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GOOD GROUP
LEADER?

Protect Your Happiness

Social media platforms
are designed to suck us in,
but too much time spent on
them can upset our moods

WITH COVERAGE FROM
nature

FROM
THE
EDITOR



Liz Tormes

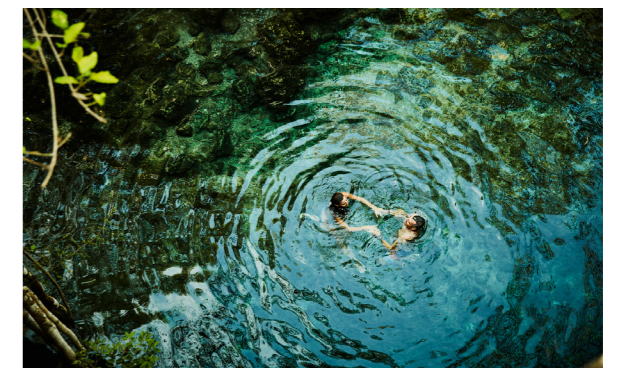
SCIENTIFIC
AMERICAN
MIND

Protect Your Mental Health

We all have the power to improve our lives, even a little bit. Research shows that two hours a week in nature can reduce stress and blood pressure. Maintaining an active social calendar prevents cognitive decline, well into old age. And for some, regular strenuous exercise appears to stave off depression as effectively as some pharmaceutical treatments. In this issue, *Scientific American* column editor Daisy Yuhas spoke with Amanda Baughan, a researcher in computer and human interactions at the University of Washington about the ways that social media can detract from self-esteem and life satisfaction (see “Why Social Media Makes People Unhappy—And Simple Ways to Fix It”). It’s become clear that our digital interactions powerfully affect mood and quality of life, and so boundaries around social media are just as important as any self-care routine.

It's been a joy bringing you the most important stories from *Scientific American* covering the remarkable human mind. We editors are continually evaluating how best to deliver the crucial coverage of these topics, and as we move forward, these PDFs you have enjoyed will become part of *Scientific American's* core digital subscription and will no longer be delivered as separate publications. Keep an eye on your in-box for more details, but I think you'll be excited for what's coming, and you can always find as many fascinating articles on the topics that intrigue you most on our Web site and in our newsletters. Thanks for reading!

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On the Cover

Social media platforms are designed to suck us in, but too much time spent on them can upset our moods.

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A Single, Quick “Mindset” Exercise Protects against Adolescent Stress

Reframing erroneous beliefs alleviates the emotional upheavals that beset young people on the cusp of adulthood

Close your eyes. Cast your mind back to high school and a high-stakes moment in your most difficult course with your toughest teacher. I’ll go first: Senior year, Mr. Trice, the final exam in AP Physics. I remember where I was sitting. I remember staring at the paper, feeling I didn’t know any of the answers. My heart was pounding; my palms were sweating. I was certain I would fail.

There wasn’t a happy ending for me about overcoming adversity. I was able to discard my final test score by taking the actual AP exam, which I also bombed. Not surprisingly, I think of that experience as all bad, an enduring embarrassment. But maybe

it didn’t have to be that way. Recalling such an experience in a new light is step one of a promising new intervention designed to help adolescents reframe stress and anxiety. Step two is equipping them with clear, accessible information so that the next time they feel that way, they will see the

experience as a path to learning and growth and even a resource to thrive.

A paper published on July 6 in *Nature* reports that this one-time online intervention, which takes about 30 minutes, improved the way young people thought about stressful events (such as my physics test) and

their fretful responses (such as my racing heart). The intervention combines growth mindsets, the belief that ability is not fixed but can be developed with effort and support, and stress-can-be-enhancing mindsets, the belief that physiological responses to stress can be an asset.



As students work through the exercise themselves, they read information about how the brain builds on experience and how the body uses stress—a pounding heart delivers extra oxygenated blood to the brain, the better to help you think. They see how it works in the real world: there is a story about a calculus professor who greets students on the first day of class with a reminder of the frustrations they will surely feel and the reassurance that struggle is learning. The intervention hints at strategies for success in stressful situations (“Remind yourself that feelings of confusion and struggle when doing difficult schoolwork won’t last forever”). And it asks participants to write about what they might do differently next time.

Rigorously tested in multiple experiments involving thousands of high school and college students before and during the pandemic, the brief, scalable intervention appears to shift something fundamental: our interpretation of the world around us and our response to it. Compared with those in a control group, participants in the intervention group thought about stress differently,

turning it into a means of energizing the motivation to accomplish a goal. But the intervention also changed their physiological responses for the better, triggering the body to respond to events as a challenge rather than a threat. It lowered cortisol levels and improved cardiovascular functioning. It also lessened overall anxiety levels, with lasting effects in some cases.

“Difficulty and struggle are your friend,” says Christopher Bryan, a social psychologist at the University of Texas at Austin and an author of the new study. Those experiences don’t feel good in the moment, he says, “but it’s the path anyone who ever became truly excellent at anything had to travel.”

The intervention is not just a hypothetical exercise. The stress that adolescents feel has reached alarming proportions. Last December, Surgeon General Vivek Murthy declared adolescent mental health a public health crisis exacerbated by the pandemic, and anxiety disorders lead the mental health challenges faced by young people. “If you can shift your mindset about what anxiety is and what it isn’t, how to be anxious in the right way, everything changes,” says Tracy Den-

nis-Tiwary, a professor of psychology at the City University of New York’s Hunter College and author of *Future Tense: Why Anxiety Is Good for You (Even though It Feels Bad)*, who wasn’t involved in the study. “This paper is a beautiful empirical demonstration of that potential.”

Criticisms of some previous mindset research emphasized the lack of statistical rigor or meaningful effects of an intervention on participants. The new paper uses Bayesian analysis, which is widely considered a more reliable measure of the effects of behavioral interventions than other techniques, such as null hypothesis tests of statistical significance. The effect sizes—measuring how strong a finding is—varied from small to large across the six experiments. And as would be expected, they were higher in the laboratory experiments than in the real world. But they were consistently meaningful. “[The study] had broad, multilevel impact on important and well-validated indices of stress and anxiety,” Dennis-Tiwary says.

Intriguingly, the intervention did not work for everyone in the same way. “The most vulnerable people in the most stressful time benefit the most,” says David Yeager, a developmental

psychologist at U.T. Austin and a co-author of the paper. He emphasizes that the intervention is not intended to be used for survivors of trauma and abuse, but administering it broadly does no harm. In addition to addressing mental health issues, a goal of the intervention is to help adolescents engage with challenging courses and projects. In a charter school in one of the experiments, 63 percent of participants passed their math and science classes, compared with 47 percent of students in a control group.

The researchers found that they had to rework a previous growth mindset intervention. That earlier exercise proved effective, especially for low-achieving students, in a national study of more than 12,000 students reported in *Nature* in 2019. But it didn’t consider the visceral butterflies-in-your-stomach feeling. “That’s a limitation of previous mindset interventions because we forgot about or didn’t tap into those stressful emotions,” Yeager says.

The usefulness of the new “synergistic” intervention could be considerable, he says, although more study of its lasting effects is warranted. The exercise is currently centered on

academic outcomes but could be tailored for use in athletics or in the workplace. It is already used with incoming first-year students in math and science classes at U.T. Austin. Once it has been more thoroughly tested, Yeager would like to make the intervention freely available to high schools and colleges nationwide. Another way to scale the idea, he says, is to show professors and managers not only how to use the intervention but also how to support the ideas it explores when they talk to young people entering campus life or the workplace.

These researchers don't just want adolescents to reframe the way they think about stress; they want adults to reframe the way they think about adolescents. "We propose an alternative narrative that emphasizes the role of young people in taking on the formidable challenges of the future," they write in the paper. "Our studies suggest that we might not teach adolescents that they are too fragile to overcome difficult struggles but that we might, instead, provide them with the resources and guidance that they need to unleash their skills and creativity in addressing big problems."

—Lydia Denworth

Suicides among Black People May Be Vastly Undercounted

Lack of data explains why

Ian Rockett has spent much of his career working closely with coroners and medical examiners researching the epidemiology of suicide. One of the questions the West Virginia University investigator has pondered over many years in the field is why the rate of suicide among Black people in the U.S. is recorded as a third of that among white people.

In recent years Rockett's research has started to provide some answers, and it illustrates the extent to which medical examiners and coroners have lacked sufficient data to accurately determine causes of death. Rockett's 2010 study published in *BMC Psychiatry* found that Black American deaths are 2.3 times more likely than white deaths to be classified as undetermined at the time they occur.

Because of that observation, Rockett and his colleagues feared that the Centers for Disease Control



and Prevention's report earlier this year of a 5.5 percent uptick in Black suicides was most likely an underestimate. "The numbers likely went up more than the data show," he says.

Numerous reasons underlie the absence of good statistics. Black Americans have typically been shut out of the mental health care system, and the pandemic worsened prospects of finding help. The lack of access to medical professionals

means Black people are less likely to receive a mental health diagnosis, and there may be no record of previous suicide attempts prior to their death.

In a January 2021 study published in the *Journal of Racial and Ethnic Health Disparities*, researchers at various institutions found that Black suicides were more apt to be categorized as undetermined because coroners and medical

examiners have less information to go on when investigating Black deaths. “When there’s less psychological documentation, they’re more likely to be labeled as undetermined intent,” says Rockett, a co-author of that paper. “This leads to suicide misclassification.”

The language that turns up in death reports tends to confirm this conclusion. An April 2022 study published in the journal *Suicide and Life-Threatening Behavior* documented a greater frequency of mental health information in reports of white suicides, likely resulting from more widespread access to care. Words such as “depression” and “anxiety” were more commonly found in white narratives, along with medication information, family problems or other indicators that might be risk factors for suicide. Black narratives contained less specific language—words and phrases such as “questionable,” “nothing” and “no further details” were common. That study found that accounts for Black people contained fewer words and less “lexical diversity,” the number of different words used to describe the manner of death.

“Our research showed that when a medical examiner is writing a narra-

tive for a Black person, there’s consistently less information recorded for a Black case, be it a suicide, homicide or an undetermined death,” says Nusrat Rahman, an author of the study and now a senior researcher at the American Psychiatric Association. Disparities in death investigations of Black people also relate to the absence of suicide notes, she says. A 2018 study that looked at data from the National Violent Death Reporting System found that a fifth of Black Americans who die by suicide leave notes, compared with a third of white Americans.

Reasons for these differences have yet to be studied, although the stigma of suicide within the Black community may be a possible contributing factor. Rahman says further research is also needed to examine why Black death reports are shorter and whether racial bias is a motivating factor.

But the consequences are clear: “In these undetermined deaths, there’s not enough text to conclude whether a death was intentional,” Rahman says. Without information about mental health–related diagnoses, suicide notes or interviews with family members, medical examiners are less likely to label the cause of

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—*Nusrat Rahman*

death as a suicide, especially in the case of a death from a drug overdose, which is often difficult to classify as intentional or accidental.

Nora D. Volkow, director of the National Institute on Drug Abuse, says that there’s a higher prevalence of suicide in individuals who misuse drugs, although we don’t know the “direction of the association”—whether drugs cause suicides or those who are suicidal are relying on drugs. She thinks the explanation is some combination of both. “Drug users are at a higher risk of dying by suicide because they don’t see a way out,” Volkow says.

Black Americans were initially less exposed to the opioid epidemic because they were less likely than white people to be prescribed

addictive drugs for pain. “This is one of those instances where discriminatory practices toward minority groups protected them early on,” Volkow says. But the landscape changed after the introduction of the narcotic fentanyl, which is mixed with illicit drugs such as heroin and cocaine and sold illegally. The drug overdose mortality rate increased by 44 percent in Black Americans in 2020, according to the CDC.

In general, coroners and medical examiners are unlikely to label drug deaths as suicides without clear evidence. As a result, Black suicides get misclassified as drug overdoses. “I would conservatively estimate that 15 percent of drug overdoses labeled undetermined are likely suicides,” Volkow says. CDC information from

2019 to 2020 shows that if 15 percent of the 15,907 Black undetermined overdose deaths were misclassified suicides, their estimated suicide rate for Black Americans would be 12.5 per 100,000 people versus the official rate of 7.5 per 100,000—a 67 percent higher rate than previous calculations.

It's not surprising that many drug deaths aren't properly investigated. Even before the pandemic, coroners and medical examiners were spread too thin, says Kathryn Pinneri, president of the National Association of Medical Examiners. "The medical examiner/coroner community has been struggling with an increasing caseload for many years, largely due to increasing numbers of drug-related and violent deaths. The COVID-19 pandemic exacerbated the problem," she says. Some deaths that would have been brought in for external examination—when coroners examine the victim's body, including scars, surgical incisions and medical devices—are now investigated with medical records alone, Pinneri notes. But in many cases, these records don't exist for Black Americans.

Right now clinicians are trained to look for suicides in white men

because statistics show they are by far the most likely to die by suicide. But a Black man's suicidality might be missed. "At a very basic level, these data impact a doctor's risk assessment in emergency rooms across the country," says Paul Nestadt, a psychiatrist who specializes in the epidemiology of suicide at Johns Hopkins University.

If the rate of Black suicides is higher than officially acknowledged, that indicates that even more resources need to be directed to prevention. When Nestadt sounded the alarm in a research study about high suicide rates in Baltimore County, lawmakers took action by starting a task force to take on the issue and installing a suicide prevention coordinator for the city of Baltimore. "Once we realized that our predominantly Black population was at risk of suicide, we took steps to prevent it," he says.

Nestadt hopes that, as understanding of the real numbers grows, Black people at risk of suicide will feel less isolated. "Knowing they're not alone normalizes these struggles and makes them feel like they're not the only ones going through them," he says. —Sara Novak

People May Pick Friends Who Smell Like Them

Similar body odors might determine if two strangers will "click"

Have you ever met someone and known right away you'd found a new friend? Was it their smile, their laugh, a twinkle in their eye or maybe a clever joke they told? In truth, the clincher might have been an underappreciated item on your subconscious checklist. As is the case for many mammals, your instant bond may have developed right after the first sniff.

Whether we notice it or not, we are constantly probing our surroundings with an olfactory radar just like rodents and nonhuman primates. Mice and chimps seem to have the scent smarts to know immediately who to befriend and who to rebuff. And though we might think of ourselves as apart from our warm-blooded relatives, new research shows that us hairless hominins may not be so different after all.

Yes, we gravitate toward a smile or people we have something in com-

mon with, such as age, personality, and even physical appearance, but it seems we might also secretly seek out those who smell like us. Inbal Ravreby, a neuroscientist at the Weizmann Institute of Science in Rehovot, Israel, got her inspiration for an experiment to test out this idea after she started to contemplate the phrase "There is chemistry between us." Sure, Ravreby reasoned, it could just be another figure of speech. "Some phrases are just phrases," she says, "but sometimes we have phrases because people notice a phenomenon. It's worth checking."

Ravreby and her research team did just that by employing a chemical sensing device called an electronic nose, along with a collection of human "smellers" to back up its measurements. Their work—published in *Science Advances*—found that friends who "clicked" when they first met smelled more alike than random pairs of people, suggesting our nose might play a part in how we know who we'll get along with best.

For the experiment, the researchers gathered 20 pairs of same-sex friends who reported clicking during their first encounter with each other. For three days, participants gave up

scented soaps, garlic and anything else that might alter their body odor, and each wore a cotton T-shirt to bed to capture their scent.

The stinky shirts were handed over to the electronic nose, which used an array of sensors to measure the chemical difference in the body odors of the members of each pair. The researchers found that twosomes who clicked with each other when they met had more similar scents, compared with randomly selected pairs of other people in the study.

To compare the electronic nose to what humans actually detect, a team of designated smellers also tested scent similarity. When sniffing body odor samples, the human smellers ranked each scent in “intensity,” “pleasantness” and another three categories. Overall, the pairs of fast friends had more similar smell rankings than the coupled strangers. The human smell squad also reported that “click friends”—when sniffed side by side—had more similar body odors than strangers, showing that the closeness in these smells was present in how people perceived them, not just the chemistry detected by the electronic nose.

Scent similarity was even able to

successfully predict which pairs of complete strangers would get along 71 percent of the time. After also embedding their odor into T-shirts for aroma analysis, the pairs of strangers were placed half a meter apart to play a game where they tried to mimic each other’s movements and then asked how they felt about their partner. Players who reported clicking with their game partners had more similar body odor chemistry, additional evidence that such odor plays a role in how humans identify prospective pals.

“I’m really excited that we have a new piece of insight into how body odors are implicated in social interaction and also in friendships,” says aroma chemist Helene Loos of the University of Erlangen-Nuremberg and the Fraunhofer Institute for Process Engineering and Packaging, both in Germany. Loos, who was not involved in the study, is excited for future research, which she hopes will build on the work of Ravreby and her colleagues by identifying the specific chemical compounds that might have a role in sparking human friendships.

Moving forward, Ravreby wants to delve deeper into the mechanisms behind our subconscious social



sniffing. She plans to measure how brain activity responds when a person smells a body odor that reminds them of themselves versus an aroma that’s very different. Her theory is that humans constantly sniff themselves to establish a baseline scent to compare with the odors of everyone around them and that this might play a role in how we

subconsciously tell friend from foe.

“I think it’s a reminder for us humans to appreciate how much we’re similar to other mammals,” Ravreby says. “[Taking] inspiration from other animals and the amazing mechanisms that they have can really help us understand what [causes] social bonding and what doesn’t.”

—Sasha Warren

A person is lying in bed, covered by a white blanket. Only their eyes and the top of their head are visible above the blanket. They are holding a black smartphone in their hands, looking at the screen. The background is a soft, out-of-focus blue and white, suggesting a bedroom setting.

Why Social Media Makes People Unhappy— And Simple Ways to Fix It

Research suggests platform designs make us lose track of time spent on them and can heighten conflicts, and then we feel upset with ourselves

By Daisy Yuhas

Disrupted sleep, lower life satisfaction and poor self-esteem are just a few of the negative mental health consequences that research has linked to social media. Somehow the same platforms that can help people feel more connected and knowledgeable also contribute to loneliness and disinformation. What succeeds and fails, computer scientists argue, is a function of how these platforms are designed. Amanda Baughan, a graduate student specializing in human-computer interaction, a subfield of computer science, at the University of Washington, believes that interdisciplinary research could inform better social platforms and apps. At the 2022 Association for Computing Machinery Computer-Human Interaction (CHI) Conference on Human Factors in Computing Systems in May, she presented findings from a recent project that explored how social media triggers what psychologists call “dissociation,” or a state of reduced self-reflection and narrowed attention. Baughan spoke with Mind Matters editor Daisy Yuhas to explain how and why apps need to change to give the people who use them greater power.

[An edited transcript of the interview follows.]

You’ve shown how changing social media cues and presentations could improve well-being, even when people strongly disagree on issues. Can you give an example?

The design of social media can have a lot of power in how people interact with each other and how they feel about their online experiences. For example, we’ve found that social media design can actually help people feel more supportive and kind in moments of online conflict, provided there’s a little bit of a nudge to behave that way. In one study, we designed an intervention that encouraged people who start talking about something contentious in a comment thread to switch to direct messaging. [People really liked it](#). It helped resolve their conflict and replicated a solution we use in-person: people having a public argument move to a private space to work things out.

You’ve also tackled a different problem coming out of social media usage called the “30-Minute Ick Factor,” a term coined by Alexis Hiniker, your graduate adviser and a computer scientist at the University of Washington. What is that?

We very quickly lose ourselves on social media. When people encounter a platform where they can infinitely scroll for more information, it can trigger a similar neurocognitive reward system as antici-

pating a winning lottery ticket or getting food. It’s a powerful way that these apps are designed to keep us checking and scrolling.

The “30-Minute Ick Factor” is when people mean to check their social media briefly but then find that 30 minutes have passed, and when they realize how much time they spent, they have this sense of disgust and disappointment in themselves. Research has shown that people are dissatisfied with this habitual social media use. A lot of people frame it as meaningless, unproductive or addictive.

You’ve argued this experience is less a matter of addiction and more an issue of “dissociation.” What is that exactly?

Dissociation is a psychological process that comes in many forms. In the most common, everyday dissociation, your mind is so absorbed that you are disconnected from your actions. You could be doing the dishes, start daydreaming and not pay attention to how you are doing the dishes. Or you might seek immersive experiences—watching a movie, reading a book or playing a game—that pass the time and cause you to forget where you are.

During these activities, your sense of reflective self-consciousness and the passage of time is reduced. People only realize that they dissociated in hindsight. Attention is restored with the sense of “What just happened?” or “My leg fell asleep while we were watching that movie!”

Dissociation can be a positive thing, especially if it's an absorbing experience, meaningful activity or a needed break. But it can also be harmful in certain cases, as in gambling, or come in conflict with people's time-management goals, as with social media scrolling.

How do you measure people's dissociation on social media?

We worked with 43 participants who used a custom mobile app that we created called Chirp to access their Twitter accounts. The app let people interact with Twitter content while also allowing us to ask them questions and test interventions. So when people were using Chirp, after a given number of minutes, we would send them a questionnaire based on a psychological scale for measuring dissociation. We asked how much they agreed with the statement "I am currently using Chirp without really paying attention to what I'm doing" on a scale of 1 to 5. We also did interviews with 11 people to learn more. The results showed dissociation occurred in 42 percent of our participants, and they regularly reported losing track of time or feeling "all-consumed."

You also designed four interventions that modified people's Twitter experience on Chirp to reduce dissociation. What worked?

The most successful were custom lists and reading history labels. In custom lists, we forced users to categorize the content they followed, such as "sports" or "news" or "friends." Then, instead of interacting with Twitter's main feed, they engaged only with content on these lists. This approach was coupled with a reading-history intervention in which people received a message when they were caught up on the newest tweets. Rather than continuing to scroll, they were alerted to what they had already seen, and so they focused on just the newest content. Those interventions reduced dissociation, and

Social media could have a healthy, meaningful place in people's lives. But that's just not the way it's being designed right now.

when we did interviews, people said they felt safer checking their social media accounts when these modifications were present.

In another design, people received timed messages letting them know how long they had been on Chirp and suggesting they leave. They also had the option of viewing a usage page that showed them statistics such as how much time they'd spent on Chirp in the past seven days. These two solutions were effective if people opted to use them. Many people ignored them, however. Also, people thought the timed messages were annoying. Those findings are interesting because a lot of the popular time-management tools available to people look like these time-out and usage notifications.

So what could social media companies be doing differently? And is there any incentive for them to change?

Right now there is a lot working against people who use social media. It's impossible to ever fully catch up on a social media feed, especially when you consider the algorithmically inserted content such as Twitter's trending tweets or TikTok's "For You" page. But I think that there is hope that relatively simple tweaks to social media design, such as custom lists, can make a difference.

It's important to note that the custom lists significantly reduced dissociation for people—but they did not significantly affect time spent using the app. To me, that points out that reducing people's dissociation may not

be as antithetical to social media companies' revenue goals as we might intuitively think.

We've found that people value being able to log in to a platform, connect with who they want to connect with, consume the media they enjoy, find the information that's relevant and then be gently nudged off the platform in a way that fits their time-management goals. Social media could have a healthy, meaningful place in people's lives. But that's just not the way it's being designed right now.

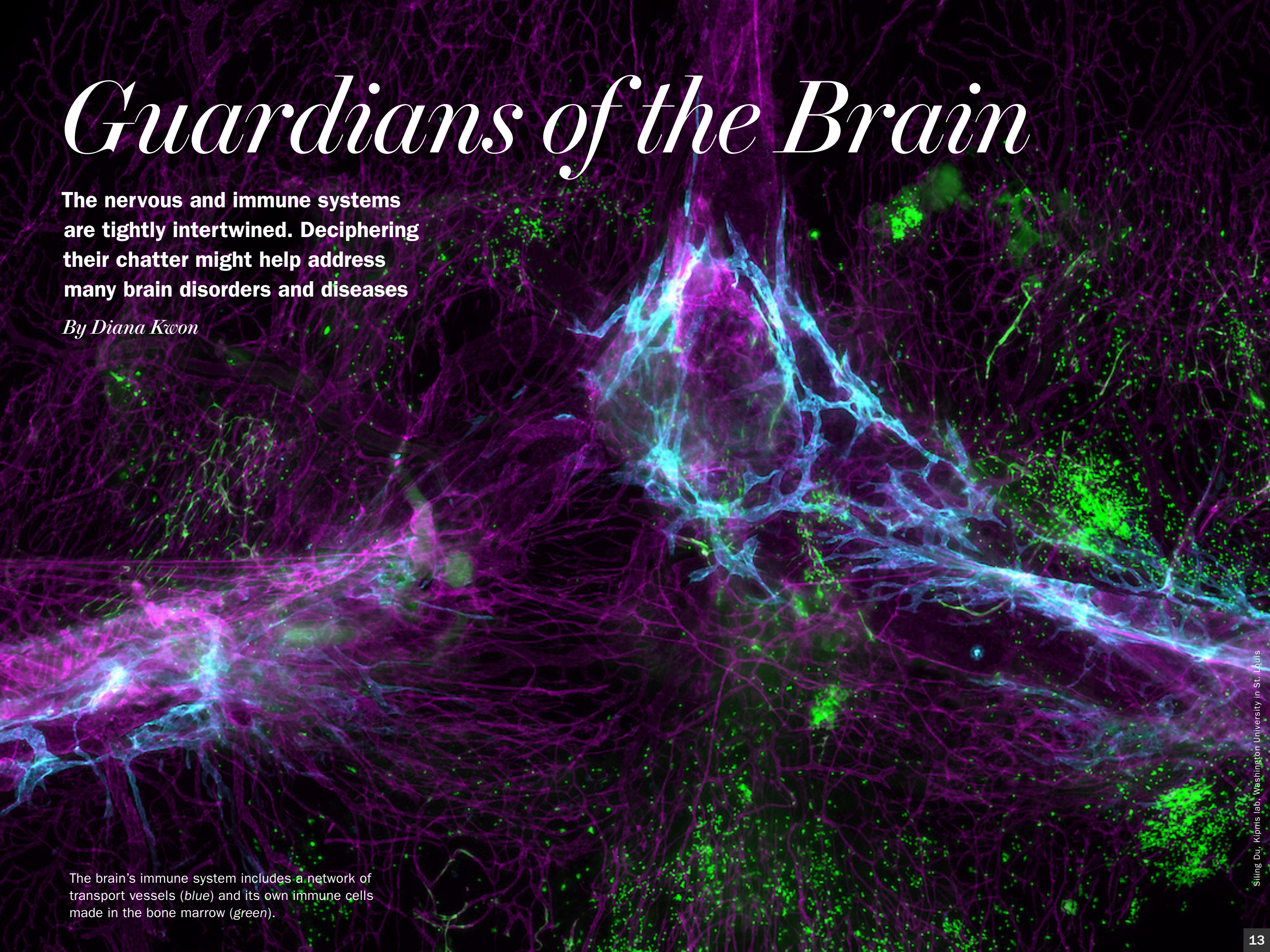
What's most important for people using social media now to know?

First, don't pile a bunch of shame onto your social media habits. Thousands of people are employed to make you swipe your thumb up on that screen and keep you doing what you're doing. Let's shift the responsibility of designing safe and fulfilling experiences from users to the companies.

Second, get familiar with the well-being tools that are already offered. TikTok has a feature that, every hour, will tell you that you've been scrolling for a while and should consider a break. On Twitter, custom lists are a feature that already exists; it's just not the default option. If more people start using these tools, it could convince these companies to refine them.

Most important, vote for people who are interested in regulating technology because I think that's where we're going to see the biggest changes made. **M**

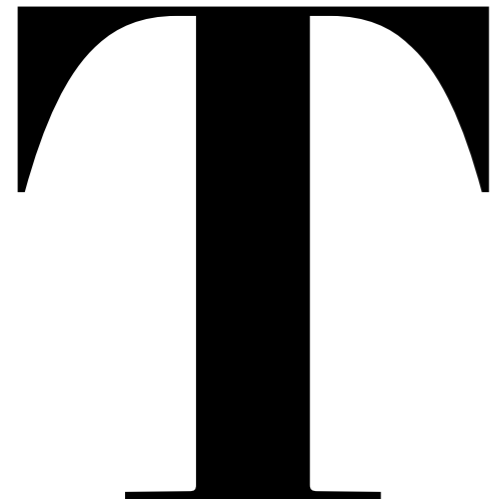
Guardians of the Brain



The nervous and immune systems are tightly intertwined. Deciphering their chatter might help address many brain disorders and diseases

By Diana Kwon

The brain's immune system includes a network of transport vessels (*blue*) and its own immune cells made in the bone marrow (*green*).



The brain is the body's sovereign and receives protection in keeping with its high status. Its cells are long-lived and shelter inside a fearsome fortification called the blood-brain barrier. For a long time, scientists thought that the brain was completely cut off from the chaos of the rest of the body—especially its eager defense system, a mass of immune cells that battle infections and whose actions could threaten a ruler caught in the crossfire.

In the past decade, however, scientists have discovered that the job of protecting the brain isn't as straightforward as they thought. They've learned that its fortifications have gateways and gaps and that its borders are bustling with active immune cells.

A large body of evidence now shows that the brain and the immune system are tightly intertwined. Scientists already knew that the brain had its own resident immune cells, called microglia; recent discoveries are painting more detailed pictures of their functions and revealing the characteristics of the other immune warriors housed in the regions around the brain. Some of these cells come from elsewhere in the body; others are produced locally, in the bone marrow of the skull. By studying these immune cells and mapping out how they interact with the brain, researchers are discovering that they play an important part in both healthy and diseased or damaged brains. Interest in the field has exploded: there were fewer than 2,000 papers per year on the subject in 2010, swelling to more than 10,000 per year in

2021, and researchers have made several major findings in the past few years.

No longer do scientists consider the brain to be a special, sealed-off zone. "This whole idea of immune privilege is quite outdated now," says Kiavash Movahedi, a neuroimmunologist at the Free University of Brussels. Although the brain is still seen as immunologically unique—its barriers prevent immune cells from coming and going at will—it's clear that the brain and immune system constantly interact, he adds.

This shift in attitude is widespread in the community, says Leonardo Tonelli, chief of the neuroendocrinology and neuroimmunology program at the U.S. National Institute of Mental Health. In his experience, almost every neuroscientist who reviews grant proposals for the agency accepts the connection, he says, although many still need to catch up with the latest discoveries in neuroimmunology, which have started to reveal the underlying mechanisms.

The rush to understand how the brain and immune

system knit together has prompted a wealth of questions, says Tony Wyss-Coray, a neuroimmunologist at Stanford University. "How important is this in normal brain function or disease? That is a very hard question to answer."

PRIVILEGED SPACE

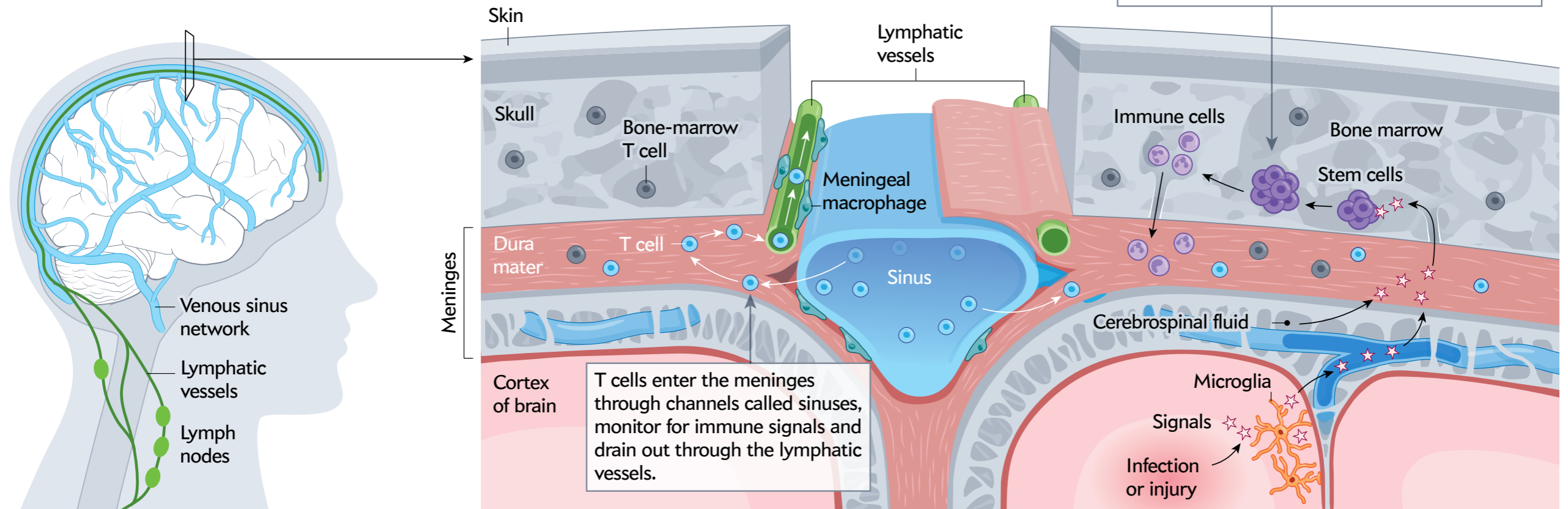
More than two decades ago, when neuroimmunologist Michal Schwartz had just set up her laboratory at the Weizmann Institute of Science in Rehovot, Israel, she couldn't stop asking herself an unpopular question: Could it really be true that the brain is completely cut off from immune protection? "It was completely axiomatic that the brain cannot tolerate any immune activity—everyone thought that if you have any immune activation, this was a sign of pathology," she says. "But it didn't make sense that tissue that is so indispensable, like the brain, cannot enjoy the benefit of being assisted by the immune system."

The idea that the brain was off limits to the immune system took root decades earlier. In the 1920s Japanese scientist Y. Shirai reported that when tumor cells were implanted in a rat's body, the immune response destroyed them, but when placed in the brain, they survived—indicating a feeble or absent immune response. Similar findings followed in the 1940s.

Most scientists also thought that the brain lacked a system for ferrying immune molecules in and out—the lymphatic drainage system that exists elsewhere in the body—even though such a system was first described in the brain more than two centuries ago. The prevailing view,

The Brain's Immune Defenses

Long thought to be cut off from the body's immune system, the brain is now known to host its own immune cells while allowing others to circulate through its fluid-filled borders, the meninges. Cell types include microglia inside the brain and T cells and macrophages at the edges. Together, these help the healthy brain to function and defend it from disease.



then, was that the brain and the immune system lived largely separate lives. The two were thought to collide only under hostile circumstances: when immune cells went rogue, attacking the body's own cells in diseases such as multiple sclerosis.

So when, in the late 1990s, Schwartz and her team reported that after an acute injury to the central nervous system, two types of immune cells, macrophages and T cells, protected neurons from damage and supported their recovery, many scientists were skeptical. "Everyone told me, you're absolutely wrong," Schwartz recalls.

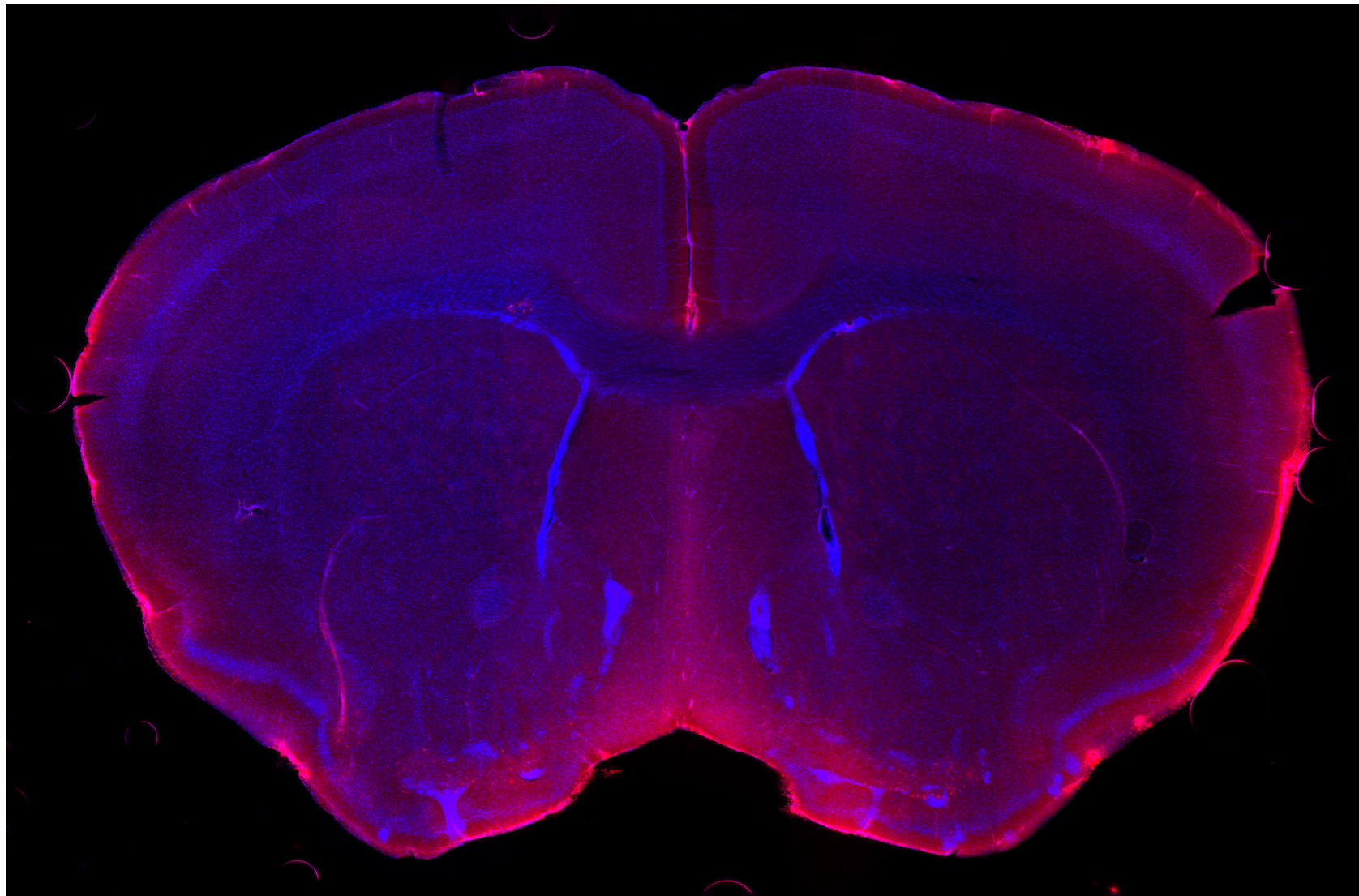
Since those early experiments, Schwartz's team and others have amassed a large body of evidence showing that

immune cells do, indeed, have a significant role in the brain, even in the absence of autoimmune disease. Researchers have shown, for example, that in mice engineered to lack an immune system, neurodegenerative diseases such as motor neuron disease (amyotrophic lateral sclerosis) and Alzheimer's disease seemed to progress more rapidly, whereas restoring the immune system slowed their progression. Scientists have also revealed a potential role for microglia in Alzheimer's.

More recently, scientists have shown that immune cells at the brain's edges are active in neurodegenerative diseases. After examining the cerebrospinal fluid of people with Alzheimer's, Wyss-Coray and his colleagues found evi-

dence of a rise in numbers of T cells in the brain's fluid-filled borders. The expansion of these immune cell populations suggests that they might have a role in the disease, Wyss-Coray says.

But whether immune cells hurt or help the brain is an open question. In their studies of Alzheimer's and other neurodegenerative disorders, Wyss-Coray and his colleagues suggest that the immune system could be damaging neurons by releasing molecules that boost inflammation and trigger cell death. Others have suggested that T cells and other immune cells could instead be protective. For example, Schwartz's group has reported that in mouse models of Alzheimer's, boosting the immune



Cerebrospinal fluid (colored red) seeps into the brain tissue (blue) through tiny gaps in the blood vessels that run through the brain's protective layers.

response leads to a clearance of amyloid plaques—a pathological hallmark of the disease—and improves cognitive performance.

BUSY BORDERS

It's now becoming clear that the brain's margins are immunologically diverse: almost any type of immune cell in the body can also be found in the area surrounding the brain. The meninges—the fluid-filled membranes that wrap the brain—are an “immunological wonderland,” says Movaheidi, whose work focuses on macrophages in the brain's borders. “There's so much happening out there.”

Some residents are exclusive to the frontiers. In 2021

Jonathan Kipnis, a neuroimmunologist at Washington University in St. Louis, and his colleagues reported that there is a local source of immune cells: the bone marrow of the skull.

When they explored how the bone marrow mobilizes these cells, Kipnis and his colleagues demonstrated that in response to an injury to the central nervous system or in the presence of a pathogen, signals carried in the cerebrospinal fluid were delivered to the skull bone marrow, prompting it to produce and release these cells.

What role these locally produced immune cells have remains to be seen, but Kipnis's group thinks that they might have a gentler role than immune cells from else-

where in the body, regulating the immune response rather than being primed to fight. Kipnis says that this distinction, if true, has implications for treatment. In diseases such as multiple sclerosis, he says, symptoms could perhaps be improved by preventing immune cells from other parts of the body from coming in. In contrast, with a brain tumor, he adds, “you want the fighters.”

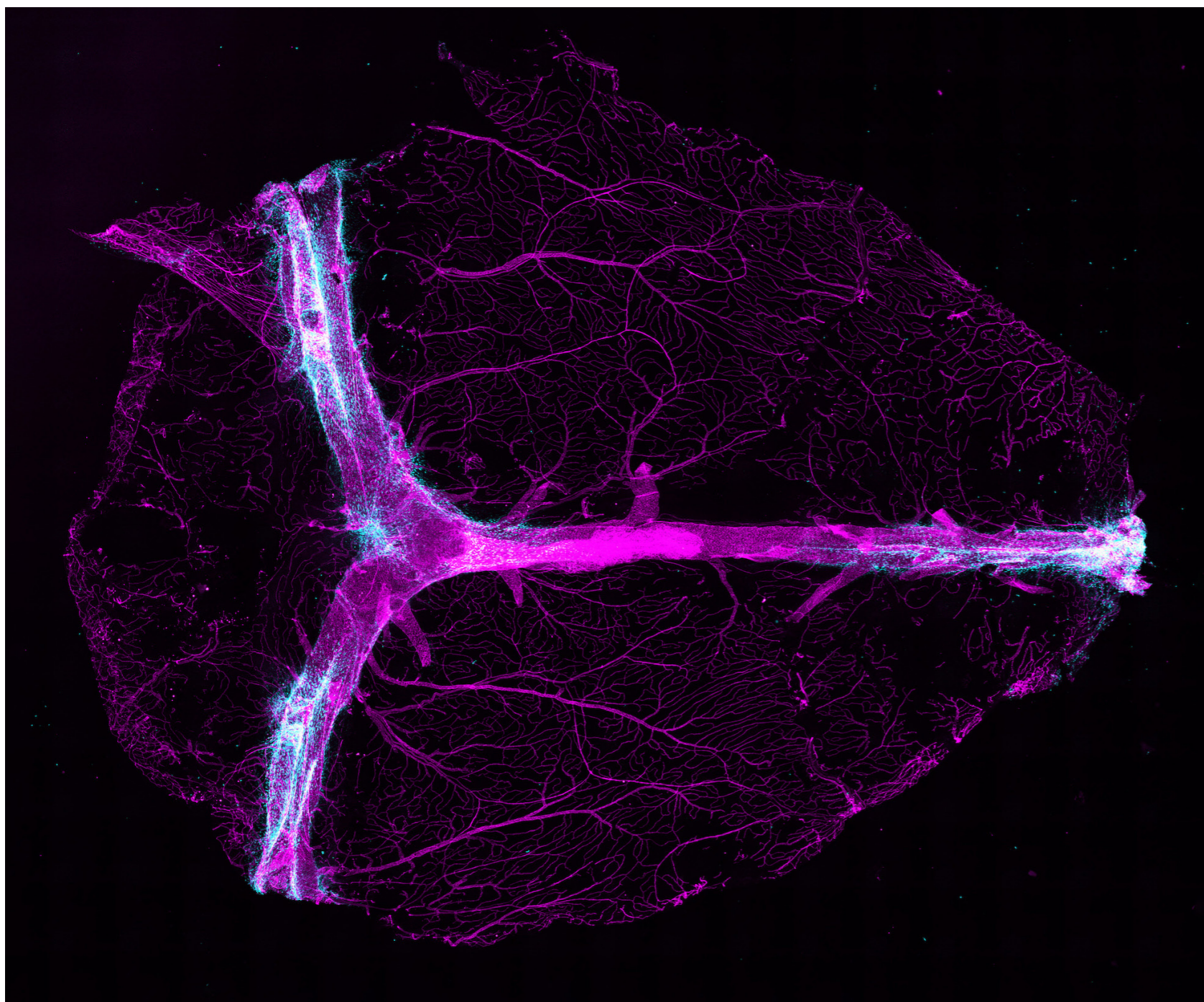
His team has also detected a network of channels that snake and branch over the surface of the brain and that swarm with immune cells, forming the brain's own lymphatic system. These vessels, which sit in the outermost part of the meninges, give immune cells a vantage point near the brain from where they can monitor any signs of infection or injury.

IN SICKNESS AND IN HEALTH

As evidence builds for the involvement of immune cells during brain injury and disease, researchers have been exploring their function in healthy brains. “I think the most exciting part of neuroimmunology is that it's relevant to so many different disorders and conditions and to normal physiology,” says Beth Stevens, a neuroscientist at Boston Children's Hospital.

Many groups, including Stevens's, have found microglia to be important to the brain's development. These cells are involved in pruning neuronal connections, and studies suggest that problems in the pruning process might contribute to neurodevelopmental conditions.

Border immune cells, too, have been shown to be essential in healthy brains. Kipnis, Schwartz and their colleagues, for example, have shown that mice that lack some of these cells display problems in learning and social behavior. Others reported in 2020 that mice that



Signals carried in the cerebrospinal fluid (*blue*) are presented to immune cells in blood vessels (*magenta*) in the brain's protective outer layers.

behavior for decades, finding, for example, that cytokines sent out by immune cells during infection can initiate “sickness behaviors” such as increased sleep. They have also shown in animal models that alterations in cytokines—induced by depleting them throughout the body or knocking out specific cytokine receptors on neurons—can lead to alterations in memory, learning and social behaviors. How cytokines travel into the brain and exert their effects remains an area of active study.

Cytokines might also be a link between the immune system and neurodevelopmental conditions such as autism. When Gloria Choi, a neuroimmunologist at the Massachusetts Institute of Technology, and her colleagues boosted cytokine levels in pregnant mice, they saw brain changes and autismlike behaviors in the offspring.

Although these insights are tantalizing, much of the work on how immune cells, especially those in the borders, operate in the brain is still in its infancy. “We are very far away from understanding what’s happening in healthy brains,” Kipnis says.

A TWO-WAY STREET

Communication between the immune system and the brain also seems to go in the other direction: the brain can direct the immune system.

Some of these insights are decades old. In the 1970s scientists conditioned rats to become immunosuppressed when they tasted saccharin, an artificial sweetener, by pairing it with an immunosuppressive drug for several days.

In more recent work, Asya Rolls, a neuroimmunologist at Technion-Israel Institute of Technology in Haifa, and

develop without a specific population of T cells in both the brain and the rest of the body have defective microglia. Their microglia struggle to prune neuronal connections during development, leading to excessive numbers of synapses and abnormal behavior. The authors propose that during this crucial period, T cells migrate into the brain and help microglia to mature.

One big mystery is how exactly immune cells—particularly those around the borders—talk to the brain. Although there is some evidence that they might occasionally cross into the organ, most studies so far suggest that these cells communicate by sending in molecular messengers known as cytokines. These, in turn, influence behavior.

Researchers have been studying how cytokines affect

her team explored the link between emotion, immunity and cancer in mice. They reported in 2018 that activating neurons in the ventral tegmental area, a brain region involved in positive emotions and motivation, boosted the immune response and, in turn, slowed tumor growth.

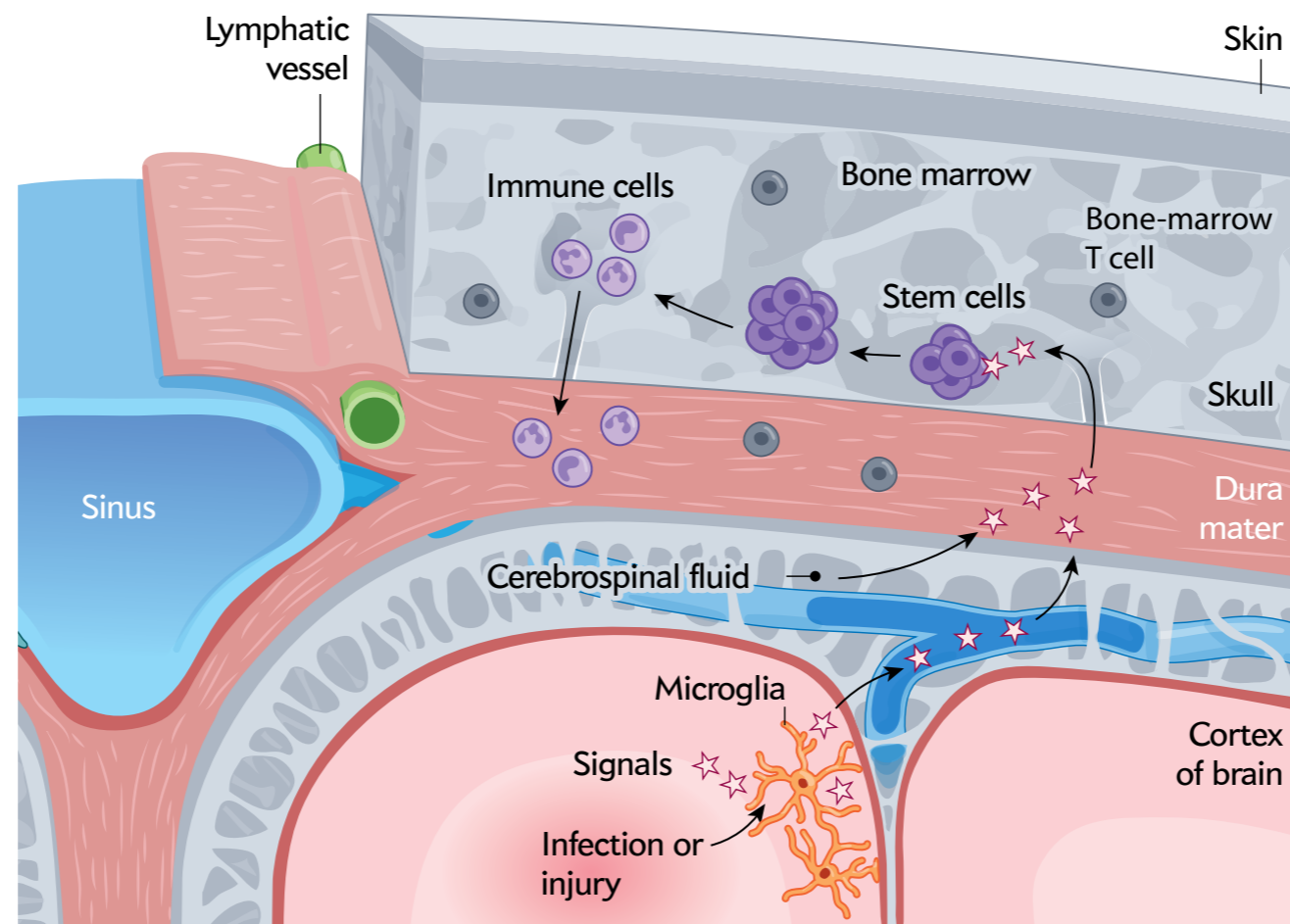
Then, in 2021, her group pinpointed neurons in the insular cortex—a part of the brain involved in processing emotion and bodily sensations, among other things—that were active during inflammation in the colon, a condition also known as colitis.

By activating these neurons artificially, the researchers were able to reawaken the intestinal immune response. Just as Pavlov’s dogs learned to associate the sound of a bell with food, causing the animals to salivate any time they heard the noise, these rodents’ neurons had captured a “memory” of the immunological response that could be rebooted. “This showed that there is very intense crosstalk between neurons and immune cells,” says Movahedi, who wasn’t involved with this work.

Rolls suspects that organisms evolved such immunological memories because they are advantageous, gearing up the immune system in situations when the body might meet pathogens. She adds that in certain cases, they can instead be maladaptive—when the body anticipates an infection and mounts an unnecessary immune response, causing collateral damage. This pathway might help explain how psychological states can influence the immune response, providing a potential mechanism

Private Protectors

Brain immune cells are produced by stem cells in the bone marrow, in response to signals from the cerebrospinal fluid indicating infection or injury in the brain tissue.



for many psychosomatic disorders, according to Rolls. It could also inspire therapies. Rolls and her team found that blocking the activity of those inflammation-associated neurons lessened inflammation in mice with colitis. Her group hopes to translate these findings to humans and is examining whether inhibiting activity using noninvasive brain stimulation can help alleviate symptoms in people with Crohn’s disease and psoriasis—disorders that are mediated by the immune system. This work is in the early phases, Rolls says, “but it’ll be really cool if it works.”

Other groups are exploring how the brain controls the

immune system. Choi’s team is tracing out the specific neurons and circuits that modulate the immune response. One day she hopes to be able to generate a comprehensive map of the interactions between the brain and immune system, outlining the cells, circuits and molecular messengers responsible for the communication in both directions—and connecting those to behavioral or physiological readouts.

One of the biggest challenges now is to tease apart which populations of cells are involved in these myriad functions. To tackle it, some researchers have been probing how these cells differ at the molecular level, by sequencing genes in single cells. This has revealed a subset of microglia associated with neurodegenerative disease, for example. Understanding how these microglia function differently from their healthy counterparts will be useful in developing treatments, Stevens says. They could also be used as markers to track the progression of a disease

or the efficacy of therapies, she adds.

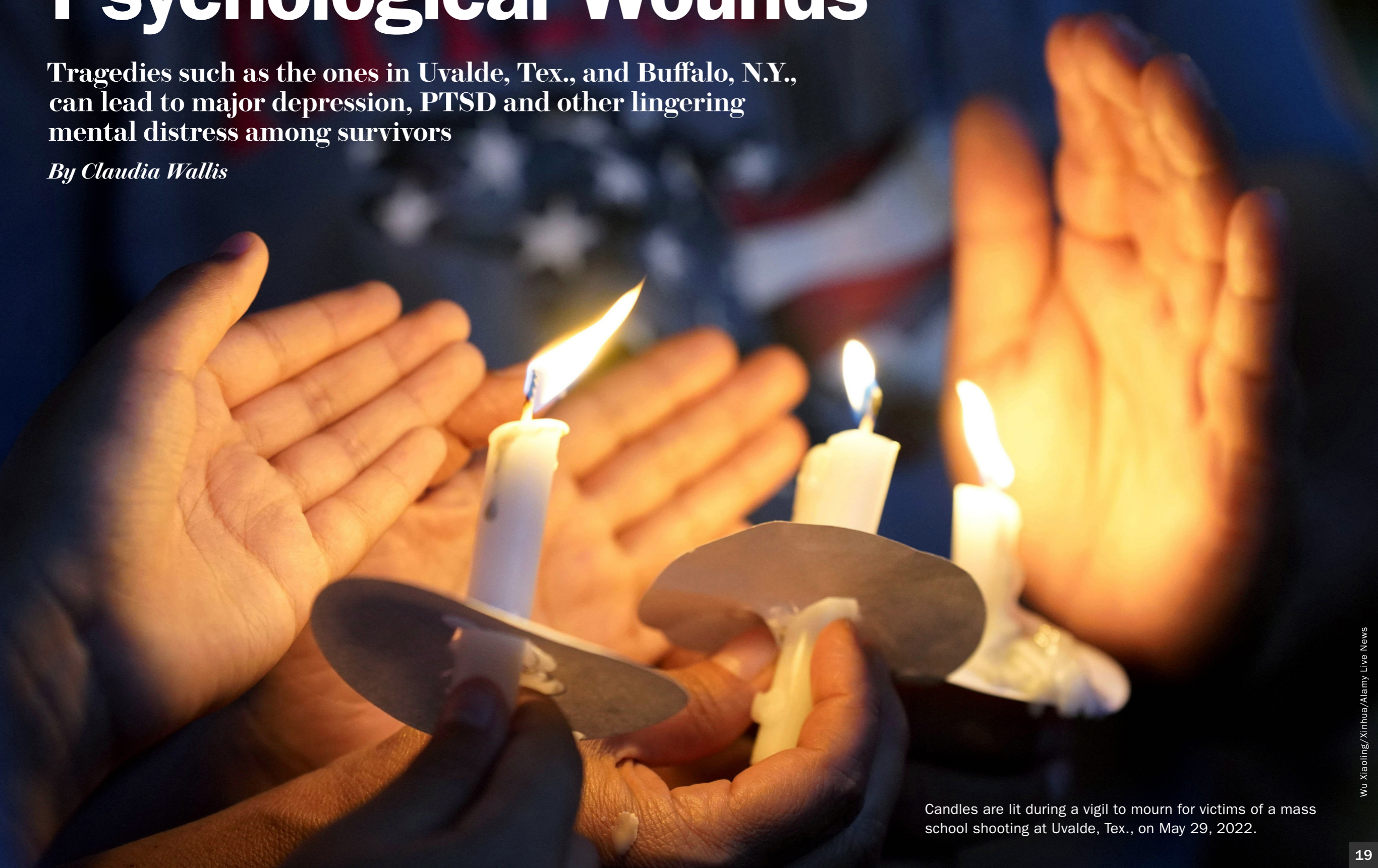
Researchers have already begun using these insights into the immune ecosystem in and around the brain. Schwartz’s team, for example, is rejuvenating the immune system in the hope of fighting Alzheimer’s. This work has opened up new avenues for therapeutics, particularly for neurodegenerative conditions, Schwartz says: “It’s an exciting time in the history of brain research.” **M**

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Mass Shootings Leave Lasting Psychological Wounds

Tragedies such as the ones in Uvalde, Tex., and Buffalo, N.Y., can lead to major depression, PTSD and other lingering mental distress among survivors

By Claudia Wallis



Candles are lit during a vigil to mourn for victims of a mass school shooting at Uvalde, Tex., on May 29, 2022.

Claudia Wallis is an award-winning science journalist whose work has appeared in the *New York Times*, *Time*, *Fortune* and the *New Republic*. She was science editor at *Time* and managing editor of *Scientific American Mind*.

BY NOW THE SIGHT OF GRIEVING, sobbing family members, terrified children and devastated communities is all too familiar from the coverage of mass shootings such as the recent ones in Uvalde, Tex., and Buffalo, N.Y. But when the cameras are gone, the dead are laid to rest and the injured have been treated, what psychological wounds linger? What are the longer-term mental health consequences for survivors, their families and the community at large? And what steps can most effectively limit the harm?

For research-based answers to these questions, *Scientific American* spoke with Sandro Galea, dean of the Boston University School of Public Health and a leading researcher on the psychological impacts of mass traumas, and psychologist Sarah Lowe, an assistant professor of public health at Yale University. Together they authored a 2015 review of 49 studies looking at impacts from 15 separate mass shootings that occurred between 1984 and 2008, 12 of them in the U.S. and nine at K–12 schools or universities. Lowe has begun the process of updating that review to cover another decade of mass shootings with data from a total of about 100 studies.

What are the most common long-term mental health consequences for survivors of a mass shooting event?

Major depression and post-traumatic stress disorder (PTSD), or some PTSD symptoms, were the most common psychiatric conditions seen in studies covered by the 2015 review paper, Galea says. Anxiety disorders, panic attacks, substance use disorders, phobias and other issues were also reported in some studies. But Lowe points out that “it’s hard to say what the most common mental health problems were because our knowledge is limited to what was assessed.”

Some studies looked at what Lowe calls “nonspecific psychological distress,” such as feelings of fear and unease. And some included physical symptoms, such as headaches and stomachaches.

How do these violent events specifically affect children who experience them?

“There are relatively few studies about the mental health consequences for children,” Galea notes. Only five of the studies he and Lowe reviewed looked at high school-age or younger children who had experienced a shooting. The prevalence of PTSD or its symp-

toms ranged from 8 to 91 percent, depending in part on how and when they were assessed.

A more recent study, published in 2020 and co-led by Maya Rossin-Slater, now an associate professor of health policy at Stanford University, found a 21.4 percent increase in antidepressant prescriptions for people under age 20 in the local area where a school shooting had occurred, compared with areas 10 to 15 miles away. The study, which included prescription data from 44 communities affected by school shootings, found an elevated use of antidepressants that persisted two years after the incident.

What makes someone particularly vulnerable to long-term psychological effects? And what things protect against them?

Research points to many factors that fall into three broad categories: before, during and after the shooting. “What people bring in with them into these events, including demographic characteristics,” is the first determinant, Lowe says. People with preexisting mental health problems, for example, are more vulnerable to depression and other psychological issues after a mass shooting. So are those who lack psychosocial resources such as family

cohesion and financial support. “We also know that being a woman or a girl is associated with increased risk for mental health problems after these types of events,” Lowe says. “Whether that’s due to biological sex differences, gender roles, women’s greater comfort with disclosing psychiatric symptoms or other factors is really unknown.”

The second category is related to the shooting itself. “People who are in greater proximity to the violence—if they see someone being shot or if they see dead bodies or people injured, that increases risk,” Lowe says. If a family member or friend lost their life, that, too, makes a person more vulnerable.

After the event, social resources can make a difference for survivors, Lowe says. “Emotional support (feeling like people are there for you), informational support (knowing what resources are out there) and tangible support (such as money and physical assistance) are things that can really matter,” she adds. Availability of mental health counseling and other services is also important. “These types of events can really shake your foundation and your core beliefs about yourself and other people in the world—like the belief that the world is a safe place and that most people are good. And those shattered assumptions can lead to an increased risk for PTSD and depression,” Lowe says.

What impacts do these tragedies have on the local community? What, for example, can the people of Uvalde expect?

Galea and Lowe say there are not a great deal of data on community-level impacts of mass shootings. “But we know from other collective trauma, like climate change-related disasters, that the resources within a community really matter,” says Lowe, who has studied the mental health consequences of such calamities. “Oftentimes after these events, there’s an outpouring of support—both formally from the government organizations and infor-

mally from other communities and strangers—but that tends to wane over time. And over time, folks who are living in less resourced communities tend to have greater risks if they face high levels of exposure [to a disaster]. That’s something that we found after Hurricane Sandy,” which struck the North American East Coast and the Caribbean in 2012.

What do we know about the impact on people watching from afar—you, me and everyone else reading about these horrific events and watching news coverage?

“We do know that people can report symptoms of mental illness from watching television or from social media,” Galea says. And, he emphasizes, “the baseline rate of depression is already quite high now, with the prolonged impact of the COVID pandemic. This is not a good time to have more traumatizing events.”

Remote impacts are not that well studied: only a few of the papers Galea and Lowe reviewed in 2015 looked at the psychological effects of mass shootings on people at a distance. Those that did, Lowe notes, found “at least temporary decreases in feelings of safety and increases in fear.”

What kinds of interventions have been shown to help people who are more directly affected?

Galea and Lowe say an approach called “psychological first aid” is recommended after traumatic events. “Psychological first aid starts with education, making people who might be affected aware” of possible mental health symptoms, Galea explains. “Then it moves on to giving them tools, and then it moves on to helping people access care if they need it. It is a way of sequencing interventions.” A school-specific manual is available from the federally funded National Child Traumatic Stress Network.

For those who show signs of distress, an intervention technique called “skills for psychological recovery” can

be helpful, Lowe says. “It seeks to restore psychological and psychosocial resources like hope and optimism, a sense of safety, social support.”

Mass shootings are so common now that about 96 percent of U.S. public schools hold “active shooter” and/or “lockdown” drills. Do these drills make kids feel safer?

What little evidence there is suggests that the answer is no. A survey published in the *Journal of Adolescent Health* in 2020 found that 60 percent of young people polled reported feeling unsafe, scared, helpless or sad as a result of such drills. A quarter said that they did not believe that drills improved safety because they suspected that students would panic when confronted with an actual threat—and because the drills could inform potential shooters.

A 2021 analysis of social media posts made by students after they engaged in such drills indicated that anxiety, stress and depression increased by 39 to 42 percent following the drills.

Lowe has not studied the response to these drills herself, but she says her students tell her they tended to take them as a joke or that the drills made them feel afraid. “I think there are probably ways to go about them that are a bit more trauma-informed,” Lowe says—including giving students a choice to opt out.

We’ve seen powerful examples of activism after school shootings from groups such as students who survived the Parkland, Fla., shooting and parents of children killed in the Newton, Conn., incident. Does activism help allay feelings of hopelessness and depression?

Lowe says she is not sure this has been studied in the context of school shootings, but she has been involved in research on climate change anxiety. “We found that if you

were engaged in environmental activism, like high levels of collective action, that was a buffer against the negative impact of climate change anxiety or depression,” she says. With activism, she points out, “you get to have support from a group of like-minded people who are all committed to the same cause..., but there is also the risk of burn-out and disillusionment.”

Has the amount of research on the mental health impacts of mass shootings greatly expanded since Galea and Lowe’s 2015 review? Are there many new lessons?

Both Galea and Lowe say that there is still insufficient research on the impacts of mass shootings. As Lowe prepared to update the 2015 study—a process that is still underway—she found about 50 relevant new papers. That means the total is about twice the 49 in the original survey. “So in less than 10 years, the number has doubled—but it’s still markedly low,” she says. In contrast, she and Galea found 100 papers in a single year that looked at the prevalence of depression and PTSD in the wake of climate-related disasters. One reason for the paucity of studies may be that a 1996 law known as the Dickey Amendment discouraged federal funding of health research related to gun violence. In 2018 Congress clarified the meaning of that law and permitted research into gun violence as long as it did not promote gun control. In late 2019 Congress finally allocated \$25 million for such research, including a much needed national study of strategies to protect schools. **M**

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John Horgan directs the Center for Science Writings at the Stevens Institute of Technology. His books include *The End of Science*, *The End of War* and *Mind-Body Problems*, available for free at mindbodyproblems.com. For many years he wrote the popular blog Cross Check for *Scientific American*.

When Things Feel Unreal, Is That a Delusion or an Insight?

The psychiatric syndrome called derealization raises profound moral and philosophical questions

Have you ever been gripped by the suspicion that nothing is real? A student at the Stevens Institute of Technology, where I teach, has endured feelings of unreality since childhood. She recently made a film about this syndrome for her senior thesis, for which she interviewed herself and others, including me. “It feels like there’s a glass wall between me and everything else in the world,” Camille says in her film, which she calls *Depersonalized; Derealized; Deconstructed*.

Derealization and depersonalization refer to feelings that the external world and your own self, respectively, are unreal. Lumping the terms together, psychiatrists define depersonalization/derealization disorder as “persistent or recurrent ... experiences of unreality, detachment,



or being an outside observer with respect to one’s thoughts, feelings, sensations, body, or actions,” according to the *Diagnostic and Statistical Manual of Mental Disorders*. For simplicity, I’ll refer to both

syndromes as derealization.

Some people experience derealization out of the blue, others only under stressful circumstances—for example, while taking a test or interview-

ing for a job. Psychiatrists prescribe psychotherapy and medication, such as antidepressants, when the syndrome results in “distress or impairment in social, occupational, or other important areas of functioning.” In some cases, derealization results from serious mental illness, such as schizophrenia, or hallucinogens such as LSD. Extreme cases, usually associated with brain damage, may manifest as Cotard delusion, also called walking corpse syndrome, the belief that you are dead, and Capgras delusion, the conviction that people around you have been replaced by imposters.

I’m glad Camille has drawn attention to the disorder because derealization raises profound philosophical questions. Sages ancient and modern have suggested that everyday reality, in which we go about the business of living, is an illusion. Plato likened our perceptions of things to shadows cast on the wall of a cave. Eighth-century Hindu philosopher Adi Shankara asserted that ultimate reality is an eternal, undifferentiated field of consciousness. The Buddhist doctrine of *anatta* says our individual selves are illusory.

Modern philosophers such as Nick Bostrom postulate that our cosmos is probably a simulation, a virtual reality created by the alien equivalent of a bored teenage hacker. The philosophical stance known as solipsism insinuates that you are the only conscious being in the universe; everyone around you only seems conscious. As I have mentioned in another article, some interpretations of quantum mechanics undermine the status of objective reality. Could derealization

have inspired all these metaphysical conjectures?

Many people, Camille suggests, undergo episodes of derealization without knowing what it is. The feeling disturbs you, so you suppress it. You try to put it out of your mind, and you don’t mention it to others. “You’re afraid that if you do tell people, they won’t know what it is,” Camille explains, “and you don’t want people viewing you differently.” I understand these reactions because derealization can be unsettling, even terrifying.

My most serious, sustained bout of derealization occurred after a drug trip in 1981, which left me convinced that existence is a fever dream of an insane god. For months the world felt wobbly, flimsy, like a screen on which images were projected. I feared that at any moment everything might vanish, giving way to—well, I didn’t know what, hence the fear. These feelings over the years have lost their visceral power over me, but their intellectual aftereffects linger.

Pondering derealization leaves me conflicted. I have moral misgivings about claims that reality isn’t, well, real. These assertions, whether Platonism, the simulation hypothesis or my insane-god theology, can easily become escapist and nihilistic. Why should we worry about poverty, oppression, environmental destruction, pandemics, war and other sources of suffering if the world is just a video game? I reject any philosophy that undercuts our responsibility to care for one another.

I’ve nonetheless come to value derealization as an antidote for habituation. Our brains are designed to accomplish many tasks with minimal conscious effort. As a result, we get accustomed

to things; we take them for granted. We become like zombies or automatons, carrying out chores and interacting with other people—even those we supposedly love—without being fully aware of what we are doing.

Derealization is like a slap across the face. It cuts through the monotony of life and wakes you up. It reminds you of the weirdness of the world, of other people, of yourself. By weirdness I mean infinite improbability and inexplicability. Weirdness encompasses all the bipolar properties of our existence, its beauty and ugliness, kindness and cruelty, good and evil.

Seeing the weirdness doesn’t negate our moral responsibility to others. Far from it. By estranging me from the world, derealization, paradoxically, makes it more real. It helps me see humanity more clearly and care about it more deeply. What once felt like a curse has become a gift.

That’s what I tell myself, anyway. Others, including those Camille interviewed for her film and Camille herself, experience derealization differently. She sees the syndrome as “your brain’s way of taking a break. It thinks you can’t handle certain things, and so it turns everything off.” She has learned that “just letting the feelings flow” rather than fighting them helps her get through episodes. Whatever derealization means to us, however we cope with it, we’re surely better off if we can talk about it openly, as Camille and others do in her brave, revealing film.

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Science Shows How to Protect Kids' Mental Health, but It's Being Ignored

Yes, the COVID pandemic has made the problem worse. But our teens were in trouble long before that

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Young people in the U.S. are experiencing a mental health crisis. Warnings from the surgeon general, the American Academy of Pediatrics, the American Psychological Association and other prominent organizations, as well as regular news reports, highlight the catastrophe, with parents struggling to help their children and students lined up in school halls to get even a few minutes with counselors, psychologists or social workers who are overwhelmed with young patients seeking services.

Has the current crisis been caused by the pandemic? No. Those of us who have been monitoring the health and well-being of youth know this



storm began years ago. In 2022 we continue to fund a system to address children's mental health that is similar to an infrastructure initiated in the 1940s, when returning veterans were the priority for mental health treatment. The system that emerged was—and is—geared to adults.

Scientific advances have identified effective mental health practices, such as school-based emotional-regulation training that teaches children how to cope with strong feelings, or school-based screenings that could allow us to detect mental health crises before they occur. Scientific advances have identified effective mental health practices, which have been largely ignored, and now is the time to act on them. Based on centuries-old and long-disproved theories of physical and mental health as two independent systems, billions are being invested annually on medical research and physician training, but staggeringly few resources are available to advance psychological science or the development of a mental health workforce.

The results are clear. Data from the Centers for Disease Control and Prevention, where one of us (Ethier) is the director of adolescent and school health, reveal that in the 10 years prior to the pandemic, a remarkably high number of young people reported feeling severe emotional distress. Specifically, in 2019, 37 percent of high school students questioned in a survey said they felt so sad and hopeless that they couldn't participate in their regular activities, and about one in five U.S. teens seriously considered or attempted suicide. Adolescent girls and youth who identified as lesbian,

gay, bisexual, transgender or who were questioning their identity were overrepresented among those teens who considered or attempted suicide.

Since the pandemic began, the situation has worsened. Children who were vulnerable before the pandemic now were in crisis, and those less vulnerable before the pandemic were at risk for the onset of psychological symptoms.

During COVID, adolescent visits to emergency departments for suicide attempts and eating disorders have increased. The CDC's Adolescent Behaviors and Experiences Survey, the first nationally representative survey of U.S. high school students during the pandemic, revealed that young people's lives were extremely disrupted, in ways unexpected or less easily managed.

More than a quarter of youth in the U.S. told us they experienced hunger, and more than half told us they experienced emotional abuse by an adult in their homes. We also heard that more than 60 percent of Asian students and more than half of Black students encountered racism in their schools. As we saw prepandemic, emotional distress and suicidal thoughts and behaviors continued to worsen, and these problems became more significant among female and LGBTQ students.

And so now a crisis that existed prior to the pandemic has been exacerbated, leaving many to wonder what can be done. The answer can be found in scientific discoveries that one of us (Prinstein) and psychological science colleagues have developed over the past several decades yet that have been largely ignored when developing

policies or best practices in schools, homes and communities.

For instance, scientists now have identified evidence-based treatments to ameliorate severe psychological symptoms, but few caregivers know how to seek treatments that have been proven to work.

Science also has identified effective strategies to prevent emotional or behavioral distress by teaching children skills for how to interpret or cope with stressors, how to develop healthy social relationships, strategies to lower anxiety, and how to spot the warning signs for depression. Yet resources are not available to allow these prevention approaches to be deployed at scale or used among populations most at need. Thus, youth continue to suffer needlessly. Schools dedicate time to teach children how to brush their teeth but not these science-based mental health strategies that could save decades of emotional distress and stop youth from self-harm.

CDC data confirm these approaches work. For instance, data show that during the pandemic, students who felt connected to others in school were less likely to experience emotional distress and other indicators of poor mental health, as well as suicide plans and attempts. Prior to the pandemic, we were making progress in addressing the needs of LGBTQ youth, for example. By 2018, 79 percent of high schools reported identifying safe spaces for LGBTQ youth, 96 percent had anti-harassment policies, 77 percent had inclusivity professional development for school staff, and 64 percent had student-led clubs for LGBTQ youth.

Recent CDC research found that having these four policies and practices in place at school improved mental health not only for LGBTQ students but for non-LGBTQ youth as well. Similar results are evident from antiracism programs that make schools less toxic for historically minoritized youth and improve the health and well-being of all students.

These approaches are not controversial. Methods to increase connectedness include classroom-management techniques that reinforce attentive, cooperative and collaborative behaviors, reduce peer victimization and help youth understand how others feel and behave. Psychological prevention strategies can teach youth how to less frequently blame themselves for harsh experiences, how to help all peers feel valued and included, and how to consider adaptive and healthy responses, even when confronted with aggression.

But these approaches, based on decades of rigorous science, will require an acknowledgement that children's mental health is in crisis. A commitment to the science of behavior is imperative, as is the deployment of innovative programs, created by scholars, that have languished in academic journals rather than being turned into practice.

Failure to address this mental health crisis will result not only in the distress of millions of youth in the U.S. today but in a change in the productivity, success and well-being of U.S. citizens-at-large as this generation matures.

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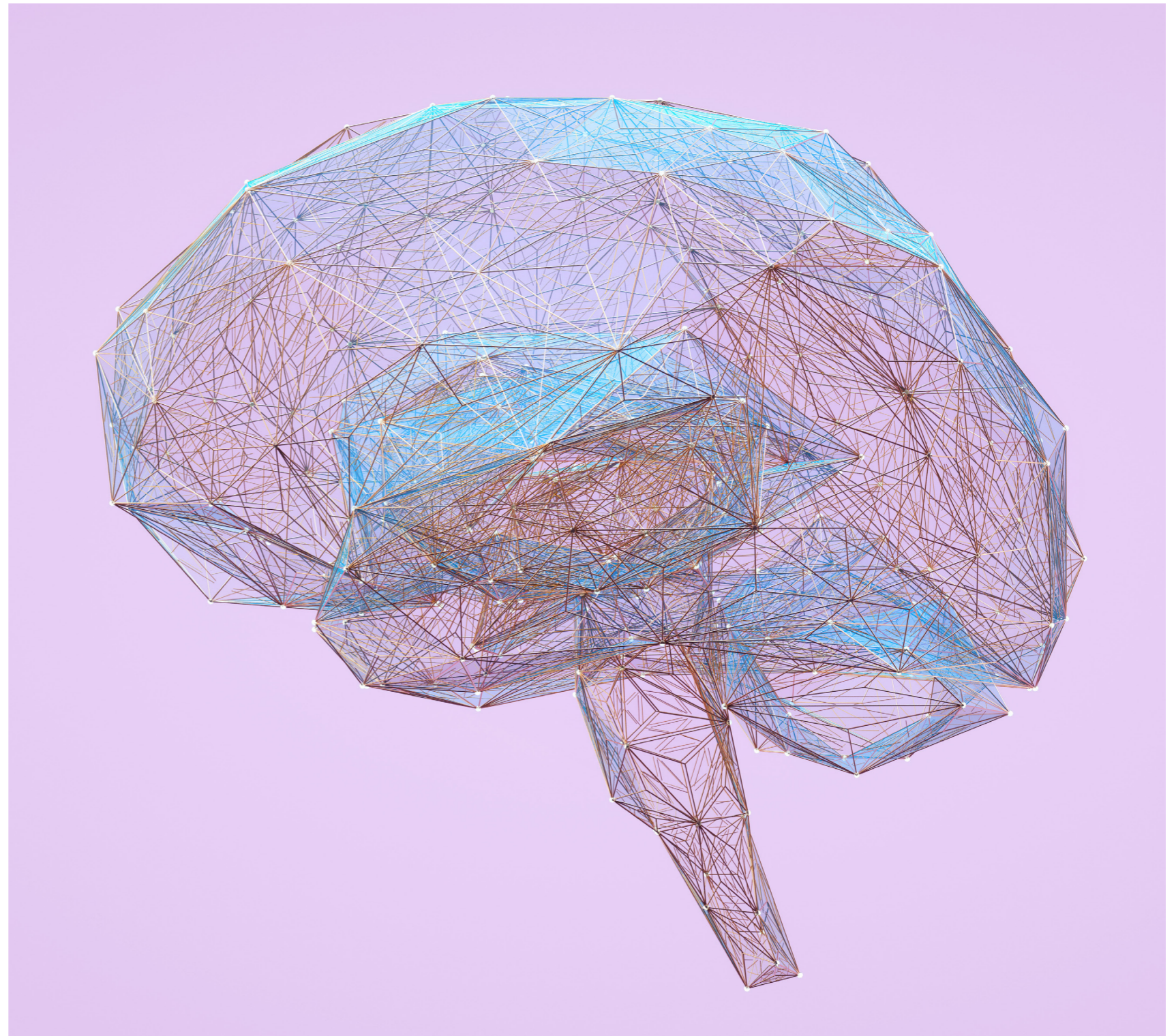
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How the Brain Tells Apart Important and Unimportant Sensations

Several recent studies point to a small, long-overlooked structure in the brain stem as a crucial gatekeeper for the body's signals

Imagine you are playing the guitar. You're seated, supporting the instrument's weight across your lap. One hand strums; the other presses strings against the guitar's neck to play chords. Your vision tracks sheet music on a page, and your hearing lets you listen to the sound. In addition, two other senses make playing this instrument possible. One of them, touch, tells you about your interactions with the guitar. Another, proprioception, tells you about your arms' and hands' positions and movements as you play. Together these two capacities combine into what scientists call somatosensation, or body perception.

Our skin and muscles have millions of sensors that contribute to somatosensation. Yet our brain does not become overwhelmed by the barrage of



these inputs—or from any of our other senses, for that matter. You're not distracted by the pinch of your shoes or the tug of the guitar strap as you play; you focus only on the sensory inputs that matter. The brain expertly enhances some signals and filters out others so that we can ignore distractions and focus on the most important details.

How does the brain accomplish these feats of focus? In recent research at Northwestern University, the University of Chicago and the Salk Institute for Biological Studies in La Jolla, Calif., we have illuminated a new answer to this question. Through several studies, we have discovered that a small, largely ignored structure at the very bottom of the brain stem plays a critical role in the brain's selection of sensory signals. The area is called the cuneate nucleus, or CN. Our research on the CN not only changes the scientific understanding of sensory processing, but it might also lay the groundwork for medical interventions to restore sensation in patients with injury or disease.

To understand what's new, we should review a few basics of how somatosensation works. Whenever we move or touch something, specialized cells within our skin and muscles respond. Their electrochemical signals travel along nerve fibers to the spinal cord and brain. The brain uses these messages to track body posture and movement and the location, timing and force with which we interact with objects. Experiments have made clear that the conscious experience of our body and its interactions with objects relies on these signals reaching the cerebral cortex, the outermost layer of the brain. Scientists have long as-

sumed that this brain area was one of the main players involved in selectively enhancing or filtering sensory signals. They believed that the CN, on the other hand, was simply a passive relay station, moving signals from the body up to the cortex.

But we were skeptical. Why would the CN exist if it did not alter the signals in some way? We decided to watch cuneate neurons in action to find out. The challenge historically has been that the CN is small and very hard to access. It's located at the highly flexible junction of head and neck, meaning an animal's movement can make it difficult to reach. To make matters worse, the cuneate nucleus is nestled in the brain stem, surrounded by vital brain regions that, if damaged, can lead to death.

Fortunately, modern neuroscientific tools let us observe the CN stably in awake animals without harming nearby areas. In monkeys, we implanted tiny arrays of electrodes that we used to monitor individual cuneate nucleus neurons. For the first time, we could study how single brain cells in this area responded when a monkey moved and touched things. This method allowed us to answer several questions about what the CN does.

For one, we studied how these neurons responded to touch signals by exposing monkeys' skin to many kinds of stimuli, including vibrations and braille-like embossed dot patterns. We then compared the responses in the CN with activity in nerve fibers that feed into this brain structure. If the area just passed along information collected by the skin's sensory cells, neural activity in the CN would essentially echo the activity in nerve

fibers. Instead we found that CN neurons did not simply pass their inputs along but transformed them. In fact, cuneate neurons showed patterns of activity that were more similar to those in the brain's cerebral cortex neurons than they were to the patterns in nerve fibers.

But the connection between the CN and the cortex is not a one-way street. In addition to sensory nerves going up, there are pathways from sensory and motor areas of the cerebral cortex going down to the cuneate nucleus. We wondered whether the CN contributed to some form of sensory filtering based on an animal's planned voluntary movements. To that end, we observed CN activity when monkeys reached toward a target and compared those signals with the CN signals generated when a robot moved the monkeys' arm in a similar fashion. We discovered that the activity in cuneate neurons did indeed change, depending on what the animals were doing and whether movements were voluntary or involuntary. As just one example, we know that signals from arm muscles can help an animal determine that a movement is going as planned. In line with this idea, we found that many signals from the arm muscles were enhanced in the CN when a monkey voluntarily moved its arm, compared with when the robot moved it.

These studies established that the processing of signals coming from our body has already begun when signals reach the cuneate nucleus. But what are the brain cells and pathways that enable the CN's selective enhancement of signals that matter and suppression of those that do not?

In a third study, we took advantage of genetic and viral techniques to probe the nervous system of mice. With these tools, we could manipulate specific types of cells, turning them on or off by shining a laser at them. We paired these techniques with behavioral tasks: By training mice to pull a string or react to various textures for a reward, we tested how the activation or inactivation of specific neurons might affect a mouse's ability to carry out dexterous tasks. This approach allowed us to first explore the functions of cells within the CN, revealing a specific set of neurons surrounding it that can suppress or enhance the passage of touch signals as they enter the brain.

Then we applied similar techniques to examine how other higher brain regions may influence the CN's activity. We discovered two different pathways from the cortex all the way down to the CN that govern how much information the cuneate allows to pass. In other words, the CN receives not only information from the body but also guidance from the cortex to help determine what signals are most relevant or important for an individual at any given moment.

Clearly, the cuneate nucleus is a far more interesting brain region than it has been given credit for. Our work helps to clarify its function: to highlight certain signals and suppress others before passing them on to brain regions responsible for perception, motor control and higher cognitive functions. That important role may help explain why the CN appears in a wide variety of mammals, including mice and primates.

Although our work is far from finished, our re-

sults already have significant implications for rehabilitation. Beyond the active tactile and muscle signals we were able to study, evidence suggests that the CN receives many more "dormant" inputs that may play a part in recovery from neurological injury. Millions of people worldwide suffer from some form of limb dysfunction, such as paralysis or loss of feeling. With a better understanding of how sensory and motor signals support movement, doctors can eventually improve diagnosis and treatment of these conditions. For example, implanted electrodes could one day electrically activate the cuneate nucleus in people who have lost sensation in their limbs, potentially restoring the ability to perceive their body.

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Lee E. Miller is a Distinguished Professor of Neuroscience in the department of neuroscience, physical medicine and rehabilitation and the department of biomedical engineering at Northwestern University. He was inducted into the American Institute for Medical and Biological Engineering in 2016 and is current president of the Society for the Neural Control of Movement.

Chris Versteeg earned his Ph.D. under the mentorship of Lee E. Miller at Northwestern University and is now a postdoctoral fellow at Emory University. He is interested in how controlled movements emerge from the dynamic coupling of the brain to the body.

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Niro Sivanathan is a professor of organizational behavior at London Business School. His research explores how social hierarchy regulates our judgment and behaviors through the psychological experience of status and power.

How Dominant Leaders Go Wrong

Highly assertive, confident individuals may foster a selfish culture that hurts productivity

“Competitive,” “decisive,” “action-oriented,” even “intimidating”: many people invoke these words to describe good leaders. Indeed, several studies suggest extraverted, dominant individuals are perceived as competent, influential leaders in industry and politics. Think of the late former General Electric CEO Jack Welch, Amazon founder Jeff Bezos or Tesla CEO Elon Musk. Many people find these leaders appealing and inspiring.

But such individuals have shortcomings as well. Dominant leaders sometimes seek to influence co-workers by fiat or force—insisting on their own way or intimidating others—rather than taking steps to discuss, debate or consult with colleagues. And that has serious downsides for the companies, organizations and nations that they lead.

In our recent research, we examined some of the unintentional negative consequences of a dominant leadership style. Across eight studies, we explored how such leaders can inadvertently



reduce cooperation among their employees by fostering a competitive climate. Past research shows that societies and organizations flourish when members help one another, share information and engage in collective problem-solving. Dominant leadership can stifle those activities,

however. We argue that's because a leader's hyperindividualist approach can foster a widespread zero-sum mindset, in which people believe they can progress only at the expense of others.

In our first foray into this investigation, we looked at political leadership, specifically compar-

ing democracies and dictatorships. Although some democratic leaders are aggressive and competitive, dictators exhibit extremely dominant behavior. They subjugate others to serve their own best interests. Given our hypothesis that dominance may foster a highly competitive culture, we wondered whether citizens in dictatorships engage in more zero-sum thinking than those in democracies. To test that idea, we examined data from 70 countries surveyed between 1981 and 2014 through the World Values Survey, which seeks to understand people's social, political and cultural beliefs. We specifically attended to how much residents reported their agreement with such statements as "people can get rich only at the expense of others." We also looked at their inclination toward helping behaviors, including how highly they rated the importance of caring for their neighbors. We found that citizens of countries governed by dictators reported greater zero-sum mindsets and were less likely to help others when compared with residents of democracies.

For our second study, we designed an experiment to directly test whether dominance influences how people think about cooperation and competition in a work context. We recruited male and female professional actors and then filmed them in a series of videos. The performers introduced themselves at the start of each video and described their leadership approach to newly onboarded workplace subordinates. One of these approaches was dominance: in it, leaders described their tendency to be authoritative and decide what is best for the team. The other approach

was what we call the prestige style. In it, leaders emphasized how much they valued others' input and an egalitarian approach.

We then recruited about 600 participants who watched one of these videos (either a male or female leader in the dominance or prestige condition). Afterward, they rated how much they agreed with statements related to zero-sum thinking and how likely they would be to engage in helping behaviors—such as listening to a co-worker's problems—if they worked for the boss whose video they had just seen. We found that participants who had watched a dominant leader were more prone to express a zero-sum mindset and less likely to help others, compared with participants who had just watched a prestige leader.

Additional questions and analysis allowed us to rule out other factors that could influence these findings. Gender had no effect: dominant men and women in the videos both reduced helpfulness and increased zero-sum thinking among participants. In a follow-up study, we asked people questions to assess how much autonomy they possessed and whether they considered assisting others to be an important part of their work. After all, if people feel they lack control over their tasks or that their job simply doesn't involve cooperation, it's no surprise they might hesitate to help others, regardless of their leader's style. But these factors, our analyses revealed, had minimal effect on thinking and behavior in comparison with leader dominance and zero-sum thinking.

We also assessed actual helping behavior rather than relying solely on people's reported inclina-

tions. We gave participants a written description of a leader. Then we put them on teams for an online task and measured the degree to which they volunteered to transcribe text for their fellow group members. Our hypothesis held. People who had read descriptions of their leader's dominant styles were significantly less willing to help their team out during these exercises.

Finally, we tested whether this finding could be replicated with actual working groups. We surveyed 249 employees in 50 teams, along with their supervisors, at companies in India. We began by asking employees about their leader's tendency to influence based on dominance and about their own zero-sum mindset. Six weeks later supervisors rated their employees' helping behaviors. When we looked at our combined data, we found a familiar pattern: Employees supervised by a dominant leader reported greater zero-sum thinking. And as their supervisors subsequently revealed, these employees displayed fewer helping behaviors. More important, this effect remained robust even when employees had a positive relationship with their supervisor and saw this leader as highly ethical, two factors that might otherwise explain variation in their thinking and behavior.

Although a number of leadership books and popular coaching manuals celebrate the effectiveness of a confident, decisive leader, our work underscores how this approach may breed an "each to their own" culture. Managers need to be aware that an assertive or forceful approach could reduce cohesiveness and collaboration. Organizations, meanwhile, should be careful about whom

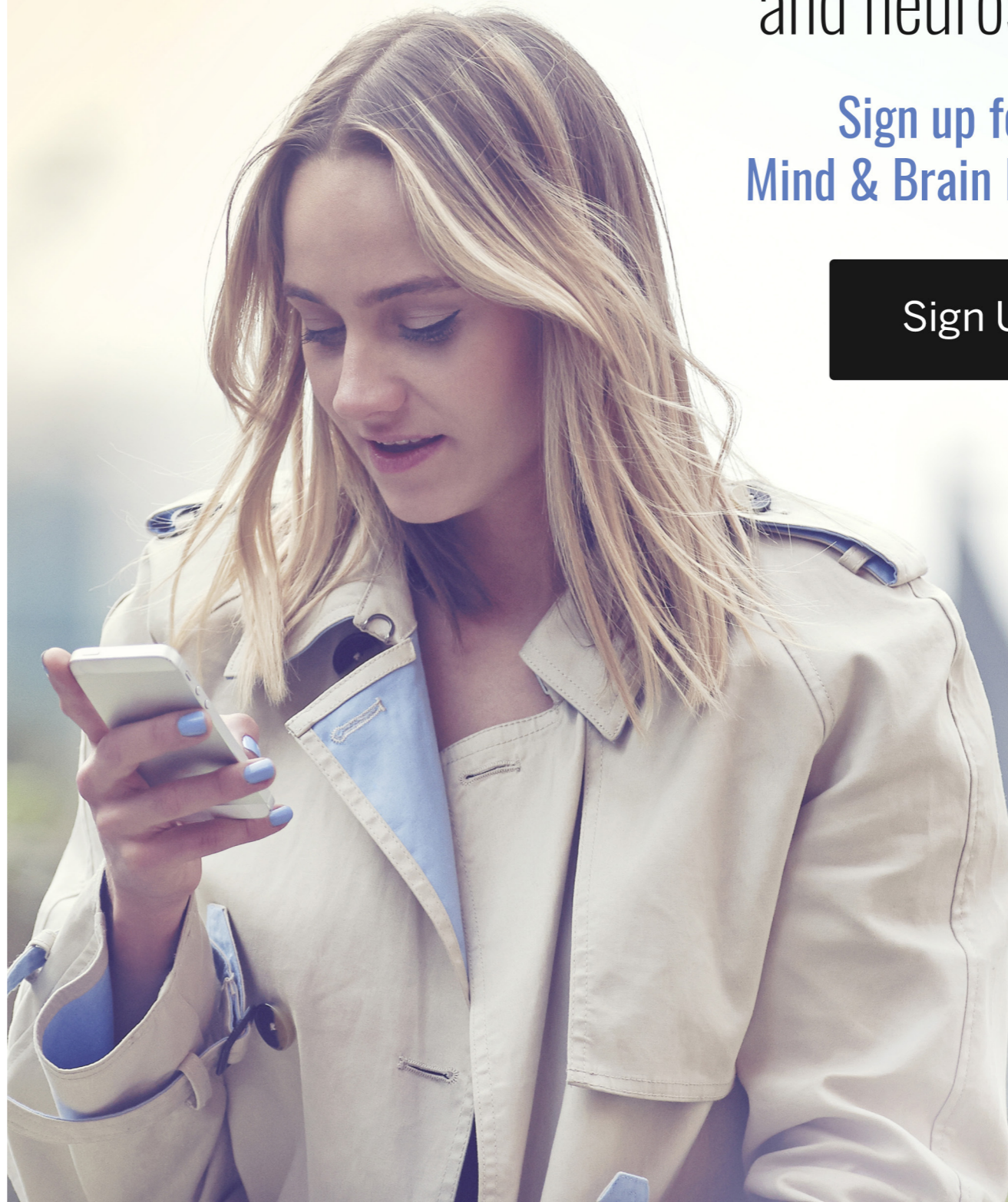
they promote. If a leader cannot rein in their dominant style, management should incentivize helping others. Companies can, for example, stress that employees understand how supporting one another's career is part of their job. And some academics have suggested that job crafting—in which organizations help employees expand and define their role to build skills—should include activities that involve helping others. Researchers have found that such structural arrangements promote employee cooperation.

Many real-world examples bear out our conclusions. For instance, changes at Microsoft in the past few years illustrate both the repercussions of dominance and the positive power of changing leadership. Steve Ballmer, former CEO of Microsoft, was known for his domineering approach. Under his management, the company lost a lot of ground to its competitors and suffered from a culture of fear and internal conflict. But company culture changed in 2014 with the arrival of its current CEO Satya Nadella, a leader known for his expertise and empathetic approach. His main focus has been to channel employees' attention away from zero-sum thinking to a growth and learning mindset, which encourages people to accept both successes and failures as opportunities to gain insight that can benefit all involved. Microsoft has since seen record revenues and stock share prices.

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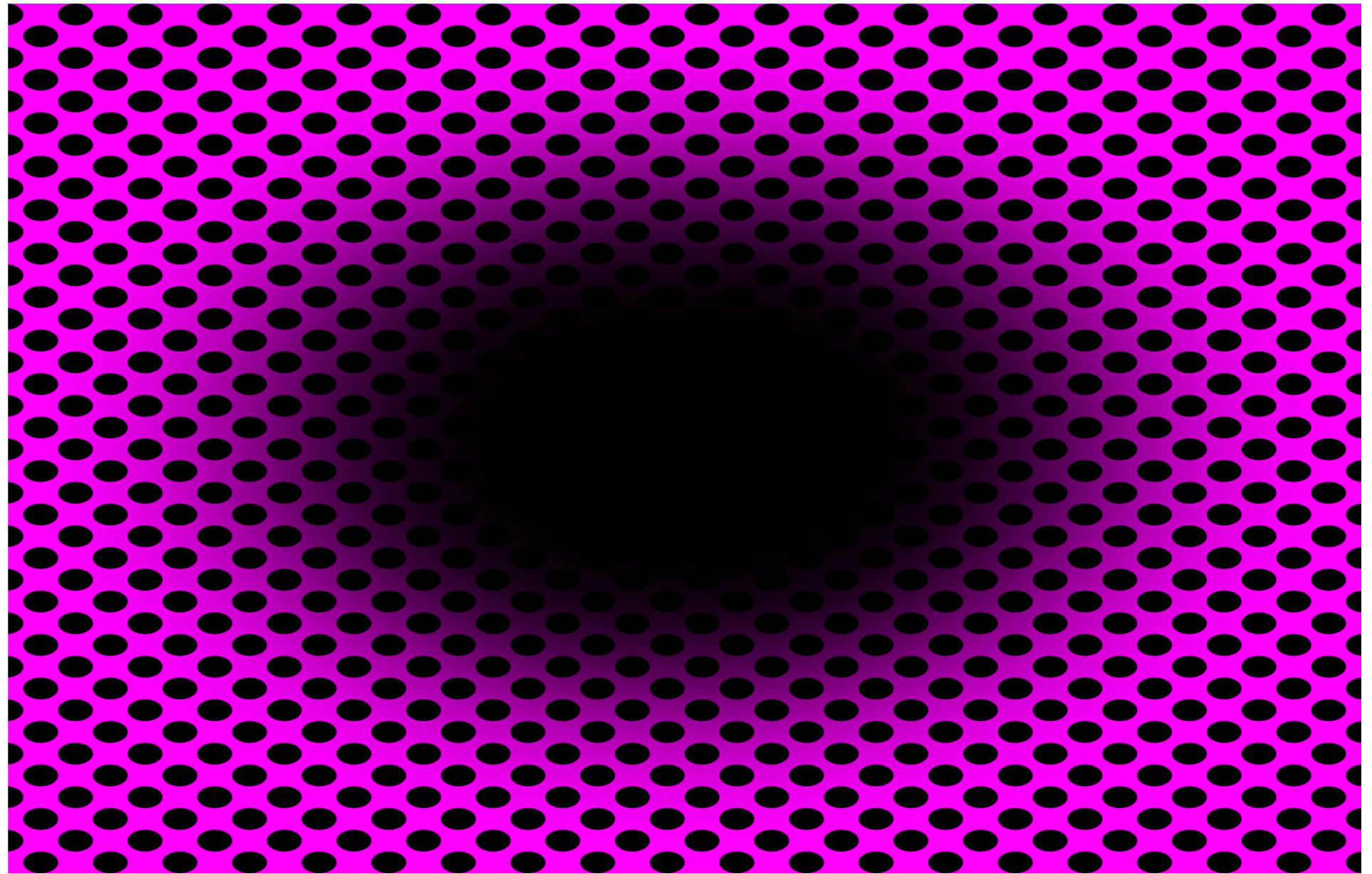


Susana Martinez-Conde and **Stephen Macknik** are professors of ophthalmology at the State University of New York and the organizers of the Best Illusion of the Year Contest. They have co-authored *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions* and *Champions of Illusion: The Science behind Mind-Boggling Images and Mystifying Brain Puzzles*.

Hello Darkness, My Old Friend

**Anticipated blackness tricks
your pupils into reacting**

Moving from a well-lit space into a dark one has always been a common experience in human lives, explains [Bruno Laeng](#), a cognitive and visual scientist at the University of Oslo in Norway. “Driving into a tunnel and [perceiving] an expanding dark hole flowing toward you at the center of your vision” is akin to what our ancestors might have experienced “when entering a dark cave.” Because such occurrences are so regular, being able to dilate one’s pupils in anticipation of the enveloping darkness could mean seeing predators and prey better and faster in dim environments. “Adjusting the pupil in advance would diminish the possibility of being temporarily, visu-



The central “black hole” appears in perpetual expansion, although the image is completely stationary.

ally, incapacitated by imminent darkness,” Laeng says.

But what if the rising darkness exists only in the mind of the observer?

In a recent [study](#), Laeng, along with collaborators Shoab Nabil, also at Oslo, and [Akiyoshi Kitaoka](#) of Ritsumeikan University in Japan, set out to

determine if subjective darkness expansion can cause pupils to dilate as they would in the presence of veridical growing blackness.

● ILLUSIONS

The research team recorded experimental participants' pupil sizes as they viewed images based on an illusion originally developed by Japanese designer Kouki Fujiwara. An example is shown on the preceding page. Although the black center of the magenta-patterned background seems in never-ending expansion, as if it were an animation, in reality nothing moves. The deceptive growth sets this illusion apart from other classic illusions in which objects seem larger or smaller than in reality (such as the [Muller-Lyer illusion](#) or the [Ebbinghaus illusion](#)) without the observer perceiving motion, Laeng adds.

The data showed that the pupillary light reflex “does not work a like a photocell opening a door—which is impervious to any other information than the actual amount of light stimulating the photoreceptor,” Laeng says. Instead the eye adjusted to the perceived light levels. Interestingly, the changes in pupil size were linked to the strength of the illusory expansion for black “holes” only and not for white or colored ones. The discrepancy made sense to the scientists because the visual system would be more challenged by moving into a space with no light than by moving into a space that was lighted differently.

In addition, not every participant experienced the illusion of expansion, but some people perceived the images as static ink blots. “This made us reflect that different individuals make different (often subconscious) assumptions about the same image—such as interpreting these 2-D displays as a 3-D scene where one can move about,” Laeng says.

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