelings. Resisting emotional responses had taxed their willpower and energy.

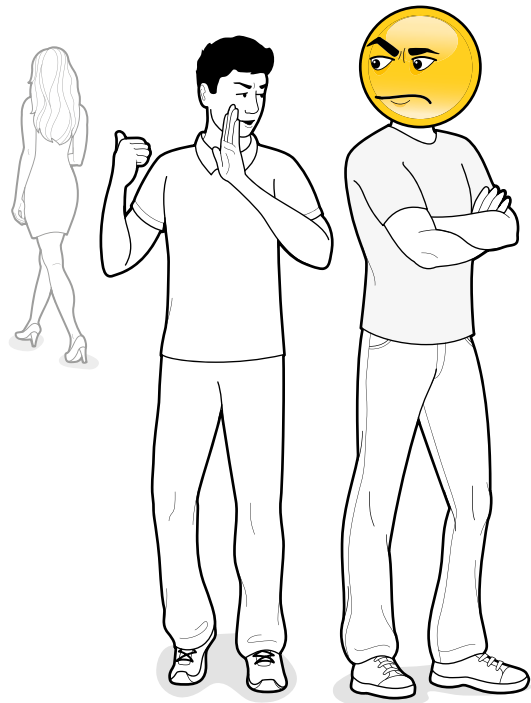
This stress and exhaustion could explain why inhibited expression of feelings is linked to health problems. Johan Denollet and his colleagues at Tilburg University in the Netherlands found in 2010 that people who regularly suppress their emotional distress—a pattern called type D personality—have an increased risk of cardiovascular disease. Denollet has also found that those who hold back emotions suffer more from chronic pain, tinnitus and diabetes than the general population.

Suppression can also put your relationships at risk, as psychologist Emily Impett of the University of Toronto and her colleagues discovered in a 2012 study. In a survey of 80 couples, Impett learned that men and women felt emotionally distanced when they discovered that their significant other had not disclosed his or her feelings in the past. In a follow-up three months later the researchers found that “suppressor couples” had worse-functioning partnerships than other participants.

In addition, a host of studies make it evident that positive feelings are far easier to squash than negative ones. Restraining your response—whether smiling in spite of your sadness or holding back an inappropriate giggle—is ultimately a powerful strategy that should be used sparingly.

The lessons from suppression research are an important reminder that regulating emotions need not mean avoiding them. Instead people can learn to better anticipate their own reactions to intense moments, visualize the outcomes they would prefer and identify the actions that could change those future feelings. By acknowledging and exploring why we feel a certain way, we can use both happy and troubling events to our advantage. They may even prompt us to dig into our beliefs, experiences and misconceptions—and discover new insights into ourselves. **M**

Restraining your responses is a powerful strategy but should be used sparingly.



FURTHER READING

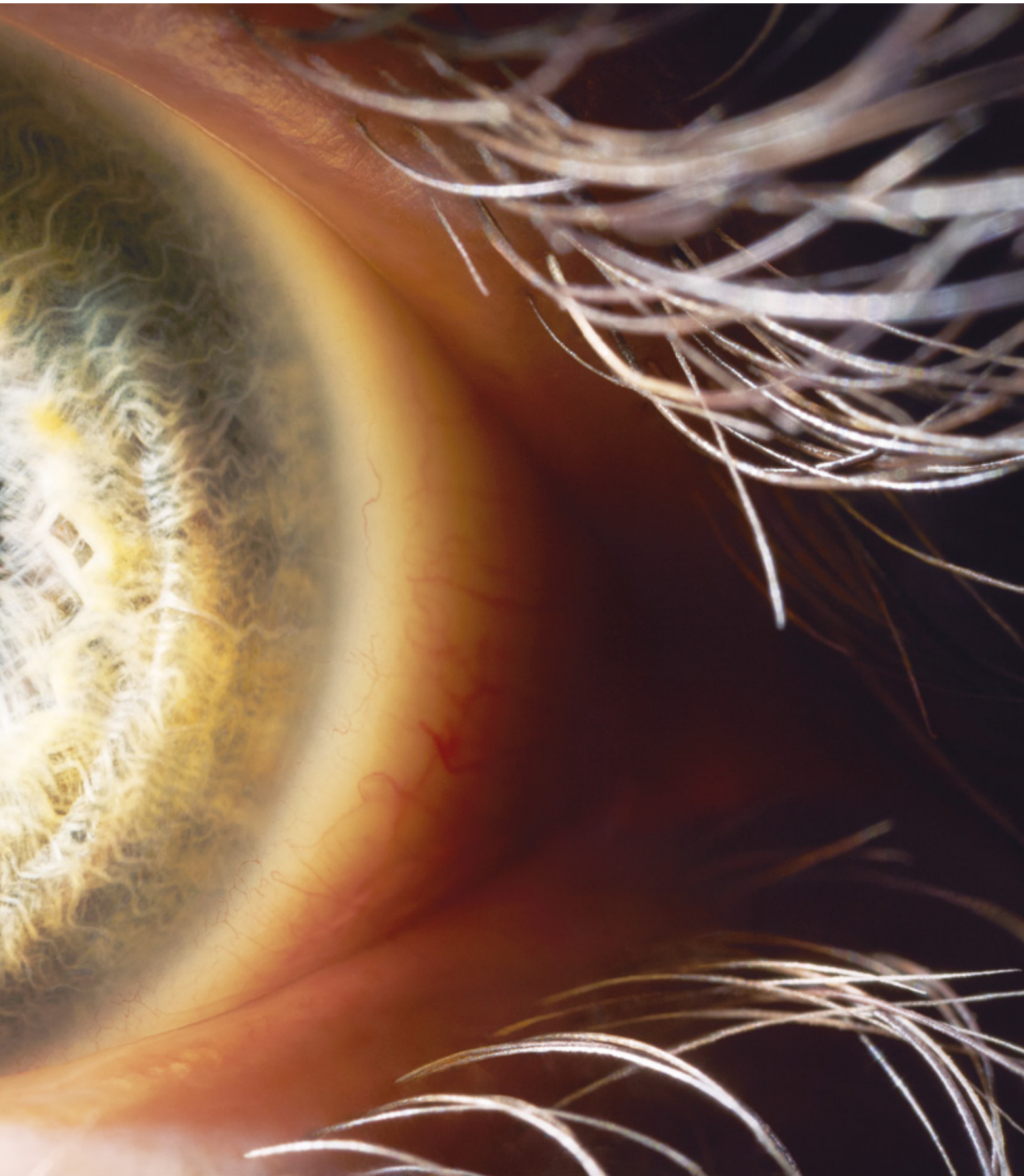
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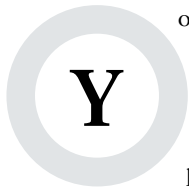
LOOK INTO MY EYES

Gaze-tracking technology lets us play video games, control gadgets and diagnose disease through the eyes alone. It can also reveal a lot about how we think and feel

BY ARRYN ROBBINS AND MICHAEL C. HOUT







ou're in your office near the end of the day, preparing to head home. You log on to your computer, navigate the desktop, open a browser, sign in to your e-mail account. You read your latest messages and write a few yourself, then log out. As you're driving home, something about the car in the next lane distracts you, but a gentle alert reminds you to pay attention to the road. When you get to your living room, you turn on your video game console. You assume an identity and traverse the virtual landscape, evading some characters, blasting others. And from the time you sit down at your desk in the office until you make your final Xbox feint, you carry out most of these interactions without using your hands or even your voice but simply by moving your eyes.

Far from being science fiction, the technology to support such a seamless merging of our digital and physical lives already exists. It is the real-world spinoff from the burgeoning field of eye tracking. Loosely defined, eye tracking refers to any technology that can monitor the direction of our gaze and the behavior of our eyes, in the process generating data that give clues to our intentions. Interactions with devices equipped with eye-tracking sensors and software can seem intuitive and effortless, as if our gadgets are reading our minds.

Not so incidentally, as the technology advances, researchers are learning ever more about the workings of our eyes and unobservable aspects of the mind: our thoughts and mental focus and the pathways into our consciousness. Eye tracking can reveal whether we are processing the things in front of us or are mentally adrift, whether we recognize a face or have never encountered it before—or whether we did encounter it but then forgot. Our new understanding of eye movements is also spurring development in a host of industries, especially gaming, computers and health care. Marketers are eager to tap into our gaze patterns, too, with implications for privacy.

Researchers developed eye tracking primarily to learn about basic visual processing (say, how we meld independent

streams from each eye into a single mental image). Clinicians were also interested in how eye movements relate to disorders involving vision problems, such as vertigo. Initially eye tracking was a matter of simple observation. The experimenter would sit across from a person and take notes about the behavior of the subject's eyes.

Early findings were surprising. Despite our subjective experience of vision as a smooth sweep across a stable landscape, the movement of our eyes is anything but steady. In most instances, our eyes stay relatively still for extremely short periods (usually around a third of a second), followed by rapid jerks until they alight on their next target. The short, still periods are known as fixations, and the quick jumps are called saccades.

The main reason for the jerky behavior is that our visual sweet spot is very small. Indeed, the part of the visual field that delivers a sharp image is about the size of a dime held at arm's length, with quality falling off sharply toward the periphery. So we move our eyes constantly to bring new pieces of information into central focus. That herky-jerky motion posed a puzzle for investigators: How, despite the constant movement, do we experience vision as stable?

Hence the quest for hardware that can track every movement of the eyes, no matter how fleet. Early in the 20th century psychologist Edmund Huey of the Western University of Pennsylvania (now called the University of Pittsburgh) created a device that could correlate eye movements with the words on a page as someone reads. It was a rather invasive apparatus, involving a plaster cup, worn on the eyeball, with a tiny hole through which the subject could see. A lever was attached to the eyecup and to the lever a pen, which made contact with a rotating drum as the participant read. To minimize irritation, the eyeball was anesthetized with cocaine, and the head was held in place using clamps and a bite bar. Other early contraptions used combinations of contact lenses, suction cups, embedded mirrors and magnetic field sensors to triangulate the focus of the viewer's attention.

Nowadays researchers rely on the way the cornea reflects light to chart the rotation of the eyeballs. In a typical experiment—say, to study reading or attention—a participant sits in front of a computer with her head on a chin rest. A small camera at the base of the computer zooms in on one (or both) of the eyes as diodes emit near-infrared light (people cannot perceive light at that wavelength, so they experience no discomfort). The light bounces back to the camera, and computer algorithms convert the reflection data into a real-time gaze path of the eye. By combining information about the pattern of corneal reflectance, the displacement of the pupil and the location of the computer in relation to the participant, tracking systems can tell pre-

RESEARCHERS ARE LEARNING EVER MORE ABOUT THE WORKINGS OF OUR EYES AND UNOBSERVABLE ASPECTS OF THE MIND.

FAST FACTS

WHAT LOOKS CAN TELL YOU

- 1 Analysis of eye movements can aid in the diagnosis of a variety of disorders and help us draw inferences about attention, memory and emotion.
- 2 Some devices already incorporate eye-tracking technology, such as phones that suspend video playback when you look away from the screen.
- 3 Marketers are tapping into data about where people are looking so they can tailor digital ads for each individual, leading to privacy concerns.

PRECEDING PAGES: TIM FLACH/Getty Images



cisely where the participant's gaze falls on the computer screen.

A greater challenge came when research moved beyond the laboratory. Spatial accuracy is critical in eye tracking because a minute error in measuring the orientation of someone's gaze will throw off any interpretation of what the person is seeing. Achieving that precision is harder in the outside world because head and body movements can interfere with measurements of gaze location. So researchers developed devices that superimposed information about the gaze onto the environment, such as a helmet topped by a camera that melded a recording of eye movements with a real-time video of the subject's field of vision. Today's wearable tracking devices take the form of light-

weight goggles, but the principle remains the same: a small sensor tracks the dark spot of the pupil to pinpoint the direction of the gaze, and a tiny camera mounted directly between the eyes records the scene.

Knowing What We See

Besides exposing the mechanics of vision, eye tracking can also help us understand the invisible elements of cognition: what we remember, how we feel, and what we are paying attention to, whether we are aware of it or not. For instance, eye movements can reveal when we are looking at something we have seen before, even if we have no memory of encountering

it. In a 2012 study led by psychologist Deborah Hannula of the University of Wisconsin–Milwaukee, subjects were asked to memorize an image of a face. When shown a panel of faces that included the original, the subjects spent more time examining the image they had seen before than those they had not. If the images instead included a slightly manipulated version of the original face, the subjects still tended to identify the altered image as the real thing. Yet their eyes were not fooled. The subjects spent less time looking at the manipulated images than the original, suggesting that the eyes recognized them as fakes. These findings have important implications for interpretation of eyewitness testimony—say, in gauging whether someone looking through a book of mug shots has seen one of the faces before.

Patterns in eye movements can also give us insights into thinking and emotion. In a 2009 study led by Rachel Bannerman of the University of Aberdeen in Scotland, researchers used eye tracking to examine how people regard threats. They discovered that the subjects' eyes moved faster toward threatening faces and body postures than benign ones, suggesting that our oculomotor system is primed to detect imminent danger. Individuals who are scared or anxious also show a bias toward threatening objects and faces and have a harder time moving their eyes away from the threats than other people do. Reinforcing this finding, a 2014 study by Jonathon Shasteen and his colleagues at the University of Texas at Dallas found that people are quicker to focus on an angry face in a crowd of happy faces than they are on a happy face in a crowd of angry faces, suggesting that danger more than singularity is what draws the eye.

Our eyes are also markers of mental effort. Eckhard H. Hess, a pioneer of pupillometry (the measurement of pupil size) in the 1960s, found that the pupils of his participants dilated when they performed challenging multiplication problems, much as our pupils widen when we enter a dimly lit room. The pupils are an ideally objective structure for research. Unlike our eyeballs, which we can consciously direct—say, by looking one way or another—we have no voluntary control whatsoever

over our pupils. Researchers hope that analysis of pupil measurements will help reveal when workers are overtaxed, especially those in risky jobs such as air traffic controllers, baggage screeners, truck drivers and surgeons.

Similar research can help the desk-bound pay attention to what they are doing, too. Psychologist Erik D. Reichle of the University of Southampton in England is working on a system that can let people know when they are zombie reading—that

phenomenon by which we move our eyes over text for a while without taking in a word we are seeing. In a 2010 study, Reichle had discovered that our eyes behave differently when we lose mental focus. If we are concentrating, our fixations tend to be shorter when we look at familiar words and longer when we look at less common ones. That variation is absent when we read mindlessly, even though our eyes are still hitting the mark. Now Reichle is trying to develop algorithms that can sift eye-tracking data and alert readers as soon as their attention wanders.

Practical Tracking

As we learn more about the relation between eye movements and the mind, eye-tracking technology is finding its way into real-world applications, especially in

the control of digital devices, gaming and health care. Eye trackers can already replace the mouse for such tasks as clicking, zooming and scrolling. Users might click by staring at an icon for a period of time, zoom in or out by fixing on a location and pressing a controller key, and scroll by moving their eyes up or down.

Adding an eye-tracking system to a computer or tablet is simple. The devices, which incorporate a light source and sensor, are small and sleek and adhere to the bottom of a monitor or the frame of a laptop or tablet, connecting through a USB port. They are relatively affordable, with models from companies such as the Eye Tribe and Tobii costing \$99 to \$139. Users install the relevant software and complete a quick calibration procedure (usually a training program that teaches the software the characteristics of the user's eyes). Current devices require the user to do some programming (such as creating drivers), so they are not quite plug and play. Computers and tablets with built-in eye-tracking technology are expected to reach the market soon, including, according to rumors at press time, an Apple iPad Pro. Indeed, Apple submitted a patent in 2013 for eye-tracking technology that would address the tendency of an image to fade from our perception if we stare at it too long.

Mobile devices that monitor eye movements are also making their way into the market. If you want a fumble-free shutter button on your iPhone, one app already lets you take photographs by winking. Google Glass will do the same. The Sam-

ANALYSIS OF PUPIL MEASUREMENTS WILL HELP REVEAL WHEN WORKERS ARE OVERTAXED, ESPECIALLY THOSE IN RISKY JOBS.

THE AUTHORS

ARRYN ROBBINS is a doctoral student focusing on visual cognition in the department of psychology at New Mexico State University. **MICHAEL C. HOUT** is an assistant professor in the department of psychology at New Mexico State University and principal investigator of the Vision Sciences and Memory Laboratory there.

Children with dyslexia have difficulty tracking objects in flight, a fact that can be helpful in early diagnosis. The left image shows the gaze path of a child without dyslexia. The choppy image on the right is the gaze path of a child with dyslexia.



sung Galaxy S4 and S5 phones already let users pause videos by looking away from the screen or turn pages on an e-book with a tilt of the head.

The industry most eager to adopt eye-tracking technology may be gaming. An eye-tracking version of a shooter game, for instance, would let players move their avatar around a virtual world by looking at the spot where they want to advance. Pressing a key might open a menu of weaponry; players would select items by blinking and attack by looking at the target and pressing the trigger key. According to an online story in the January 2014 *Gizmag* by Jonathan Fincher, gamers who tested early versions of the technology said that using it was a little uncomfortable at first, with the urge to reach for the mouse especially hard to resist, but in the end they found that aiming and shooting with their eyes was faster and more accurate. Eventually players equipped with eye-tracking gear will likely have a speed advantage over those using standard mouse controls, and nothing drives a technology like an arms race.

Good Medicine

Eye tracking is also on its way to becoming an important tool in health care. Already the technology has streamlined the screening and diagnosis of a variety of disorders with visual components, and it will soon help people with disabilities navigate the world.



People without speech will be able to communicate by staring at an icon on a screen and blinking.

On the diagnostic frontier, eye tracking is particularly useful in detecting Parkinson's disease, schizophrenia, and a host of childhood maladies, including autism, attention-deficit hyperactivity disorder (ADHD) and dyslexia. People with these disorders have unique patterns of eye movements that simple computer tests can spot. In pioneering work at the University of Southern California, for example, neuroscientist Laurent Itti's lab devised algorithms that have helped identify people with Parkinson's with 90 percent accuracy and people with ADHD with nearly 80 percent accuracy. A 2014 study by psychologist Eva Nouzova of the University of Aberdeen and her colleagues reported progress in using eye tracking to diagnose major depression. And in work published in 2012 psychologist Philip Benson, also at Aberdeen, and his colleagues developed tests that can distinguish patients with schizophrenia from healthy controls with nearly perfect accuracy.

The schizophrenia test takes advantage of an anomaly in eye movements: when we track a moving object like a ball flying through the air, we follow the object smoothly, without saccades. The implication is that smooth pursuit uses different neural circuitry than activities such as reading. When people with schizophrenia try to follow moving objects, however, their eye movements are jerky. So to screen for schizophrenia, technicians ask subjects to follow a dot as it moves around a computer screen and flag anyone whose eyes show telltale saccades. (Benson's team won an award for its research and will use the prize money to bring the program to market.)

Beyond diagnostics, researchers are using eye tracking to help people with physical disabilities live independently. Individuals with neurological disorders and brain and spinal cord injuries often have limited ability to communicate. Computers equipped with gaze-interaction technology would let people use their eyes to open a browser, find their e-mail inbox and "type" by selecting words on the screen. For those who cannot talk, voice-output systems would play the text through speakers. For most, the systems would likely supplant so-called BCI (short for brain-computer interface) spellers, in which a person observes a grid of letters while wearing a cap studded with electrodes that can identify brain activity. To select a letter in the grid, the user must focus on it for several seconds. Eye tracking, in contrast, can detect the location of a viewer's gaze instantaneously.



Do You See What I See?

Like many new technologies, eye tracking raises a host of ethical and privacy concerns. In this increasingly data-driven age, we have cause to wonder who will have access to the kind of information our technology collects. Any number of people could be looking over our shoulders as we browse the Internet with an eye-tracking PC or drive a car with a tracker installed (such as Hyundai's HDC-14 concept car). Could advertisers get hold of this information? What about insurance companies or the police?

Currently advertisers use cookies to track the Web sites you visit so they can serve you ads for products that might interest

you. When computers come with eye-tracking systems, these advertisers could use information about where you are looking on a page to tailor the ads even more. Some users might find the fine-tuning helpful, but imagine if pop-up ads moved around a page with your gaze or the video ads on YouTube “knew” when you were not watching them and paused until you looked at them again. These tricks are well within the scope of the technology, and clashes with consumers are bound to occur.

In 2012, for instance, Microsoft patented eye-tracking technology for its Kinect gaming devices to let the company collect information about where users were looking on a screen while playing, causing worries that Microsoft would be tracking

which ads gamers were looking at and for how long. The company got into hot water over privacy concerns the following year, with rumors that the company would sell Kinect data to marketers and use Kinect for targeted advertising. Microsoft was also planning to tailor ads to the mood of the user by running the images captured by the eye-tracking system through facial-expression analysis. Some Kinect users voiced concern that the device would be always on and always listening, like Big Brother. Microsoft responded with a series of statements in October 2013 assuring users that they would be able to turn off the device and ad-tracking features and that the company would not collect the data unless the user wanted it to.

The use of eye tracking as a means of identification is evoking more uneasiness. Researchers in the computer science department at Texas State University are testing biometric systems that can identify people from their unique eye-movement patterns as they read text or view a picture. In recent studies, the accuracy of eye tracking in identifying subjects was a little more than 70 percent. That rate is far below the accuracy of iris scans (90 to 99 percent) or fingerprints (up to 99 percent). As computing systems and tracking technologies develop, however, the gap will likely narrow. Even now the technology has clear benefits for home security and protection of technology. For example, intruders would be locked out of your computer because the system would know from their eye move-

GOOGLE COULD DEPLOY A “PAY PER GAZE” SYSTEM IN WHICH ADVERTISERS PAID THE COMPANY FOR EACH LOOK AT ONE OF THEIR ADS.

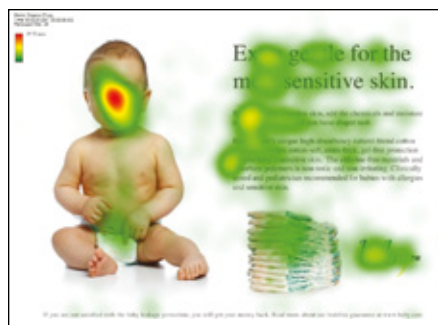
ments that they were not the owners. The technology is also easier on the subject than iris scans, which require the user to hold still. The worry, however, is that an eye-tracking ID system is amenable to covert and invasive deployment.

No gadget has more potential for invasiveness and general spookiness than Google Glass, a wearable computer that projects images through a series of lenses onto the user’s retina. Like most portable devices, it will have a camera, too, facing outward. Although the current beta version of Glass does not have built-in eye tracking, Google has filed a patent to incorporate the technology into head-mounted devices. The patent, which covers the ability to track gaze and measure pupil size, suggests that Google plans to

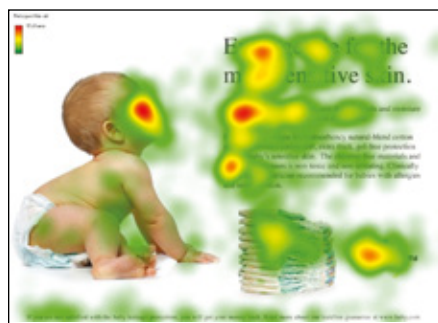
assess user engagement when people look at ads. Gaze tracking would tell Google what the users were seeing (ads, objects, people); pupillometry would measure their emotional response to these objects and to people in the environment. Armed with these data, Google could deploy a “pay per gaze” system in which advertisers paid the company for each look at one of their ads. The technology would work with anything in the user’s field of vision, including billboards, magazines and other print media, as well as images displayed on Glass.

The ethical concerns are obvious: the device could potentially identify not only where people were when they were wearing it but also what, and whom, they encountered. Google’s patent addresses privacy issues by making the data collection anonymous and letting users opt out of this form of tracking. Yet will these assurances hold if someone on the NSA watch list happens to pass before your gaze?

In the end, even when eye-tracking technology lets us control the devices that are tracking us, our sense of command may be illusory. If the eyes are the windows to our souls, we need to know who else is looking through them. **M**



Marketers are using eye-tracking heat maps to figure out where our gaze settles when we look at an ad, with red indicating areas of intense focus. In the upper image, the baby’s face captures most of the attention. In the lower image, by having the baby look at the text block, the marketer throws the reader’s gaze in that direction, too.



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WOMEN IN
SCIENCE:
**THE
PATH TO
PROGRESS**

Blatant bias no longer blocks women from blossoming into scientists and engineers. Yet societal factors still nudge women away from academic science

**By Stephen J. Ceci, Donna K. Ginther,
Shulamit Kahn and Wendy M. Williams**

ILLUSTRATIONS BY PETER HOEY

For centuries men dominated academic science and engineering. Gender bias once greatly imperiled the progress of any woman inclined to pursue science, technology, engineering or math (STEM). Over the past 40 years, however, society has gradually be-

gun to accept, if not embrace, the notion of the female biologist, mathematician or engineer, and the number of women in science at all levels has increased dramatically. In the early 1970s women received 29 percent of bachelor's degrees and 10 percent of Ph.D.s in STEM. By 2011 women held just



More Science

See the *Psychological Science in the Public Interest* article "Women in Academic Science: A Changing Landscape," on which this story for *Scientific American Mind* is based, at the Association for Psychological Science's Web site: www.psychologicalscience.org/index.php/publications/women-in-academic-science.html



over half of STEM bachelor's degrees, about the same as their proportion of high school graduates, and 41 percent of Ph.D.s.

Yet those promising statistics belie two areas of stagnation for women in STEM. First, a marked deficit of women remains in certain disciplines: geoscience, engineering, economics, mathematics, computer science and the physical sciences. Although women outnumber men among college graduates overall, they currently make up only 25 percent of college majors in these math-heavy fields, and their numbers

have been dropping since 2002. Once a woman enters one of these fields, however, her progress toward a Ph.D. and a tenure-track job resembles that of her male counterparts. About 10 percent of both men and women with college degrees in math-intensive fields proceed to Ph.D.s, and 35 to 38 percent of those with Ph.D.s receive assistant professor jobs. According to the U.S. National Science Foundation's 2010 Survey of Doctorate Recipients, women make up 30 percent or less of assistant professors and 7 to 18 percent of full professors in these disciplines.

Meanwhile, in psychology, life sciences and social sciences, the reverse situation persists: women's ranks among college majors have overtaken those of men, but the female presence shrinks at higher levels. The percentage of female assistant professors in psychology, life sciences and social sciences from 2008 to 2010 was 31.6 percent, compared with 53.2 percent in the corresponding Ph.D. years—a gap of 22 percentage points. Women now hold just 40 percent of full professorships in psychology and about a quarter of these in life and social sciences.

People have put forth myriad explanations for these phenomena—from biased interviewing, hiring and promotion to a gender disparity in quantitative ability and career preferences. Our research group has whittled away at these explanations to determine the most influential ones for each gap.

For the math-centered academic fields, in which women are scarce by the end of college, a difference in interests is a more important factor than a disparity in ability. Cultural messages suggest (incorrectly) that girls are not competent in math. That misconception, along with a lack of female mentors, may influence the number of girls seriously considering these fields. Later on, women who pursue biology, psychology and other social sciences are less likely to get stuck on the ladder—say, because of institutional bias—than to simply jump off, opting out of the competition for faculty positions because they do not believe these jobs are compatible with having families. Addressing the tendency of women to leave academic science will mean making these fields more amenable to work-life balance.

The Math Gap

The percentage of women receiving advanced degrees in a field is negatively correlated with that area's mathematical content. Simply put, the more math, the fewer women. Many have suggested that differences in mathematical aptitude might contribute to this gender gap.

Girls and boys do not differ in average mathematical ability. Using national probability samples involving millions of school-aged children, psychologist Janet S. Hyde of the University of Wisconsin–Madison and her colleagues have repeatedly found that the average performance of boys on standardized math tests almost entirely overlaps with that of girls. The researchers' 1990 meta-analysis of 100 studies involving three million children revealed no sex differences at any age or for

problems of any complexity, except that boys performed slightly better on advanced high school–level math problems. By the beginning of the 21st century, however, girls had evened the score on the hardest problems on the National Assessment of Educational Progress for high school students—most likely a result of having taken more math courses.

Of course, the individuals entering math-intensive fields are not average in mathematical ability, and at the high end of the math scale boys do outnumber girls. For example, in a study published in 2009 educational psychologists David F. Lohman of the University of Iowa and Joni M. Lakin, now at Auburn University, analyzed 318,599 American third to 11th graders and found that among the top 4 percent of high scorers, two thirds of the kids were male and one third female. Similarly, in 2013 psychologists Gijsbert Stoet, now at the University of Glasgow, and David C. Geary of the University of Missouri found slightly more than twice as many boys as girls in the top 1 percent of scores from 15-year-olds on the Program for International Student Assessment from 2000 to 2009.

A 2-to-1 ratio favoring male students could be instrumental in impeding women from achieving at high levels in math-intensive fields. Yet the average quantitative scores of Ph.D. candidates in the most math-heavy fields hover around the 75th percentile, a level where the sex gap is considerably less than 2 to 1. For that matter, sex differences in mathematics scores do not translate into grades in math classes (in which female students fare slightly better), and 40 to 48 percent of baccalaureates in mathematics have been awarded to women for four decades. (Although women are majoring in math in numbers approaching those of men, fewer women are majoring in most of the math-related fields.)

What is more, this disparity in test scores does not exist everywhere or in every ethnic group, suggesting it is mutable. In the U.K., the male-to-female ratio at the top 4 percent is smaller: 3 to 2 compared with 2 to 1 in the U.S. In Iceland, Singapore and Indonesia, *more* girls than boys scored in the top 1 percent at certain ages. In 2009 Hyde and oncologist Janet E. Mertz of the University of Wisconsin–Madison School of Medicine and Public Health found a similar pattern among Asian-Americans, with more female students appearing in this high-scoring group. Thus, sociocultural factors are driving some of the sex differences among the young math elite.

The Culture Gap

Among these influences is a phenomenon known as stereotype threat. Researchers such as social psychologist Claude M. Steele, now at the University of California, Berkeley, have shown that the awareness that others expect members of a social group to do poorly in math is sufficient to create anxiety and worse performance among members of that group. Even subtle priming of sex can hamper female performance in math. For example, female test takers who marked the gender box after completing the SAT Advanced Calculus test scored higher than female peers who checked the gender box before starting the test (although

FAST FACTS

GIRLS IN THE HOOD

- 1 Over the past 40 years the number of women in science has risen dramatically, yet large gender gaps remain in certain fields and jobs.
- 2 Although women outnumber men among college graduates, they make up only one quarter of the majors in math-intensive fields such as geology, physics and engineering, and that fraction has been declining.
- 3 In math-intensive fields, a difference in interests contributes more to the lack of women than does a disparity in ability.

some critics of this work have claimed that the effect is not as robust or as large as claimed).

Some of the attitudes that lead to stereotype threat also may depress girls' interest in math-intensive fields. In a 2012 review of recent work sociologist Lara Perez-Felkner of Florida State University and her colleagues revealed that by age five, girls receive the message that math is for boys. By middle school, 9.5 percent of boys expect to work in science or engineering compared with less than half as many girls (4.1 percent).

These early preferences often change in individuals. But in high school, when they are far more stable, a gender tilt remains. In a book published in 2003 sociologists Yu Xie of the University of Michigan and Kimberlee A. Shauman of the University of California, Davis, found that among college-bound high school seniors, more than three times as many males as females expected to major in science and engineering. In 2013 sociologist Stephen L. Morgan of Cornell University and his colleagues reported that male high school students were more than four times as likely as female students to have listed only STEM occupations apart from the life sciences (and excluding medical, biological, health and clinical sciences) in their plans.

These findings are in line with data showing that females tend to prefer people-oriented professions such as nursing, counseling and teaching. (For the ratio of boys to girls taking science AP exams, see the upper left illustration on the next page.) Overall, studies show that high school students' expectations of their future college major explain 28.1 percent of the gender gap in science and engineering baccalaureates.

College experiences are also important for recruiting women into math-intensive fields. Women who major in science and engineering are more likely than men to start down that path in college rather than in high school. In addition to exposure to these fields, women need role models. According to a 2010 study led by economist Scott E. Carrell of U.C. Davis, female students at the Air Force Academy who had female professors in introductory STEM courses (which are randomly assigned at the academy) were more likely to pursue a STEM major than were peers assigned to male professors.

Women may need more academic support to stick with a science major because they attach greater importance to getting high grades than men do and are therefore more likely to drop courses in which their grades may be lower—the so-called fear of a B. In a 1997 study sociologist Elaine Seymour of the University of Colorado Boulder and historian Nancy Hewitt of Rut-

gers University found that loss of self-esteem caused by low grades in introductory science and math courses was associated with women's leaving science and engineering majors.

Challenging Bias

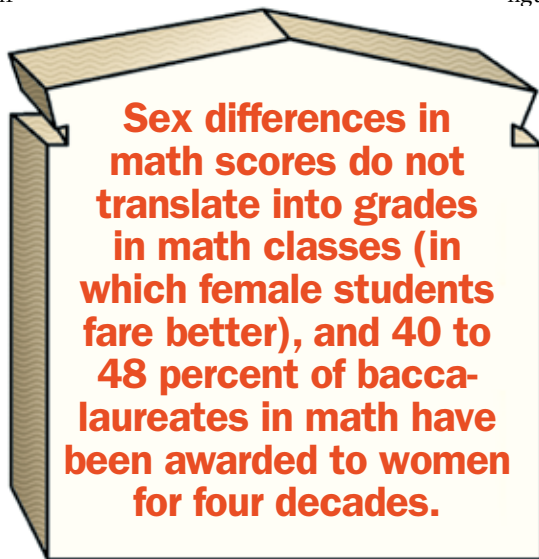
The women who do graduate with majors in math-heavy fields, however, advance in them just as often as men do. Women held 26.3 percent of the Ph.D.s in these fields in 2011, a

figure that mirrors their numbers among baccalaureates in the same fields seven years earlier, up from 16.8 percent in 1994; their proportion of assistant professorships rose from 14.3 to 22.7 percent, percentages not significantly different from those of women obtaining Ph.D.s in these fields five to six years earlier.

In contrast, in psychology and in the life and social sciences, the attrition of women after college is considerable. Since the mid-1990s women have received 60 percent or more of the bachelor's degrees in these fields; in 2011 they received 57.9 percent of the Ph.D.s, up from 46.1 percent in 1994. Yet

although women still hold the most assistant professorships in psychology, men significantly outnumber them as assistant professors in the life sciences.

Many people believe that gender bias remains a significant factor in this drop-off (although why the discrimination would affect the life and social sciences more than mathematical fields is not clear). Numerous small experiments involving hypothetical applicants point to the existence of gender bias. For instance, in 2012 psychologist Corinne Moss-Racusin, now at Skidmore College, and her colleagues reported that when 127 science faculty at six U.S. universities evaluated fictitious applicants with bachelor's degrees for a laboratory manager post, they rated males higher and recommended higher

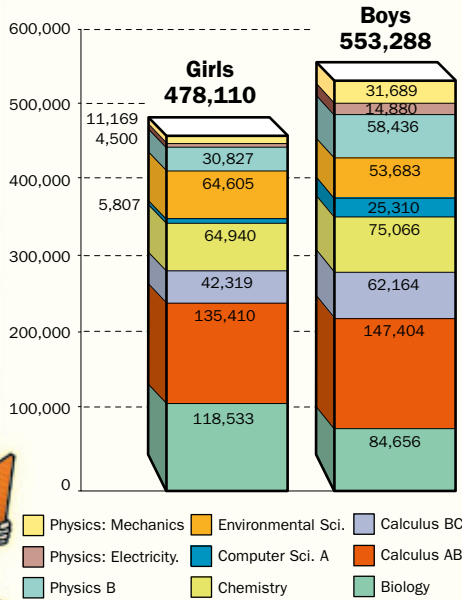


THE AUTHORS

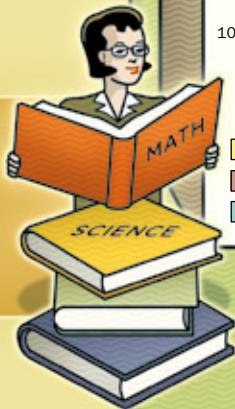
STEPHEN J. CECI is Helen L. Carr Professor of Developmental Psychology in the department of human development at Cornell University. He serves on *Scientific American Mind*'s board of advisers. **DONNA K. GINTHER** is a professor of economics at the University of Kansas, where she directs the Center for Science, Technology and Economic Policy. **SHULAMIT KAHN** is an associate professor in the Boston University School of Management. **WENDY M. WILLIAMS** is a professor in the department of human development at Cornell. She directs the Cornell Institute for Women in Science.

THE PATH FROM STUDENT TO PROFESSOR

Number of Students Taking AP Test in Mathematics and Science
Girls outnumber boys among AP test takers in only two science subjects.



By age five, girls receive the message that math is for boys.



Percentage of Female Applicants for Tenure-Track Positions at 89 U.S. Research Universities

Women were offered jobs at rates higher than their proportion of the applicant pool.

	Mean % of Female Applicants	Mean % of Female Applicants Invited to Interview	Mean % of Female Applicants Offered Positions
Physics	12%	19%	20%
Biology	26%	28%	34%
Chemistry	18%	25%	29%
Civil Engineering	16%	30%	32%
Electrical Engineering	11%	19%	32%
Mathematics	20%	28%	32%

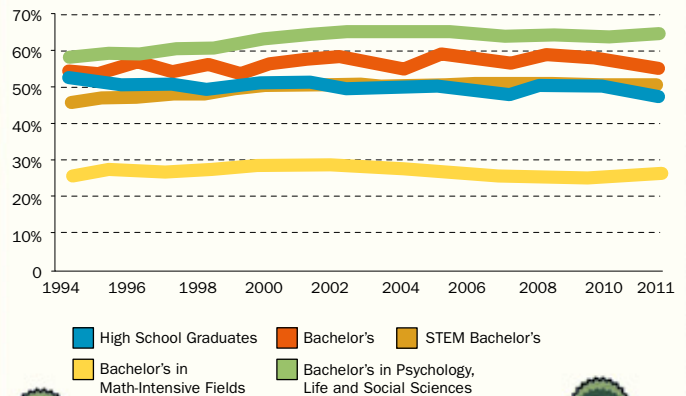


Forty to 48 percent of baccalaureates in math have been awarded to women for 40 years.

Female students who had female professors in introductory STEM courses were more likely to pursue a STEM major.

Percentage of Female High School Graduates and Bachelor's

Women make up their fair share of STEM and life science fields. The same is not true for the math-intensive fields.

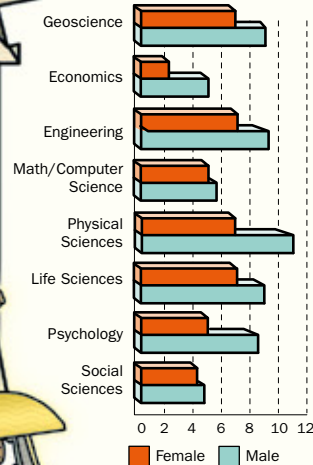
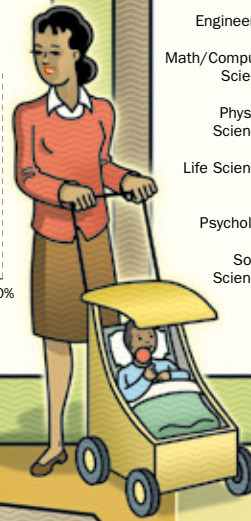
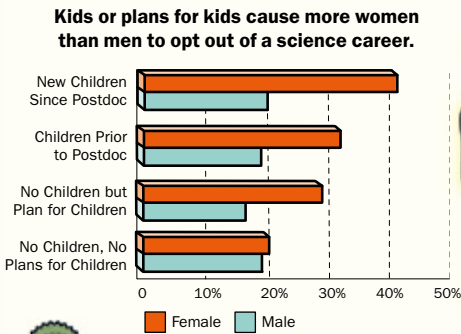


Among college-bound seniors, more than three times as many males as females expect to major in science and engineering.



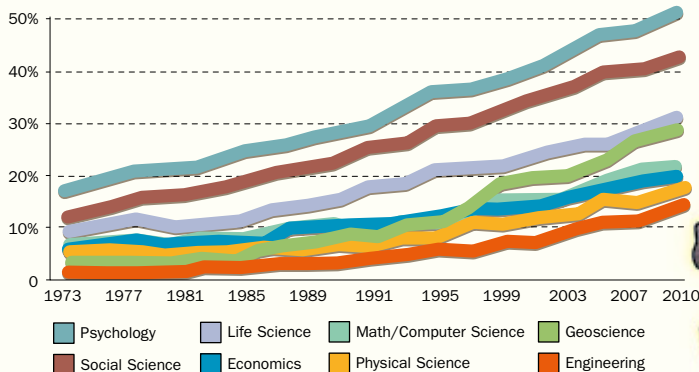
Instead of being denied jobs in academic science, female applicants are just leaving it.

Percentage of Postdocs* Who Switched Away from Emphasis on Research Professor Career as Function of Presence of Children



Percentage of Female Tenured and Tenure-Track Faculty

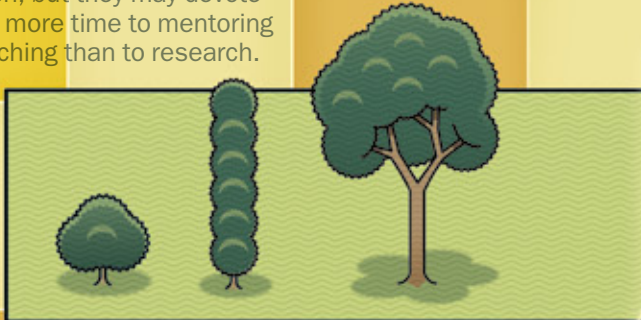
The number of women in math and science careers has grown steadily in recent decades.



As assistant professors, women are less productive than men.



Women do not seem to work less than men, but they may devote relatively more time to mentoring and teaching than to research.



Our analysis shows the roots of these problems lie less in biased hiring and promotion decisions and more in the choices women make to maintain work-life balance.



starting salaries and more mentoring for them than for female applicants, even though there was no difference between their applications.

Yet real hiring data are inconsistent with the results from these mock situations. A 2010 U.S. National Research Council survey looked at hiring in six STEM disciplines—biology plus five math-intensive fields—including almost 500 departments at 89 prestigious universities nationwide from 1995 through 2003. The women who applied for tenure-track assistant professor positions were invited to interview and offered positions in each of these fields *more* often than would be predicted by their fraction of the applicant pool [see box on preceding pages]. Women were also offered posts for more senior, tenured positions at rates higher than their fraction in the applicant pool. Two other large-scale analyses, conducted in 2008 and 2010, similarly showed that women are hired at rates comparable to or better than men. What is more, no counterevidence exists. Simply put, no real-world hiring data show a bias against hiring women.

Of course, bias could still be a factor if female applicants are, on average, better than their male competitors. In that case, the high proportion of female Ph.D.s hired might mask bias that prevented an even greater percentage of women from getting jobs. There is no evidence of such superiority among female candidates, however. In a study submitted for publication in 2014 two of us (Ceci and Williams) sampled faculty from 347 universities and colleges in the U.S. to look for bias in the hiring of tenure-track assistant professors in STEM fields and failed to show that female superiority in hiring outcomes was related to objectively higher-quality female applicants. Moreover, objective measures of productivity such as publications do not indicate that women in the applicant pool are stronger than men.

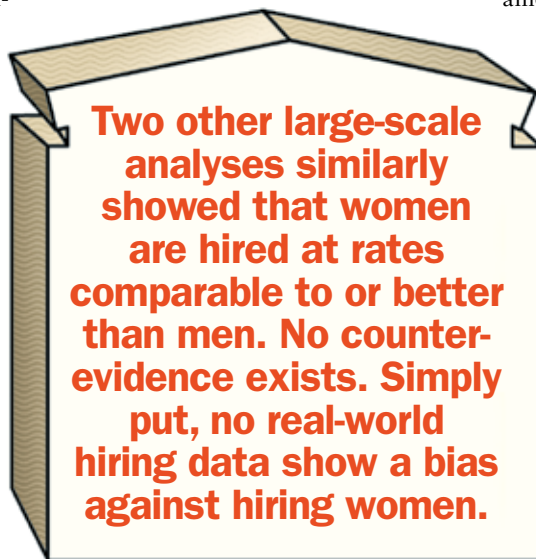
Real-world data may conflict with those from fabricated hiring situations, in part because committees or departments, not individuals, typically make real academic hiring decisions. This process may mitigate the effects of bias, given people's reluctance to publicly express prejudice. In addition, many of the most prominent studies showing bias, including the one led by Moss-Racusin, did not involve academic tenure-track jobs but lower-level posts. Such studies also depicted candidates as having ambiguous academic credentials, which may create more room for bias than would occur when a candidate is clearly competent, as those in real academic hiring situations typically are.

Opting Out

Gender bias in science most likely still exists. But the data do not convince us that instances of bias meaningfully contribute to the growing deficit of female assistant professors in psychology and in the life and social sciences. Instead of being denied jobs in academic science, women are leaving on their own.

Currently the most important barrier to women advancing in STEM fields, at least in statistical terms, is the perception

among female Ph.D. recipients and postdoctoral fellows that academic positions are not compatible with families. In work published in 2011 legal scholar Mary Ann Mason of the U.C. Berkeley, and her colleagues found that women Ph.D.s with no children and no plans to have children fared as well as men in applying for and getting STEM tenure-track jobs. In contrast, those who planned to have children opted out of the tenure-track pipeline at research universities in favor of careers they believed were more compatible with their plans, such as positions at teaching-intensive colleges or adjunct posts. In the survey, 28 percent



Two other large-scale analyses similarly showed that women are hired at rates comparable to or better than men. No counterevidence exists. Simply put, no real-world hiring data show a bias against hiring women.

of female postdocs who planned to start families opted out compared with 17 percent of men who anticipated having children; for those who already had children before taking their postdoc position, the attrition rates were 32 percent for women and 19 percent for men.

In 2007 pharmacologist Elisabeth Martinez of the University of Texas Southwestern Medical Center and her colleagues reported similar child-related attrition in a survey of 1,300 postdocs at the U.S. National Institutes of Health. Concerns about children may have a particularly strong impact on obtaining a tenure-track job in the life sciences because postdoc positions in these fields require long hours with little discretion over when those hours are. In addition, women in the life sciences have abundant opportunities to do science in nonacademic settings. As of 2008, 55 percent of jobs for biomedical Ph.D.s were outside of academia. Reviewing 2010 statistics from the Survey of Doctorate Recipients, two of us (Ginther and Kahn) found that women with Ph.D.s in psychology and the life and social sciences were the ones least apt to pursue tenure-track positions and most likely to have shorter hours in their nonacademic jobs than professors do.

Women also exit the labor force more than men do. Analysis of the 2010 doctorate survey indicates that women were more than twice as likely as men to have left the labor force—either from a job or right after getting a Ph.D. Most of those who were not retiring stepped out because of family consider-

ations, compared with only a third of the few nonretiring men. Combining those who move from an academic post to another job with those who are no longer employed or who are seeking a job (but are not retired), women are indeed more likely than men to leave science: 12.5 versus 9.6 percent.

Promotion

Women are less likely than their male colleagues to be full professors in STEM disciplines, a 2012 study from the National Science Foundation found. Although there are no significant sex differences in promotion to tenure and full professorships in most math-intensive fields, women are promoted significantly less often in the life sciences, psychology and economics, according to two analyses of the doctorate recipient survey.

One probable contributor to this gap is that, as assistant professors, women are less productive than men. The 2008 doctorate recipient survey indicates that the average difference in their five-year publication count—the number of articles accepted by peer-reviewed journals—is 2.1 fewer articles for female academics, which represents a productivity gap of 19.6 percent. The reasons for this gap are unclear. Women do not seem to work less than men: the 2010 Survey of Doctorate Recipients shows surprisingly small gender differences in the weekly hours that tenure-track STEM faculty worked outside the home.

Children are not a primary cause, either. Using data from the 2008 Survey of Doctorate Recipients, we found that women without children publish noticeably more than women with children only in geoscience and psychology. Thus, except for these two fields, the presence of children cannot explain the gender-specific difference in publications. (Other surveys suggest that having children does reduce academics' work hours, but this effect is similar for both genders.)

Higher demands on female faculty's time for teaching or service could be important, however. In their 2003 book Xie and Shauman found that faculty teaching 11 or more hours a week had much lower research productivity. Some data suggest that female faculty spend relatively more time teaching than male faculty do. In our 2010 analysis of tenure and tenure-track scientists in the Survey of Doctorate Recipients, 37 percent of men listed research as their primary work activity, whereas only 31.5 percent of women did; in contrast, 53 percent of women versus 47 percent of men listed teaching as their primary work activity.

Many female academics may enjoy being mentors and teachers, of course, a pattern that would be consistent with women's overall preference for people-oriented fields. Nevertheless, if we are serious about encouraging women to enter math-heavy fields and enabling them to advance in psychology and the life and social sciences, we need to deal with the most important factors holding them back.

The deficit of girls in math-intensive disciplines is apparent by college. For cultural or other reasons, girls lean toward fields that involve living things rather than objects, an incli-

nation that is evident by middle school. From a young age, female students profess to be more interested in medicine, biology, law, psychology and veterinary medicine, whereas males gravitate toward engineering and computer science. Although different interests may be acceptable, if we want to encourage girls to pursue math-intensive areas of study, we should find ways to mentor and support high school and middle school girls in math and science. We should also urge all entering college students to take science and math as early as possible, given that women often switch into math-centered STEM fields after starting college. Female role models are important for recruiting girls and women into science fields and keeping them there.

The problem of retaining women in the pipeline after college graduation occurs mainly in psychology and in the life and social sciences. Our analysis shows the roots of that problem lie less in biased hiring decisions and more in the choices women make to maintain work-life balance. Striking such a balance is particularly difficult in academia. Even so, female faculty members can and do become mothers, and university policies such as stopping the tenure clock and paid parental leave are a step toward making the tenure track compatible with the lives that many women want.

More adjustments may be needed, however. For instance, an option of part-time tenure, in which women with academic jobs work reduced hours, might help boost the number of female faculty. And a culture that is more accepting of family commitments—one in which faculty meetings are scheduled around them, for instance—may be necessary to encourage more talented women to contribute to important advancements in science. **M**

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FEAR OF FAT

When Eating Becomes an Illness

Getting the facts straight about eating disorders can save lives

"I am forever engaged in a silent battle in my head over whether or not to lift the fork to my mouth, and when I talk myself into taking the bite, I taste only shame," writes Jena Morrow in her memoir, *Hollow: An Unpolished Tale* (Moody Publishers, 2010). In her book Morrow recounts the pain and suffering she endured as she struggled to overcome the eating disorder anorexia nervosa.

Morrow's silent battle echoes those of the 0.6 percent of the U.S. population who will develop anorexia at some point in their life. Another 1 percent will experience bulimia nervosa, according to a 2007 survey by psychiatrist James I. Hudson of Harvard Medical School and his associates. Although these figures are lower than for most other psychological



conditions, eating disorders can be emotionally and physically devastating.

Sufferers of both anorexia and bulimia are preoccupied with their weight and the shape of their body, and their self-esteem is based largely on how satisfied they are with these two physical characteristics. Individuals with anorexia often refuse to eat, lose significant amounts of weight and are consumed by a fear of becoming overweight. Sufferers also have the distorted belief that they are overweight when, in fact, they are not.

Bulimia is characterized by frequent binges during which an unusually large amount of food is consumed. People with bulimia fear that they will gain weight from their binges, and so they try to avoid putting on pounds, usually by forcing themselves to vomit or taking large amounts of laxatives and diuretics.

Proper understanding of these disor-

ders is critical for knowing who is at risk and getting them proper treatment. Yet many people hold serious misconceptions about anorexia and bulimia. Here are five of them:

Myth #1: Eating disorders are extremely rare in men and boys.

Fact: Although eating disorders are more common among females than males, a significant percentage of males struggle with them. Hudson and his associates found that 0.9 percent of females and 0.3 percent of males had or currently have anorexia. The corresponding figures for bulimia were 1.5 and 0.5 percent.

Myth #2: Anorexia is the only life-threatening eating disorder.

Fact: Eating disorders have the highest mortality of any mental illness because of medical complications and suicide. In

BY HAL ARKOWITZ
AND SCOTT O. LILIENTELD



Hal Arkowitz and Scott O. Lilienfeld serve on the board of advisers for *Scientific American Mind*. Arkowitz is an associate professor of psychology at the University of Arizona, and Lilienfeld is a psychology professor at Emory University.



Send suggestions for column topics to editors@SciAmMind.com

DENNIS GALANTE AP Photo (woman); SEAN MCCABE (Arkowitz and Lilienfeld)

a 2009 paper, psychiatrist Scott Crow of the University of Minnesota Medical School and his colleagues analyzed the death records of 1,885 people who were evaluated eight to 25 years previously at an eating disorders clinic at Minnesota. The mortality rates for anorexia and bulimia in this group were about the same: approximately 4 percent. Other investigators have found somewhat higher mortality for anorexia than for bulimia, but bulimia can be deadly, too.

Myth #3: Purging is an effective way to lose weight.

Fact: Most people with bulimia very likely believe in this myth, or they would not vomit or use medications in an attempt to eliminate calories. Although purging is one of the formal criteria for bulimia, many people with anorexia purge as well. Yet purging is not effective for weight loss. Laxatives and diuretics cause water loss, which is soon replaced. Laxatives get rid of only 10 percent of the calories eaten. Vomiting is also relatively ineffective. By the time a person has induced vomiting, typically immediately after the binge has ended, the body has absorbed 50 to 75 percent of the ingested food. Not only is purging ineffective for weight loss, but it can cause serious dehydration, electrolyte imbalances and other problems, all of which may lead to serious illness or death.

Myth #4: Body weight is one clue that a person has bulimia.

Fact: Despite bingeing, individuals with bulimia have body weights that are indistinguishable on average from those who do not have the disorder. Perhaps the most obvious sign of bulimia is puffy cheeks because of the enlargement of the salivary glands from purging. Still, friends and family are often unaware that bulimia causes this physical sign. Because the disorder can be difficult to spot, those who suffer from it often fail to get the support they need to seek treatment.

In contrast, an excessively thin appearance may be a clue that a person has anorexia. In the later stages, when an

individual is 20 to 30 percent or more underweight, the disorder becomes even more obvious.

Myth #5: Recovery from eating disorders is rare.

Fact: Many studies support the efficacy of a type of cognitive-behavior therapy (CBT) for bulimia in which therapists educate patients about bulimia—for example, they explain why purging is ineffective—alter dysfunctional thoughts about weight, and teach strategies for resisting the impulse to binge and purge. In a report published in 2000 psychiatrist W. Stewart Agras of the Stanford Univer-

sity School of Medicine and his colleagues gave 220 individuals diagnosed with bulimia either 19 sessions of CBT or of interpersonal therapy (IPT), which focuses on the interpersonal context of the problem and resolving conflicts that may contribute to the disorder. When treatment ended, 29 percent of those who received CBT had recovered, compared with only 6 percent of those who underwent IPT. One year later, however, the success rates were more comparable; 40 percent of the CBT recipients and 27 percent of those given IPT no longer had the disorder. Although there is considerable room for improvement, these findings suggest that certain types of therapy can be very helpful for bulimia.

The picture is less encouraging for

anorexia. The first goal is to restore body weight to normal or near normal, something that is often achieved in a hospital. Surprisingly, 85 percent of hospitalized patients gain enough weight to go home, where the challenge is to keep them at a healthy weight. Some data suggest that CBT similar to that used for bulimia can prevent relapse of anorexia. In 2003 psychologist Kathleen M. Pike of Columbia University and her colleagues assigned 33 patients with anorexia who had been released from a hospital to a year of either CBT or nutritional counseling. At the end of treatment, only 22 percent of the CBT group had relapsed or dropped

out compared with 73 percent of the group that received nutritional counseling. What is more, 44 percent of the CBT patients showed significant improvement and 17 percent full recovery compared with 7 and 0 percent, respectively, in the nutritional-counseling group. Although the results for CBT are promising, we are not close to a cure for anorexia, especially given that other researchers who have followed patients for longer have found much higher relapse rates.

Still, some individuals with anorexia do recover. And the more people who know the facts about eating disorders such as anorexia and bulimia, the sooner these serious illnesses will be recognized and treated. **M**

EATING DISORDERS HAVE THE HIGHEST MORTALITY OF ANY MENTAL ILLNESS BECAUSE OF MEDICAL COMPLICATIONS AND SUICIDE.

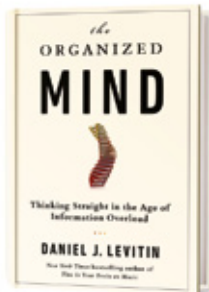
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BRAIN DRAIN

The Organized Mind

by Daniel J. Levitin. Penguin, 2014 (\$27.95)



The subtitle of *The Organized Mind* is “Thinking Straight in the Age of Information Overload.” If you are hoping this lengthy book (512 pages) will help you do that, think again.

Instead of helping you focus, Levitin, a professor of psychology and music at McGill University, makes your head spin by rambling unevenly and inexplicably over the entire range of topics you would find in almost any introductory psychology text. He even includes the mandatory passages on why correlation does not imply causation.

This is where the book truly disappoints. Rather than simply giving us straight talk about how disorganized our thoughts and lives are (but we knew that) and how we can do better (tell us, please!), Levitin insists on informing us repeatedly and in detail about how various regions or pathways in the brain are “involved in” the various cognitive and behavioral phenomena he surveys. He really means that increased neural activity in these areas of the brain is *correlated* with certain behavioral and cognitive phenomena, which actually means only that such activity tends to occur *at about the same time* as the behavioral and cognitive phenomena. That is not saying much, which is why Levitin keeps implying more with that vague phrase, “involved in.”

University of Pennsylvania law professor Stephen Morse has dubbed this practice the “brain overclaim syndrome”—the pathological tendency to fool people into thinking you have a profound understanding of something by pointing to brain studies. It goes without saying that any distinctive thing we do—raising an arm, thinking of sheep or shouting, “Hooray!”—must be accompanied by some corresponding neural activity, but that does not *explain* the activity.

On the practical side, the book contains a dozen or so tips to help you get organized, but you have to work hard to find them, and there are none you have not heard before: stay focused, go to bed the same time every night, stay mentally active, avoid multitasking, divide complex tasks into “chunks,” write things down

(especially on index cards), do not procrastinate, exercise regularly and, of course, *prioritize*.

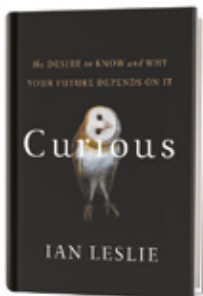
Although these are sound tips, Levitin’s lengthy expositions and neuroscientific rationales do not ring any more true than the justifications your parents or grandparents gave you when they offered similar advice, and some of them have been around since the days of Samuel Smiles’s popular book, *Self-Help*, which was published the same year Charles Darwin published *On the Origin of Species*.

If you want to get your head organized, you are better off with leaner, meaner books, such as David Allen’s practical and focused best seller, *Getting Things Done: The Art of Stress-Free Productivity* (from which Levitin borrows openly), Ori and Rom Brafman’s playful primer, *Sway: The Irresistible Pull of Irrational Behavior*, or Gerd Gigerenzer’s latest tour de force on clear thinking, *Risk Savvy: How to Make Good Decisions*. —Robert Epstein

THE QUEST FOR KNOWLEDGE

Curious: The Desire to Know and Why Your Future Depends on It

by Ian Leslie. Basic Books, 2014 (\$26.99)



What is required for a fulfilling life? First, the basics: food, shelter and, because we are social animals, companionship. If we are lucky, maybe we procreate and experience the selflessness of parenthood. What else?

In his new book, writer and adman Leslie focuses on curiosity, the drive to explore and understand, which he believes is an essential but often overlooked criterion for a rewarding life. In recent years we have heard a lot about what is required for success—grit, perseverance and focus, among other traits. Leslie asserts that being curious will incidentally engender these other basic qualities and more.

Leslie begins his exploration by defining three types of curiosity: diversive curiosity, best exemplified by the meandering exploration of the toddler; epistemic curiosity, the drive to understand how things work; and empathic curiosity, the desire to know what other people are thinking and feeling. He then gives us a tour of the science of curiosity. Curious babies make bet-

ter adolescent students; parents can foster curiosity by asking their children questions; and infants can sense when they are interacting with an “idiot.” For instance, when children receive useless information from adults, their drive to know more wilts.

Like any other skill, curiosity requires cultivation, which, Leslie argues, is happening less and less. Technologies—such as computers and the search engine Google—would seem to open the world to exploration. Yet by giving users exactly what they want, these innovations end up limiting curiosity. In fact, some experts think we live during a period of “great stagnation”—a relative lack of innovation and invention. Technological advances may be paradoxically stifling inquisitiveness and creativity.

Toward the middle, the book arrives at what feels like the point Leslie has been itching to make: there is no getting around the grunt work of acquiring true understanding. He uses chess as an example. Players become masters not because they have learned any universal equation but because they have memorized hundreds of games. Those internalized narratives serve as a reference library, a simulator in which to “play out” the many possible outcomes of a game. The more comprehensive that internal database is, the more capable the player can be.

In other words, old-fashioned memorization is the real basis for skill, creativity and mastery. Because new knowledge sticks to preexisting knowledge, the more you know, the more readily you will learn new things. This point may seem tangential to curiosity. But Leslie contends that if people follow their drive to understand, they will incidentally absorb immense amounts of information and acquire the large memory banks that allow for creativity and expertise. As Leslie puts it, “Skills come from struggle.”

Here the book mounts a defense of an old ideal: the well-rounded individual with a basic education. Leslie agitates for the importance of breadth while encouraging enough depth for people to excel at something. Curiosity is key—it is what drives and shapes our intellect.

Leslie’s book is engaging, moving fluidly from one idea to the next. He provides a refreshingly commonsensical voice in the ongoing argument over how to best mold human minds. Readers may come away with a renewed appreciation for their own drive to know more because curiosity often emerges as an urge that has no immediate payoff—the deceptively simple, open-ended question, Why?

—Moises Velasquez-Manoff

ROUNDUP

Distinctively Human

Three books explore what makes us unique

Our fascination with what makes us *us* has inspired decades of research. One popular idea is that our capacity for language sets us apart from other animals. More recent accounts have incorporated emerging insights from evolutionary and developmental psychology. For instance, in **A Natural History of Human Thinking** (Harvard University Press, 2014), Michael Tomasello argues that our ability to take on different perspectives makes us exceptional. Tomasello writes that as our environment pushed us to become more cooperative, humans had to adapt their behaviors accordingly. In doing so, we developed the ability to see the world from other points of view. Tomasello even asserts that language came out of this growing need to know the minds of others.

Another take on the question of what sets us apart comes from brain science. In **The Making of the Mind: The Neuroscience of Human Nature** (Prometheus, 2013), cognitive psychologist Ronald T. Kellogg takes the broad view, adopting the stance that a network of interacting traits, rather than a single ability, makes humans special. The key factors, Kellogg proposes, are our complex memory, capacity for language, social intelligence and relationship with time, which allows us to mentally travel into the past and future.

For readers less wrapped up in the question of us versus them, science writer Jennifer Ouellette's book on me versus you might appeal. Ouellette (who blogs for *Scientific American*) tackles why, in spite of sharing nearly identical genetic materi-



al, our personalities can diverge so widely. In **Me, Myself, and Why: Searching for the Science of Self** (Penguin Books, 2014), she explains why our genes do not necessarily define who we are or who we become. She embeds herself into the narrative, taking us on her journey as she gets her genome sequenced and her brain scanned. Ultimately delving into the science of ourselves will not yield firm conclusions about our identities. Rather we come closest to understanding who we are through the narratives we weave about our own lives. —Victoria Stern

TRAVERSING THE MIND

Your Brain

Franklin Institute, Philadelphia.
Ongoing (general admission:
children ages three to 11, \$14.50;
adults, \$18.50) (www.fi.edu/exhibit/your-brain)

Lights flash as you scramble through a two-story maze of netting. The netting, which represents our neural pathways, lets you experience your brain on a microscopic level: from the perspective of a neurotransmitter passing from a neuron's axon to its dendrite. With each flash, you know that the neuron in which you are clambering has fired.

As you scale this jungle gym—the Franklin Institute's Neural Climb—you



are becoming acquainted with the way information travels through the brain. This interactive structure is a highlight of the institute's new permanent exhibit, *Your Brain*, which opened last June.

Neural Climb is one of a series of displays on how the brain works. Hands-on activities allow visitors to move a model of a brain scanner to view MRI images of the brain and to launch Ping-Pong balls in a demonstration of neurotransmitters rushing from a neuron when it fires. Galleries early on explore the basic elements of the brain—neurons, neural pathways, brain regions and their functions—and later rooms

build on this knowledge, focusing on our five senses. In these subsequent galleries, visitors encounter optical illusions; learn how the brain fills in the gaps when, say, a train conductor's announcement gets garbled; and come to understand how something they cannot see can be

found—for example, locating a fly by tracking the changing volume of its buzz.

Each interactive experience generally lasts less than five minutes, in keeping with a child's limited attention span. The blurbs on the walls are also short, aiming more to spark curiosity and conversation than to instruct visitors in complex biological phenomena. Yet for those willing to fight the impulse to run from one display to the next, the exhibit can provide a solid foundation of how the brain works.

The final gallery attempts to situate this knowledge in a broader context by exploring neurological enigmas, including the nature of consciousness, and ethical issues, such as those that arise around the science of altering memories. If the exhibit has a flaw, it might be that it conveys the impression of a solved science. In reality, the brain remains one of the greatest mysteries known to humankind—one that will require the brightest minds of the next generation to crack. —Emily C. Lenneville



Is there a biological basis for the famous seven-year itch?

—via e-mail

Helen Fisher, a biological anthropologist at Rutgers University and author of *Anatomy of Love: The Natural History of Monogamy, Adultery and Divorce*, responds:

Several years ago I embarked on a project to see if the seven-year itch really exists. I began by studying worldwide data on marriage and divorce and noticed that although the *median* duration of marriage was seven years, of the couples who divorced, most did so around their fourth year together (the “mode”). I also found that divorce occurred most frequently among couples at the height of their reproductive and parenting years—for men, ages 25 to 29, and for women, ages 20 to 24 and 25 to 29—and among those with one dependent child.

To try to explain these findings, I began looking at patterns of pair bonding in birds and mammals. Although only about 3 percent of mammals form a monogamous bond to rear their young, about 90 percent of avian species team up. The reason: the individual that sits on the eggs until they hatch will starve unless fed by a mate. A few mammals are in the same predicament. Take the female fox: the vixen produces very thin milk and must feed her young almost constantly, so she relies on her partner to bring her food while she stays in the den to nurse.

But here’s the key: although some species of birds and mammals bond for life, more often they stay together

only long enough to rear their young through infancy and early toddlerhood. When juvenile robins fly away from the nest or maturing foxes leave the den for the last time, their parents part ways as well.

Humans retain traces of this natural reproductive pattern. In more contemporary hunter-gatherer societies, women tend to bear their children about four years apart. Moreover, in these societies after a child is weaned at around age four, the child often joins a playgroup and is cared for by older siblings and relatives. This care structure allows unhappy couples to break up and find a more suitable partner with whom to have more young.

In fact, serial pair bonding may have been beneficial to survival among our forebears because having children with more than one partner produces offspring with greater genetic variety and a wider range of skills. Hence, in the changeable environment of ancient Africa, some offspring would have had a better chance of enduring.

The four-year divorce peak among modern humans may represent the remains of an ancestral reproductive strategy to stay bonded *at least* long enough to raise a child through infancy and early toddlerhood. Thus, we may have a natural weak point in our unions. By understanding this susceptibility in our human nature, we might become better able to anticipate, and perhaps be able to avoid, the four-year itch. **M**

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1 SENTENCE SNAKE

A punny statement is coiled in the grid below. To spell it out, start with a "T" and move to an adjacent letter in any direction. All letters will be used exactly once. (Hint: The enumeration is 3, 5, 4, 10, 3, 11.)

T	H	T	L	E	D
P	E	N	U	R	G
I	G	S	D	I	S
Y	G	A	W	S	I
W	H	L	Y	N	T
I	T	A	R	G	I

2 MISSING LINK

What one letter, indicated by the question mark, combines with the letters in each box to form a common word?

Y	L		Y
			E
N			S
		?	
E	R		C
U	O		E
C	T		P
E			T
			E

3 WORD MORPH

Go from FAIL to PASS in only four steps, changing one letter at a time and making a common English word at each step.

F	A	I	L
—	—	—	—
—	—	—	—
—	—	—	—
P	A	S	S

4 MAGIC SQUARE

Complete the word square by inserting the nine letters below into the grid, one per square, to create the same words reading across and down.

AA	W	A	L	L
E	A			
II	L			
R	L			
NN				
O				

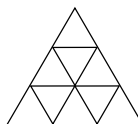
5 PARTIAL PROVERB

The following puzzle consists of a proverb with all its vowels removed. The remaining letters have been broken into groups of four. Put back the vowels to find the proverb.

FLND HSMN YRSN PRTD

6 CRAFTY COUNT

How many triangles are in this drawing?



9 REFLECTIONS

Fill in each blank below with a word that fits the definition at the left and, when read backwards, that fits the definition on the right.

- a) Skin eruptions _____ / _____ Dried grass
- b) Wicked _____ / _____ To exist
- c) A political unit _____ / _____ To sketch
- d) Part of a staircase _____ / _____ Cats, for example

10 FROMAGERIE

Find the names of three famous cheeses intermixed in the following line. All the letters are in the correct order for each word.

RLCOIMHQBEUUDERDFOGERRATR

7 COILED QUIP

The following coiled sentence contains an idea that every motorist agrees with. Start at the right spot and move, letter by letter, in any direction to find the sentence.

V	E	O	E	T
E	U	Y	L	P
R	Y	S	L	A
H	T	R	O	M
I	N	A	A	D
G	E	X	R	T
E	C	O	E	I
P	O	T	F	D
T	H	W	O	L

8 TIMES TEASER

The digits from 0 to 9 are used once each in the multiplication equation below. Fill in the missing numbers.

$$\begin{array}{r} ?02 \\ \times ?9 \\ \hline 1???8 \end{array}$$

Answers

- 9. a) WARTS, STRAW.
- b) EVIL, LIVE.
- c) WARD, DRAW.
- d) STEP, PETS.
- 10. CHEDDAR, ROQUEFORT, LIMBURGER.

- 6. 13.
- 7. A ROAD MAP TELLS YOU EVERYTHING EXCEPT HOW TO REFOID IT.
- 8. $\begin{array}{r} 15,678 \\ \times 39 \\ \hline 402 \\ 15,678 \end{array}$

4.

L	A	N	E
L	I	O	N
A	R	I	A
W	A	L	L

5. A FOOL AND HIS MONEY ARE SOON PARTED.

- 1. THE PIGGY WITH LARRYNITIS WAS DISGRUNTLED.
- 2. X: LYNX, SEXY, EXECUTOR, EXCERPT.
- 3. One solution: FAIL, PAIL, FALL, PALS, PASS.

HUMANS HAVE USED CANNABIS, THE MARIJUANA PLANT, FOR THOUSANDS OF YEARS.



(DID WE GET STONED IN THE STONE AGE?)

Mary Jane



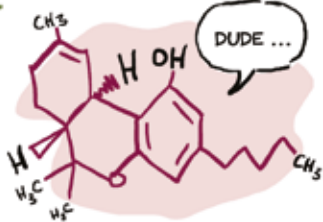
On the Brain

BY DWAYNE GODWIN & JORGE CHAM

A POPULAR MYTH IS THAT THE LEGENDARY CHINESE RULER SHENNONG (~2700 B.C.) RECOMMENDED IT FOR AILMENTS SUCH AS GOUT, RHEUMATISM, MALARIA AND ABSENTMINDEDNESS.

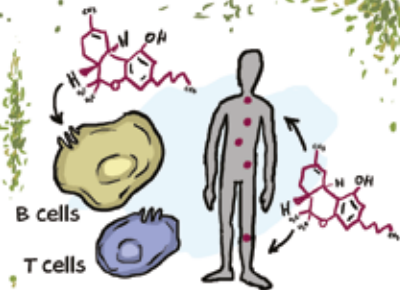


POT CONTAINS TETRAHYDRO-CANNABINOL (THC), WHICH RESEMBLES MESSENGER MOLECULES IN YOUR BODY CALLED ENDOCANNABINOIDS.



WHEN YOU SMOKE OR INGEST POT, THC OVERACTIVATES TWO TYPES OF RECEPTORS IN YOUR BODY:

CB1 RECEPTORS INHIBIT THE FLOW OF NEUROTRANSMITTERS BETWEEN NEURONS LOCATED IN BRAIN AREAS RELATED TO MEMORY, EMOTION, COGNITION AND MOVEMENT.



CB2 RECEPTORS INHIBIT INFLAMMATORY AND IMMUNE RESPONSE. BOTH RECEPTORS CAN BE FOUND IN OTHER REGIONS OF THE BODY.

IS POT ADDICTIVE? THE LIFETIME RISK OF DEPENDENCE IS LOWER THAN OTHER RECREATIONAL DRUGS BUT RISES WHEN STARTED IN ADOLESCENCE.



THIS INCREASED RISK DROPS AFTER AGE 25.

ADOLESCENT BRAINS ARE STILL DEVELOPING, AND STUDIES OF HEAVY USERS WHO STARTED AS TEENS SHOW DISRUPTIONS IN THE BRAIN'S CONNECTING FIBERS, OR WHITE MATTER.



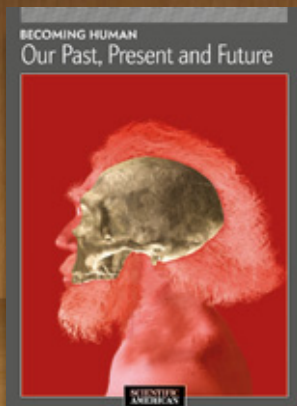
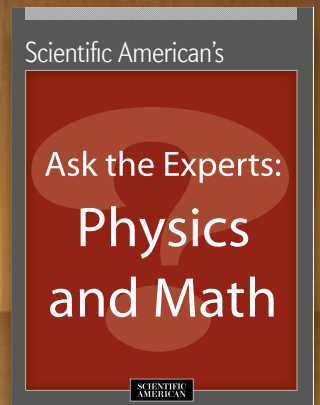
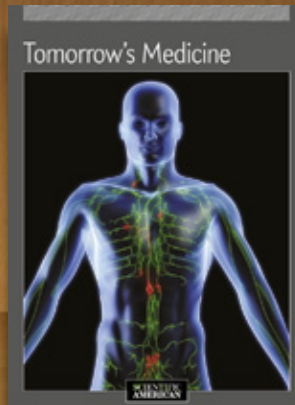
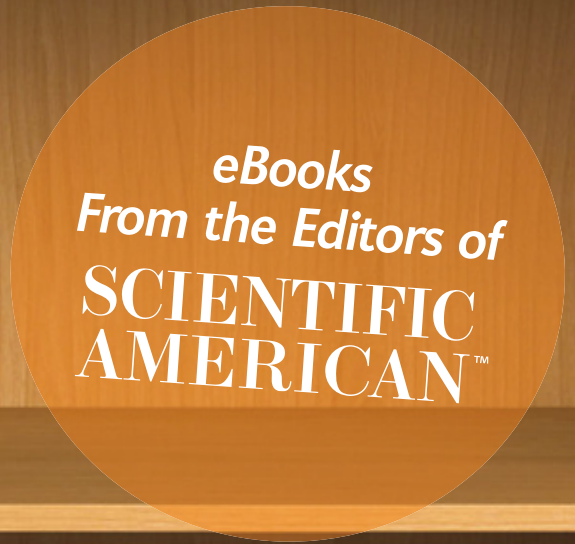
HEAVY USE HAS ALSO BEEN LINKED TO SEVERAL PSYCHIATRIC CONDITIONS, INCLUDING SCHIZOPHRENIA.

WHILE SOME STATES HAVE LEGALIZED POT USE FOR RECREATION, FEDERAL LAW STILL PUTS IT IN THE SAME CATEGORY AS HEROIN AND LSD, WHICH INHIBITS RESEARCH INTO ITS EFFECTS.



AND THAT'S THE STRAIGHT DOPE.

● **Dwayne Godwin** is a neuroscientist at the Wake Forest University School of Medicine. **Jorge Cham** draws the comic strip *Piled Higher and Deeper* at www.phdcomics.com.



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