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BEATING PANDEMIC FATIGUE

Top things our brains need to help us get through the coming months

PLUS

WHEN SELF-IMPROVEMENT IS JUST AN EGO BOOST

COVID DELIRIUM

EVOLUTIONARY ORIGINS OF FRIENDSHIP

WITH COVERAGE FROM nature

LIZ TORMES

On the Other Side of That Pandemic Wall

As I write this, it's been nearly one year since our editorial team decided to start working from home out of concern for the novel coronavirus sweeping the country. To say that we're living in a so-called new normal is a gross misnomer. The realities of social isolation, virtual remote learning, rolling lockdowns, and nearly half a million dead in the U.S. are as far from normal as one could imagine. As the virus and its toll continue to deplete us, mental exhaustion has started to kick in, as neuroscientist David Badre writes in this issue's cover story (see "How We Can Deal with 'Pandemic Fatigue' "). He has some insight into how behavioral science might help us get across the pandemic end zone. The sooner the better.

Elsewhere in this collection, psychologist Scott Barry Kaufman explores a new phenomenon whereby self-improvement efforts—yoga, smoothies, meditation—end up feeding the ego rather than engendering enlightenment (see "The Science of Spiritual Narcissism"). And reporter Carrie Arnold investigates cases of COVID delirium and what they might mean for future mental health (see "The Link between Delirium and Dementia"). Thanks for reading, get some rest, and carry on.

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On the Cover

Top things our brains need to help us get through the coming months

WHAT'S INSIDE

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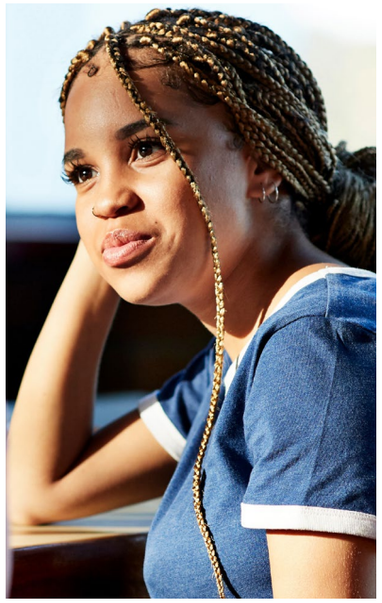

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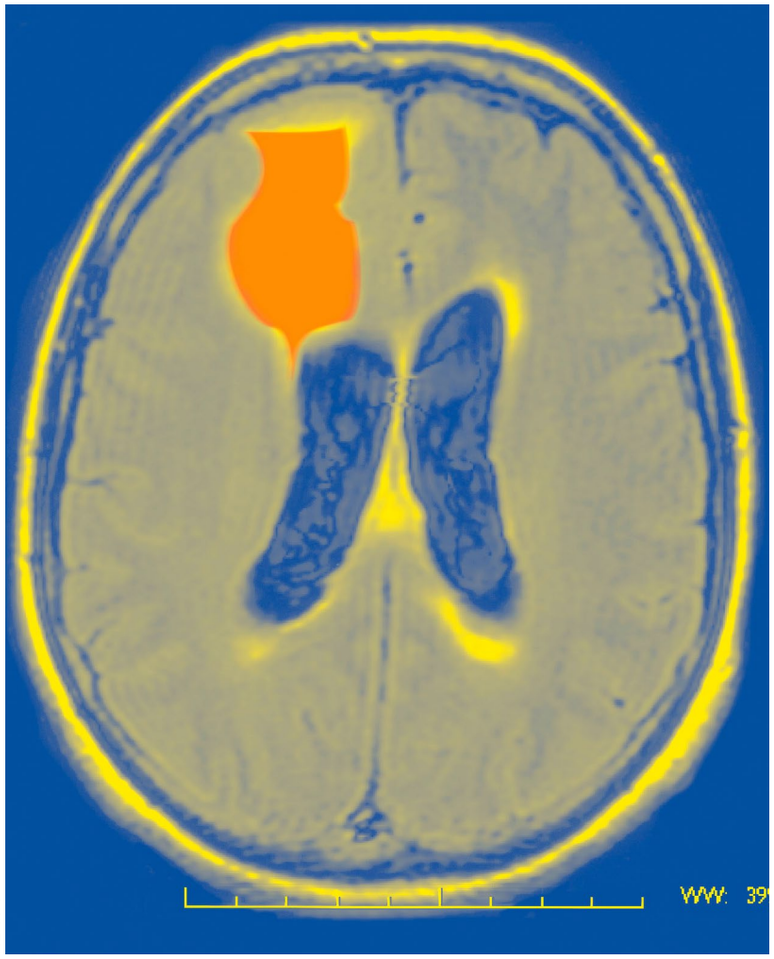

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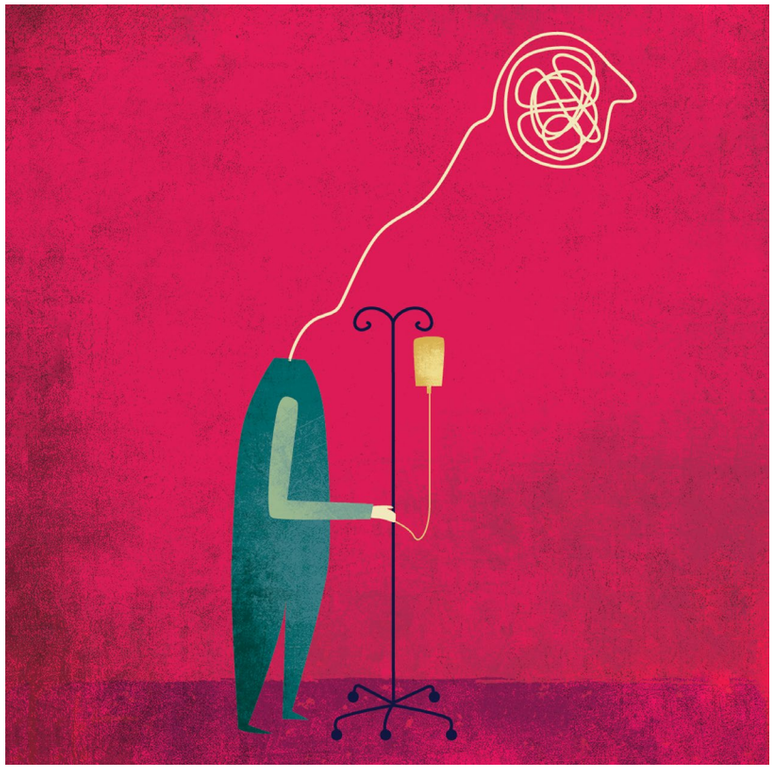


FATINHA RAMOS

FEATURES

OPINION

ILLUSIONS

When Our Gaze Is a Physical Force

Research documents a strange illusion

Have you ever sensed that someone might be watching you? You get a prickly feeling at the back of your neck and turn to see a stranger staring at you across the room. It sometimes seems that we can feel a person's gaze as a physical sensation. And, from a single glance, we can tell a lot about a person, such as their moods, intentions and focus. Is their gaze dangerous, interesting or attractive? Do they stare directly or glance to the side? If "eyes are the window into the soul," then a glance reveals far more than we know.

Recent studies demonstrate that humans attribute gaze with physical properties. We create tacit mental schemes in which the visual attention of others is computed as a forceful beam emitted from the viewer's eye and directed at the object of interest. These mental schemes allow us to take cognitive shortcuts to process people's visual attention quickly and efficiently.

Gaze is an elemental form of communication that can coordinate activities and convey social dynamics without a gesture or spoken word. It requires a rapid interpretation of the meaning behind another's gaze, but the trade-off for the speed of that interpretation is the mistaken understanding of gaze as something that

KLAUS VEDFELT *GETTY IMAGES*

can move things in our environment. These studies show that this interpretation is subconscious and automatic and that it occurs even in those who would consciously deny that vision exerts any force.

You might expect that such an erroneous interpretation would be detrimental. In fact, while there seem to be few if any adverse consequences, these findings may underlie rich and diverse cultural references to the outward force and power of the gaze. The results of the experiment demonstrate an ancient human idea linking gaze with physical properties. This notion, as old as the Greeks, is known as the "extramission" theory of vision. Extramission literally means "sending out," and the extramission theory is the belief that vision is a force emitted from the eye. It is an intuitive understanding of vision common among children that persists among many adults. In contrast, the modern visual theory is called "intromission" and is based on the notion that vision results from light entering the eyes.

When we direct our gaze at something or someone, others who notice subconsciously direct their gaze in the same manner. We can take advantage of this tendency to deliberately influence the gaze of others.

Using a series of ingeniously simple experiments in one study, researchers found that subjects associate gaze with a physical force. Subjects viewed a computer display that had an image of a tube, roughly the size of the end of the paper towel roll, standing vertically on a table. At one end of the table was an image of a face gazing at the tube (researchers dubbed the face avatar Kevin). Subjects were instructed to tilt the tube toward Kevin's image using specific keys on a keyboard until they felt the tube had reached the critical angle at which it would tip over. The critical angle reported by subjects depended on whether Kevin was blindfolded. If Kevin was perceived as gazing at the tube, the critical angle was greater than when Kevin was blindfolded, suggesting that his gaze was impressing some force on the tube that needed to be overcome for the tube to fall.

Likewise, in a second experiment, subjects were presented with the image of Kevin either gazing at the tube or gazing away in the opposite direction and asked to report the critical angle of the tube before toppling. Once again, the angle depended on Kevin's perceived gaze and was much greater when Kevin gazed straight at the tube compared with when Kevin was turned away. Finally, in a third experiment subjects were told that Kevin was either looking directly at the tube or focused beyond the tube at a wall at the other end of the table. Once again, the critical tilt angle was greater if subjects thought Kevin was gazing at the tube rather than the wall.

Participants in this study were screened for belief in extramission beforehand, and those who expressed such a belief were excluded. So it is remarkable that all remaining participants intuited a force based on gaze, even while they disavowed any belief in such a force emanating from the eye. What has emerged in this study is an implicit, unrecognized cognitive shortcut employed by humans to rapidly process gaze but that leads us to comprehend it as something that affects objects in the world.

To test this theory, researchers employed brain-imaging methods to demonstrate that gaze perception activates brain regions associated with motion. In this case, subjects were presented images of moving dots or an image of a face gazing at a tree. Brain activity was measured using functional magnetic resonance imaging (fMRI), which detects brain activity by measuring local brain oxygen consumption. Areas of the brain involved in processing visual motion (the right middle temporal cortical areas) and in understanding the thoughts and intentions of others (the right temporal parietal junction) were involved in processing the face's gaze when staring at the tree. But just as with the blindfolded Kevin, these fMRI signals halted when the face in these studies was blindfolded. Here

the brain processes the gaze as movement even when no movement occurs, again showing an extraordinary misapprehension of reality.

Belief in the power of gaze appears in stories and myths throughout the centuries. Medusa turned people to stone with her gaze. The catoblepas and, more famously, the basilisk, both described by Pliny the Elder, could kill with the single glance. In Shakespeare's *Venus and Adonis*, Venus complains of the pain caused by Adonis' glance: "Thine eye darts forth the fire that burneth me." While in John Donne's *The Ecstasy*, the glances of the lovers intertwine and bind them as if they were their clasped hands. And, of course, no list of cultural references to gaze would be complete without mention of the Jedi master or Superman.

Gaze is a powerful element of social interaction. It reveals where a person is focusing their attention, and, when directed at us, it can have a strong emotional effect. Gaze can play a role in social organization, with a direct gaze demonstrating social dominance and gaze aversion indicating passivity. Eye contact can elicit alertness and bodily awareness, while indifference or aversion to eye contact can signal emotional or neurological disorders. When we direct our gaze at something or someone, others who notice subconsciously direct their gaze in the same manner. We can take advantage of this tendency to deliberately influence the gaze of others. Magicians take advantage of the ability to redirect gaze and attention to enhance their sleight of hand. Visual artists can manipulate attributes of a work of art such as luminosity in order to direct visual gaze to specific features of a painting. In dance, gaze can be used to convey the power dynamics between the characters on stage, while musicians rely on gaze as an essential means of communication, using it to help in cuing and synchronization during the performances of orchestras and choirs.

Gaze is a means of communication that impacts us in many ways, subconsciously and quickly, so quickly and energetically that one investigator described the effects of gaze as "exuberant." And while magicians may know how to manipulate gaze to enhance their illusions, the illusion of gaze as a physical force is magic enough.

—Robert Martone

Forecasts of Epilepsy Seizures Could Become a Reality

Making predictions up to several days in advance may help with care

Seizures are like storms in the brain—sudden bursts of abnormal electrical activity that can cause disturbances in movement, behavior, feelings and awareness. For people with epilepsy, not knowing when their next seizure will hit can be psychologically debilitating. Clinicians have no way of telling people with epilepsy whether a seizure will likely happen five minutes from now, five weeks from now or five months from now, says Vikram Rao, a neurologist at the University of California, San Francisco. "That leaves people in a state of looming uncertainty."

Despite the apparent unpredictability of seizures, they may not actually be random events. Hints of cyclical patterns associated with epilepsy date back to ancient times, when people believed seizures were tied to the waxing and waning of the moon. While this particular link has yet to be definitively proven, scientists have pinpointed patterns in seizure-associated brain activity. Studies have shown that seizures are more likely during specific periods in the day, indicating an association with sleep-wake cycles, or circadian rhythms.

In 2018 Rao and his colleagues reported the discovery of long-term seizure-associated brain rhythms—most commonly in the 20- to 30-day range—which they dubbed "multidien" (multiday) rhythms. By examining these rhythms in brain activity, the group has now demonstrated that seizures can be forecast 24 hours in advance—and in some patients, up to three days prior. Their findings, published on December 17 in the *Lancet Neurology,* raise the possibility of eventually providing epilepsy patients with seizure forecasts that could predict the likelihood that one will occur days in advance.

In its latest study, Rao's group conducted a retrospective analysis of data collected during a nine-year clinical trial with participants who had a Food and Drug Administration–approved, implanted neurostimulation device, NeuroPace, which uses a type of electroencephalograph (EEG) to monitor both seizures and interic-

tal epileptiform discharges—pathological spikes in brain activity that occur between seizures. (One of the study's authors, Thomas Tcheng, is the senior director of preclinical research at NeuroPace.)

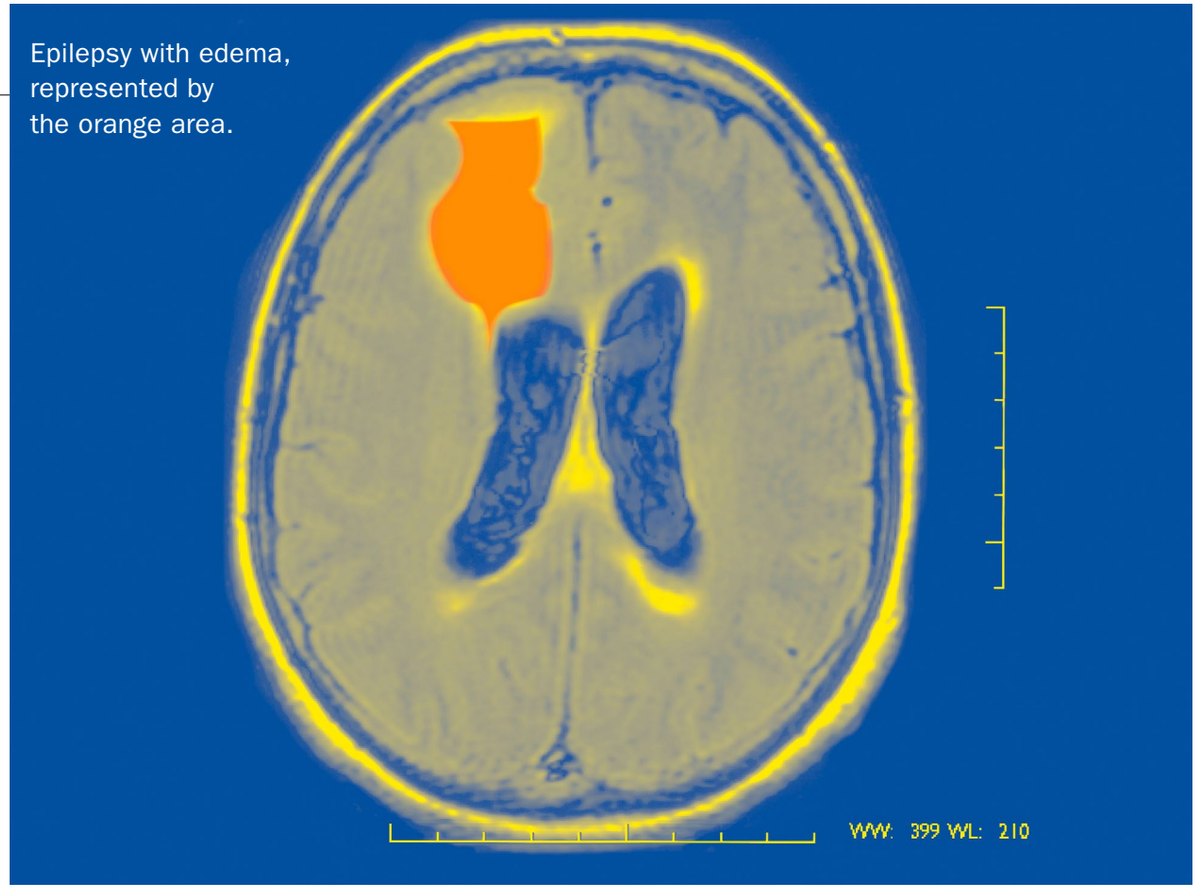
Using data about the timing of interictal epileptiform discharges and past seizures, the team developed a computational model that estimated whether or not a patient was at risk of a seizure in the subsequent hours or days. Maxime Baud, an epileptologist at the University of Bern in Switzerland and a co-author of the study, explains that the researchers were not trying to predict when, exactly, the next seizure will happen but rather to identify the probability that a seizure would happen over a given time period—akin to how weather forecasts provide a percentage of the likelihood of rain or shine on a given day.

When the researchers compared their forecasts with the actual occurrence of seizures in 18 participants, they found that in 15 of them (83 percent), the algorithm performed better than chance at predicting seizures 24 hours in advance. In two of the patients (11 percent), it was able to forecast seizures up to three days in advance. To further validate the model, the team applied it to another, larger data set with 157 participants—this time, assessing whether the algorithm could forecast self-reported seizures, which are the primary tool used for assessment in the clinic. The researchers found it could forecast seizures over 24 hours in 103 participants (66 percent) and up to three days ahead in 61 (39 percent). In general, chances of a seizure were highest during periods when both circadian and multidien cycles of brain activity were near their peak.

"Prior work has been mostly focused on forecasting seconds to minutes to a few hours ahead of time. This group has built on the work with multidien cycles to [introduce] a multiday predictor," says Hitten Zaveri, a professor of computational neurophysiology at Yale University, who was not involved in the research. "[The study] has clearly been done very well, with good data and good observations."

Forecasting on these longer horizons could provide significant benefit for people with epilepsy. One of the biggest advantages is that it could help rectify deficiencies of existing treatments, says Jacqueline French, chief medical and innovation officer at the Epilepsy Foundation and a professor of neurology at New York University, who was not involved in this study. The major issue with one of the main therapeutics used to prevent seizures, a class of drugs called benzodiazepines, is that if they are taken continuously, they lose their efficacy. (Long-term use can also lead to addiction.) Limiting their intake to days when people are at high risk for seizures could make them more effective, French says. Seizure forecasts may also improve the efficacy of devices such as NeuroPace, which monitors brain activity and delivers pulses of electricity when seizures are imminent to attempt to ward off the event, Rao notes.

For some people, however, seizure forecasts could prove more frustrating than helpful. "If I told you that tomorrow, there's a 90 percent chance of rain, and you packed an umbrella, and it doesn't rain, you might be upset that you had to pack an umbrella. Or conversely, you might be upset with me if I said there's a 5 percent chance of rain tomorrow,



Epilepsy with edema, represented by the orange area.

ALAMY

and you go outside in shorts, and it rains," Rao says. This dilemma is one of the reasons a prospective trial—in which participants are followed forward in time (rather than doing an analysis of previously collected data)—would be beneficial, Rao adds. Not only would such a study provide more robust evidence that seizure forecasting is indeed feasible, researchers would also be able to assess how participants actually use this information. Only one prospective study of a seizure advisory system has been conducted to date: the NeuroVista trial, which demonstrated that it was possible to predict the likelihood of seizures minutes in advance.

One key limitation of Rao and Baud's forecasting technique is that it requires a brain implant to record neural activity. But Baud contends that the interictal epileptiform discharges used to generate these forecasts can be picked up with the less invasive measure of placing EEG electrodes just under the scalp (subscalp EEG). One of the next steps is to attempt to use this method to generate seizure forecasts as well.

Other groups are working on completely different measures to generate these kinds of seizure forecasts. Philippa Karoly, a research fellow at the University of Melbourne in Australia, and her colleagues have found evidence that multiday cycles in heart rate are also associated with seizure occurrence in patients. (These results have been posted onto medRxiv, a platform that hosts papers that have not yet been peer-reviewed.) "We believe that we can measure these underlying biological cycles not just from the brain but also from the heart and from other aspects of physiology that are affected by the same triggering factors that are driving the cycles in the brain," Karoly says.

The promise of seizure forecasts could transform clinical practice. Still, key questions, such as why multiday cycles of brain activity exist in people with epilepsy, remain unsolved. Scientists speculate that fluctuating hormones may play a role—or that they may have something to do with the underlying disruptions in the brain associated with epilepsy. It is also possible that multiday rhythms, like circadian rhythms, are one aspect of how every brain functions. "That's one very important question that has not been answered yet," Baud says.

—Diana Kwon

Take This Quiz to See If You Are a Face "Super-Recognizer"

Many with this skill have a feeling they are special. A freely available test helps them confirm their intuitions

Some people are truly exceptional at recognizing faces. Once they have seen a person, they can often remember the individual's face decades later. Even if the person spotted was a youngster at the time and has meanwhile become a grown woman or a man with a full beard, they can still make the ID.

Psychologists at Australia's University of New South Wales (UNSW) have been looking for these "super-recognizers" for years, using a specially designed online test.

On a typical face-recognition test, a super-recognizer will score 100 percent. But the UNSW group went a step further and created a particularly difficult test on which most test takers will score between 50 and 60 percent on which but a super-recognizer will reach 70 percent. The highest score ever was 97 percent, and no one has ever achieved a perfect score, the researchers reported in *PLOS One*. They estimate that they have identified about 2,000 super-recognizers among the 50,000 people who have taken the online test since 2017.

"What we have learned from analyzing this test is that while all super-recognizers are exceptional at face recognition, some are better than others," says James Dunn, a psychologist at UNSW and lead author of the study. "We hope that with more people completing the test we can find the 'Einstein of face recognition,' that special extraordinary individual who is the best of the best."

Other researchers in face recognition have also weighed in. "This is an excellent advance in the field of super-recognition research, and it provides a powerful new tool for the identification of individuals with superior face-identification ability," says David Robertson, a lecturer in psychology at the school of psychological sciences and health at the University of Strathclyde, Glasgow, who was not involved in the study.

"I have no doubt that this test will be very useful in identifying people

with extraordinary face perception abilities, which will prove useful not just for our understanding of human face-recognition ability but also for appointing people to face-specific roles within various professions (jobs that require identifying people)," says Kay Ritchie, a senior lecturer in cognitive psychology at the University of Lincoln in England, who also was not involved in the study.

In the study, Dunn and his colleagues describe people who have taken the UNSW test and who had an inkling they were better than others at facial recognition. The online test, which takes about 20 minutes to complete, then revealed whether that talent was really exceptional. For instance, one woman named Jessica knew she was better at recognizing faces than her husband. But it was only when the UNSW team contacted her that she found out how much better."Then a lot of things suddenly made sense in my life," she told the researchers.

DIMITRI OTIS GETTY IMAGES

Super-recognizers often learn to conceal their ability, the scientists write. A woman named Sallie told the team she has to pretend she has never seen a person she remembers well, for fear of giving the impression that she is a stalker.

The researchers hope to recruit super-recognizers to examine, among other things, how the brain processes faces. To do this, high-level test performers may be invited to the lab to undergo further testing to confirm that their results are really well above average.

These exceptional individuals appear to have an innate ability that cannot be achieved through training. An ascertained super-recognizer may be in demand from a range of institutions that have an interest in reidentifying people—from police to intelligence agencies to casinos.

—Jan Dönges

Electrical Brain Stimulation May Alleviate Obsessive-Compulsive Behaviors

Noninvasive electrical zaps, tuned specifically to individual brain-activity patterns, appear to reduce checking, hoarding and other compulsions for up to three months

Obsessive-compulsive disorder (OCD) is marked by repetitive, anxiety-inducing thoughts, urges and compulsions, such as excessive cleaning, counting and checking. These behaviors are also prevalent in the general population: one study in a large sample of U.S. adults found more than a quarter had experienced obsessions or compulsions at some point in their life. Although most of these individuals do not develop full-blown OCD, such symptoms can still interfere with daily life. A new study, published on January 18 in *Nature Medicine*, hints that these behaviors may be alleviated by stimulating the brain with an electric current—without the need to insert electrodes under the skull.

Robert Reinhart, a neuroscientist at Boston University, and his group drew on two parallel lines of research for this study. First, evidence suggests that obsessive-compulsive behaviors may arise as a result of overlearning habits—leading to their excessive repetition—and abnormalities in brain circuits involved in learning from rewards. Separately, studies point to the importance of high-frequency rhythms in the so-called high-beta/low-gamma range (also referred to as simply beta-gamma) in decision-making and learning from positive feedback.

Drawing on these prior observations, Shrey Grover, a doctoral student in Reinhart's lab, hypothesized with others in the team that manipulating beta-gamma rhythms in the orbitofrontal cortex (OFC)—a key region in the reward network located in the front of the brain—might disrupt the ability to repetitively pursue rewarding choices. In doing so, the researchers thought, the intervention could reduce obsessive-compulsive behaviors associated with maladaptive habits.

To test this hypothesis, Grover and his colleagues carried out a two-part study. The first segment was aimed at identifying whether the high-frequency brain activity influenced how well people were able to learn from rewards. The team recruited 60 volunteers and first used electroencephalography to pinpoint the unique frequencies of beta-gamma rhythms in the OFC that were active in a given individual while that person took part in a task that involved associating symbols with monetary wins or losses. Previous work had shown that applying stimulation based on the particular patterns of rhythms in a person's brain may enhance the effectiveness of the procedure.

The participants were then split into

Electrodes to administer noninvasive electrical brain stimulation—similar to the technique highlighted in this story—are placed on the head of a test subject before he performs a cognitive test at the Non-Invasive Brain Stimulation (NIBS) lab at the Air Force Research Laboratory at Wright-Patterson Air Force Base in Ohio on July 19, 2016.

J.M. EDDINS *ALAMY*

three groups, all of whom received a noninvasive form of brain stimulation known as transcranial alternating current stimulation (tACS), which was applied to the OFC for 30 minutes over five consecutive days. Each group had a different type of stimulation: One received personalized currents tuned to an individual's beta-gamma frequencies. Another was exposed to an "active" placebo, consisting of stimulations at a lower frequency. And the third was a "passive" placebo group in which no significant current was applied to the brain. Those who received the personalized beta-gamma stimulation became less able to make optimal choices on the reward-based learning tasks—changes not observed in the two placebo groups.

Further assessment of the participants' behavior using computational models of reward-based learning suggested that the personalized tACS disrupted the learning process by making people more likely to try out different options rather than sticking with only one—even if they were less likely to result in a reward.

These findings set the stage for the second part of the study, in which the team set out to examine whether manipulating the beta-gamma rhythms typically engaged during reward-based learning would influence obsessive-compulsive behaviors. The researchers carried out a similar set of experiments on another set of volunteers: 64 people who did not have a formal OCD diagnosis but who exhibited symptoms such as checking, hoarding and obsessing. Participants received either personalized beta-gamma stimulation or an active placebo. Those in the personalized beta-gamma group experienced a reduction in compulsive behaviors that persisted for up to three months. And those with more of those OCD characteristics prior to stimulation exhibited the biggest changes.

According to Grover, the team decided to study people with symptoms of OCD but no diagnosis of the disorder because researchers have increasingly been viewing obsessive-compulsive behaviors on a mild-to-severe spectrum. And even in the absence of clinically diagnosed OCD, such symptoms can cause significant distress. "By examining a nonclinical population exhibiting a range of obsessive-compulsive behaviors, we were able to examine the effectiveness of [an intervention] that may be helpful to a larger pool of individuals," Grover says. Yet the researchers' findings also suggest "that if we were to extend such an intervention to individuals diagnosed with OCD disorder or to other conditions of compulsivity—gambling disorder, addiction, some forms of eating disorders—we might be able to observe strong effects."

"[Neuromodulation] is certainly a treatment that should be investigated rigorously for conditions like OCD."

—Trevor Robbins

The long-lasting effects on obsessive-compulsive behaviors is "quite impressive," says Trevor Robbins, a professor of cognitive neuroscience at the University of Cambridge, who was not involved in this research. "[Neuromodulation] is certainly a treatment that should be investigated rigorously for conditions like OCD."

Carolyn Rodriguez, a psychiatrist and neuroscientist at Stanford University, who was also not involved in the study, says that because it was carried out in a nonclinical population without a formal diagnosis, the implications of these findings remain to be seen. "The neurobiology of people who are nonclinical but have these kinds of behaviors may be different than individuals who are diagnosed with OCD," she adds. "These findings are an interesting start, [but] we need to understand how it's relevant to people who have OCD." Rodriguez also points out that there are already several treatments available for the condition, including medication, therapy and a Food and Drug Administration–approved device that utilizes transcranial magnetic stimulation (TMS), a noninvasive method that uses magnetic fields to stimulate the brain. (Rodriguez is currently leading a clinical trial of TMS for OCD.)

The potential therapeutic effects of tACS on memory, food craving and

other neural processes have been tested in dozens of studies in the past. Questions have been raised about whether this method actually exerts any meaningful changes in the brain, however. In the new study, what exactly the high-frequency tACS did to the brain remains unknown. But Grover notes that the researchers' two placebo conditions—particularly the one that involves stimulating at a different frequency—provide strong evidence that the high-frequency stimulation was responsible for the behavioral effects the team observed.

Grover and his colleagues are currently working on further experiments to pinpoint the mechanisms underlying their intervention. And they hope to conduct studies with clinical populations diagnosed with OCD in the near future. "[The recent paper] is just a preliminary step toward further understanding why this high-frequency activity is so important for obsessive-compulsive behavior," Grover says. "The fact that we can observe changes in these symptoms even now suggests there may actually be clinical benefit to this—and gives us all the more reason to try to extend the findings of this research."

—*Diana Kwon*

For a Better Connection, Talk Instead of Typing

The phone is not as awkward as you think, and you may have a more satisfying interaction

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Throughout the COVID-19 pandemic, the term "social distancing" has been at the center of public conversation, but this phrase is a bit of a misnomer. Taken literally, the phrase seems to endorse social separation. But it's not "social" distance we are trying to promote. It's physical separation. In fact, preserving social ties—even at a distance—is essential for both mental and physical health. The results of epidemiological meta-analyses, for example, indicate that a lack of social support is on par with smoking cigarettes as a risk factor for morbidity and mortality and is even more harmful than other stressors, such as obesity and air pollution.

Given this empirical fact, how might we best stay connected to others while maintaining physical distance? Would we better off e-mailing a friend? Making a phone call? Setting up a video chat? Modern technology has provided us with many tools at our disposal. Not all tools foster social connection equally, however. And often such seemingly small choices can make a big difference between cultivating stronger social connections and giving in to growing social distance.

In a paper soon to be published in the *Journal of Experimental Psychology*: *General*, Nick Epley and I tested whether the media through which people interact affect their sense of connection—and how expectations about certain technologies impact the communication media they choose to use. Note that these expectations can be misguided. Although voice-based interactions (such as phone calls) can produce stronger connections, text-based media (such as e-mails) are often preferred because of mistaken beliefs about how social interactions will unfold. Any interaction we have

can come with advantages and disadvantages, and decisions about how to connect tend to be based on expectations of these potential costs and benefits. When people overestimate the cost or underestimate the benefit of voice-based communication, it can create a misplaced bias for text-based media.

In one experiment, for instance, we asked participants to reconnect with someone that they hadn't interacted with recently, either through e-mail or over the phone. Participants first made predictions about what it would be like to get in touch if they reached out in these two ways. More specifically, these participants predicted how connected and how awkward they would feel in each situation. In this experiment, they did generally intuit that they'd feel more connected when interacting via the phone than over e-mail. But they also predicted that talking on the phone could be more uncomfortable than dashing off an e-mail. Participants additionally indicated which option they preferred. Although these participants believed that talking encouraged stronger bonds, most of them said they'd rather send an e-mail than call the person up. Fears about awkwardness, it seems, push individuals toward text-based methods for communicating.

Our results showed that, contrary to participants' expectations, worries about awkwardness are largely unwarranted. In the next part of the experiment, we had participants actually reconnect using one randomly determined mode of communication—either e-mail or phone—and then followed up with them after they had done so. As expected, we found that people do form meaningfully stronger bonds when interacting over the phone than over e-mail. More mportant, though, there was no difference in the amount of discomfort when reconnecting on the phone. The human voice appears to provide benefits for connection without the expected costs.

In another experiment, we had individuals connect with each other by asking and answering a series of relatively personal questions (for example, "Is there something you've dreamed of doing for a long time? Why haven't you done it?"). These conversations took place by texting in real time during a live chat, using only audio or engaging in a video chat. Once again, participants first made predictions about how they believed they would feel and then actually had a discussion with someone else. We again measured awkwardness and connection, in this case using statements such as how much they would get to know their conversation partner, how much they would like that person, and how strong of a bond they would feel. Here participants didn't expect that the media through which they communicated would matter. But when they actually interacted, people again felt significantly more connected—and notably, no more awkward—when they communicated by talking rather than typing. Interestingly, visual cues didn't add more to what voice-based media already provided. Media containing only audio, as in a phone call, created as strong a sense of connection as audiovisual media, and both produced higher-quality social interactions than text-based media.

Although voice-based interactions (such as phone calls) can produce stronger connections, text-based media (such as e-mails) are often preferred because of mistaken beliefs about how social interactions will unfold.

Our work suggests that these miscalibrated expectations can affect how people choose to connect with others and therefore how well they do so. Misunderstanding the costs and benefits of different interactions can lead individuals to choose inferior methods for connecting, leading them to text, e-mail, or send a message on Slack instead of picking up the phone, which results in a more positive interaction. In light of this evidence, it is critical that we not only focus on the content we are trying to convey but also the context in which it is conveyed. The next time you think about how best to connect, consider calling or setting up a video chat. You're likely to feel better as a result. E-mail or text messaging can sometimes be useful for sending attachments or scheduling a time to talk, to be sure. Feelings of social connection, however, are optimally facilitated by one's voice rather than their keyboard.

—Amit Kuma

How We Can Deal with "Pandemic Fatigue"

The first step is to understand that it's not just about exhaustion or tiredness—or depleting a mental resource

By David Badre

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David Badre is a neuroscientist at Brown University and author of *On Task: How Our Brain Gets Things Done*.

The U.S. is tragically nearing 500,000 COVID-19 deaths, and case numbers and hospitalizations are still at record levels around the world. With vaccines now rolling out, there is reason to hope that there is an end in sight. By most estimates, however, widespread vaccinations will not be in place until the middle of the year at the earliest. So we have some ways to go yet with social distancing, mask wearing and other pandemic mitigation behaviors.

It is worrying, therefore, that the world is witnessing a consistent decline in compliance with these mitigation behaviors over time. For example, a Gallup poll from last fall that tracked social distancing habits among Americans found that the percentage of respondents avoiding small gatherings declined by 40 points since the previous April, while those avoiding public places declined by 25 points. Public health experts term this phenomenon "pandemic fatigue," and they cite it as a contributor to the increase in incidence rates being witnessed here and in Europe.

Understanding pandemic fatigue is challenging because it is not one phenomenon and likely stems from several causes. Some of these include political and social trends, such as changes in libertarian attitudes or diminishing trust in scientific authorities. But pandemic fatigue also occurs for people who are ostensibly onboard with societal attempts to control spread of the virus. So why would compliance with public health advice decline in these people? Despite its name, pandemic fatigue in these cases is not really about exhaustion or tiredness or depleting a mental resource. Rather pandemic fatigue should be understood in terms of motivation for the tasks we choose to do. As such, lessons from the psychology and neuroscience of cognitive control may be informative.

Humans have a remarkable capacity to conceive of a task they have never done before and plan and execute the actions needed to do it. For example, most of us probably didn't have a routine of wearing a mask around other people before last year. But once we understood that it stemmed the spread of COVID-19, many of us started doing so. It didn't take hundreds of trials of training to learn this behavior or, indeed, thousands of years of evolution. Rather we incorporated mask wearing into our daily lives almost immediately. Humans can link our abstract goals, ideas, rules and knowledge to our behavior at a speed and on a scale that no other species can match and no AI yet built can emulate. We can do this because of a class of function scientists term "cognitive control," a function that is supported by several interacting systems and mechanisms that are uniquely elaborated in the human brain, including the prefrontal cortex.

More important, cognitive control is motivated. When deciding to do a task, our control system balances at least two factors: the value we get from doing that task and the costs we will experience while doing so. The former is obvious. Experimental studies on people's choices about what tasks they would like to do tell us that they prefer and engage more with tasks that lead to desired outcomes, whether that outcome is money, good health, companionship or whatever else they value. Yet our control system also takes account of our mental efficacy when computing this value, as in how much mental investment is needed to gain from a particular task.

Thus, people won't do just any amount of mental work for any outcome. Difficult tasks, and particularly tasks involving heavy mental investment, come with an aversive experience of mental effort. People treat that mental effort as a cost that discounts whatever value might be gained from a task. The reasons for these effort costs are still open, but one promising explanation is that they derive from opportunity costs. We can't do more than one difficult task at a time. So we penalize difficult tasks because they limit our ability to gain value by performing other tasks. Thus, when we decide to perform a task, our

brain does a cost-benefit analysis: weighing our gains against our mental pains.

Life during the pandemic is brimming with tasks requiring control and mental effort, and so the widespread subjective experience of mental exhaustion is not surprising. We are constantly adjusting to new rules and policies. Everything from working to getting groceries to holiday shopping is different from what we know, involves new rules and protocols, and so requires cognitive control to plan out novel behaviors and monitor what we're doing every step of the way. And for many of us, we are faced with ongoing costs of multitasking, dividing attention between work, children and other priorities all at once. To succeed in this environment requires heavy engagement of our control systems, and so we experience the cost of this mental effort. Changes in either the perceived value or efficacy of these behaviors will make those effort costs harder to tolerate over the long term, and compliance will decline.

What can be done? It follows from this analysis that addressing pandemic fatigue requires a robust and multipronged response that tackles not only the political and social aspects but also motivation in terms of costs and benefits of mitigation behaviors. One target is the opportunity cost. While we are social distancing or sheltering in place or homeschooling our children, we are not doing other valuable things. Many people are unable to work remotely, businesses are slowed or closed, and we are separated from loved ones. Thus, left on its own, the value in complying over time, discounted by its mental effort, is increasingly outweighed by the value in not doing so.

This is one reason that economic relief from a larger individual stimulus relief package is needed—not only because it provides economic relief but also because it addresses this opportunity cost of compliance.

Second, as noted earlier, our willingness to invest mental effort in a task is dependent on our belief about the efficacy of doing so. The more difficult the task, the more likely a positive outcome needs to be. Misinformation is rampant, and we have lacked consistent guidance from federal leadership about what effective actions to take, from sanitization protocols to how to open schools safely. We need a clear set of guidelines that we know to be effective from an expert source, such as the CDC, in order to balance against our experienced effort costs.

Relatedly, once an effective set of rules is in place, we need those rules to be as stable as possible. Planning and adjusting to ever changing policies and procedures for basic living can place near-constant demands on our control system to manage every task as new. In contrast, keeping the situation stable allows us reduce effort costs by integrating a consistent set of behaviors into our daily habits and routines.

Finally, living and working all together in the same place, such as our homes, results in a state of immersive multitasking. We do not have separate environments for work tasks and home tasks, and so they interfere with one another, which puts demands on our control system that we experience as effort. And multitasking costs are particularly severe for parents with young children. So measures that help reduce this burden, such as safe procedures for opening schools and places of work, will greatly help reduce these mental costs.

One fundamental facet of pandemic fatigue is motivational in nature and is related to the demands that life during a pandemic places on our systems for cognitive control and the mental effort costs this incurs. As we have described, measures that help reduce the costs of mental effort may help stem its downward pull. **M**

The Science of Spiritual Narcissism

Self-enhancement through spiritual practices can fool some of us into thinking we're evolving and growing when all we're growing is our ego

By Scott Barry Kaufman

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Scott Barry Kaufman is a humanistic psychologist exploring the depths of human potential. He has taught courses on intelligence, creativity and well-being at Columbia University, New York University, the University of Pennsylvania, and elsewhere. He hosts The Psychology Podcast and is author and/or editor of nine books, including *Transcend: The New Science of Self-Actualization, Wired to Create: Unravelling the Mysteries of the Creative Mind* (with Carolyn Gregoire), and *Ungifted: Intelligence Redefined*.

"Ego is able to convert anything to its own use, even spirituality."
—Chögyam Trungpa

A purported benefit of mind-body spiritual practices such as yoga, meditation and energy healing is that they will help "quiet the ego," providing an effective antidote to the exalted self. Indeed, such practices do have the potential for such an awakening, allowing us to get more in touch with reality as it is right here and now, including the qualities we don't like about ourselves. Spiritual practices also have the potential to help us cultivate compassion, concern and unconditional positive regard toward others—things that can truly evolve our consciousness as a species.

This is all much easier said than done, however. As has been observed by many spiritual leaders, spiritual practitioners and psychologists over the years, the ego has an incessant need to be seen in a positive light and will eagerly hijack whatever flow of consciousness it can use for its own enhancement. As Indian philosopher Sri Aurobindo noted: "At every moment [the seeker] must proceed with a vigilant eye upon the deceits of the ego and the ambushes of the misleading Powers of Darkness who ever represent themselves as the one source of Light and Truth and take on them a simulacrum of divine forms in order to capture the soul of the seeker."

Likewise, in his classic book *Cutting Through Spiritual Materialism,* Tibetan Buddhist spiritual leader Chögyam Trungpa wrote: "Walking the spiritual path properly is a very subtle process: it is not something to jump into naively. There are numerous sidetracks which lead to a distorted, ego-centered version of spirituality; we can deceive ourselves into thinking we are developing spirituality when instead we are strengthening our egocentricity through spiritual techniques."

Psychologists have also pointed out the potential for spirituality to serve as a tool of self-enhancement. According to William James, the "father of American psychology," any skill that increases its centrality in the self-system is likely to breed a bias toward self-enhancement. As it turns out, no domain of human skill has been found to be exempt from this "self-centrality principle." It seems to be an inextricable part of human nature.

This includes the domain of spirituality. Self-enhancement through spiritual practices can fool us into thinking we are evolving and growing, when in fact all we are growing is our ego. Some psychologists have pointed out that the self-enhancement that occurs through spiritual practices can lead to the "I'm enlightened and you're not" syndrome and spiritual bypass, by which people seek to use their spiritual beliefs, practices and experiences to avoid genuine contact with their psychological "unfinished business." In my recent book *Transcend,* I call it "pseudo-transcendence"—transcendence built on a very shaky foundation.

Just how much of a problem is all this, really? Perhaps on the whole, spiritual practices really do help quiet the ego, and spiritual narcissism isn't that widespread. What do the empirical data actually have to say on one of the greatest paradoxes of our time, which is: If a major point of yoga is quieting the ego and reducing focus on self, why are there so many yoga pose pictures on Instagram?

SELF-CENTRALITY AND SPIRITUALITY

In the past few years a number of high-quality studies have started to unearth the existence of spiritual narcissism and self-enhancement among spiritual practices that purport to quiet the ego. In one set of high-powered studies, Jochen Gebauer and his colleagues looked at both yoga and meditation practices.

In their first experiment, they followed 93 yoga students for up to 15 weeks. They repeatedly assessed self-enhancement levels among people directly after participating in yoga and among people who had not practiced yoga within the past 24 hours. Self-centrality was measured by items such as "Focusing mindfully on the exercises across the whole yoga class is...," measured on a scale of 1 (not at all central to me) to 5 (central to me).

They measured self-enhancement through a standard measure of self-esteem, as well as by asking people the degree to which they perceived themselves as better than the average yoga student in their yoga class. They also

included a measure of "communal narcissism," an often underdiscussed form of narcissism in which one thinks that they alone will save the world and that they are the most helpful person of them all (for example, "I will be well known for the good deeds I will have done"). Research shows that communal narcissism is correlated with grandiose narcissism and all of the entitlement, arrogance and overconfidence that goes along with it (just applied to a helping domain).

The researchers found higher levels of self-centrality as well as self-enhancement (higher self-esteem, better than average judgments, and communal narcissism) among those who had just completed a yoga class compared with those who hadn't engaged in any yoga class in the past 24 hours. They also found suggestive evidence that the augmented self-enhancement of the yoga practice played a key role in the well-being benefits of yoga through increases in self-esteem. This finding hinted at the idea that the well-being benefits of this spiritual practice may actually come through boosting self-esteem and not through ego quieting.

In their second experiment, they followed 162 meditation practitioners for up to four weeks. They repeatedly assessed meditation's self-centrality and self-enhancement directly after meditation and in the absence of prior meditation. This time, they directly measured well-being, including a comprehensive battery of measures of hedonic well-being (happiness and high life satisfaction) as well as eudaemonic well-being (higher levels of autonomy, environmental mastery, personal growth, positive relations with others, purpose in life and self-acceptance).

Their self-centrality questions included items such as "How central is it for you to be free from envy?" And their self-enhancement scale included items such as "In comparison to the average participant of this study, I am free from envy." Again, they included a measure of communal narcissism.

The researchers found that after meditation, self-centrality in meditation-relevant domains was exacerbated, not diminished, and self-enhancement in meditation-relevant domains was augmented, not curtailed. Additionally, increased levels of self-enhancement explained the effect of meditation on higher well-being (both hedonic and eudaemonic).

It's important to point out that they sampled Western participants, and the yoga and meditation programs the participants engaged in—which included engagement in hatha yoga and loving-kindness meditation—don't necessarily generalize to all yoga and meditation practices. Nevertheless, the researchers did find greater self-enhancement in the yoga and meditation conditions even among very advanced mind-body practitioners. These findings suggest that contrary to the purported benefits of mind-body practices as "quieting the ego" and reducing focus on self, they may actually boost self-centrality and self-enhancement. Furthermore, and intriguingly, it seems as though it is precisely those self-related boosts that contributed to the well-being benefits of the spiritual practices.

SPIRITUAL SUPERIORITY AND SPIRITUAL PRACTICES

In a more recent set of studies, Roos Vonk and Anouk Visser conducted an exploration of "spiritual superiority." They interviewed several psychologists, spiritual trainers and laypeople and asked them to describe people who use spirituality as a self-enhancement tool. They then translated these qualities to six items:

- I am aware of things that others are not aware of.
- I am more in touch with my senses than most others.
- I am more aware of what is between heaven and earth than most people.
- Because of my education and experience, I am observant and see things that others overlook.
- Because of my background and experiences, I am more in touch with my body than other people.
- The world would be a better place if others, too, had the insights that I have now.

In three studies, they assessed the relation between their scale of spiritual superiority and other variables. In study 1, they focused on people who engaged in some form of spiritual training. Participants were recruited via mindfulness schools and energetic training centers, which aim to train skills that classify as paranormal, such as reading auras and regressing to previous lives. In studies 2 and 3, participants were recruited via a popular psychology magazine with a broad audience interested in psychological and spiritual development. The comparison was with people without any spiritual training.

Overall, the researchers found that the correlation of spiritual superiority with self-esteem was lower among the no-training group than those participating in any of the spiritual training groups. Their measure of spiritual superiority was related to "spiritual contingency of self-worth," the degree to which people derive higher self-esteem from their spiritual practices (for example, "I feel better about myself when I notice I develop myself spiritually"). According to the researchers, this illustrates that the self-enhancement function of spirituality is similar to other contingency domains of self-esteem.

Interestingly, their scale of spiritual superiority was more strongly correlated with communal narcissism than self-esteem, providing evidence for the notion of "spiritual narcissism." Indeed, it's important to distinguish between healthy self-esteem and narcissism. The problem isn't with self-esteem but with the pursuit of self-esteem. Healthy self-esteem—consisting of a positive evaluation of one's self-worth and mastery—emerges naturally and organically through the engagement of authentic mastery and positive relationships rather than by pur-

suing self-esteem as the goal. Increases in healthy self-esteem as a result of spiritual practices may be a good thing and are not necessarily indicative of spiritual narcissism, which is why it's good that the researchers were able to tie their measure of spiritual superiority to a specific form of narcissism: communal narcissism.

The researchers found differences depending on the form of spiritual practice, however. Spiritual superiority scores were consistently higher among those who came from energetic-training centers than the mindfulness trainees. In fact, those who underwent energy training were more likely to claim special knowledge of mindfulness, more so than those who were actually in the mindfulness condition! The energetic healers were also especially likely to score high in "supernatural overconfidence," scoring high in items such as "When I randomly open a book on a page number that is meaningful to me, this is no coincidence," "I can send positive energy to others from a distance" and "I can influence the world around me with my thoughts."

While their study is correlational, it's likely that there is a bidirectional relation among these factors. It's likely that spiritual practices can be used as a tool to bolster the narcissistic self, enhancing one's feeling that one is special and entitled to special privileges. But it's also likely that some spiritual training programs attract people with strong personal development goals that are related to Western narcissistic culture. As the researchers noted, the idea of exploring one's own personal thoughts and feelings and becoming an "enlightened being" may be particularly attractive to people with high levels of both overt and covert narcissism.

Taken together, the researchers concluded: "Our results illustrate that the self-enhancement motive is powerful and deeply ingrained so that it can hijack methods intended to transcend the ego and instead adopt them to its own service.... The road to spiritual enlightenment may yield the exact same mundane distortions that are all too familiar in social psychology, such as self-enhancement, illusory superiority, closed-mindedness, and hedonism (clinging to positive experiences) under the guise of alleged 'higher' values."

HEALTHY TRANSCENDENCE

Is there any way around the allure of spiritual narcissism? It's all well and good that gurus espouse the importance of quieting the ego (often while driving in their Rolls-Royces), but in practice can we ever really override the universal self-centrality principle and transcend spiritual narcissism?

I think we can, but I believe the first step is simply being aware that it's incredibly difficult to do so. One serious obstacle to healthy transcendence, as I see it, is how spiritual practices are "sold" to the masses. Yoga and mindfulness are big businesses in America. The purported benefits of mindfulness meditation have generated a billion-dollar industry (see here, here and here). Yoga is the most popular mind-body practice in Western societies. Many of these programs offer a long list of promises, including the reduction of stress and anxiety, along with greater confidence, creativity, focus, achievement, success, eating habits, sleep and even happiness.

Here's the thing: Healthy transcendence doesn't stem from an attempt at distracting oneself from displeasure with reality. Healthy transcendence involves confronting reality as it truly is, head on, with equanimity and loving kindness. As I put it in *Transcend,* healthy transcendence "is not about leaving any parts of ourselves or anyone else behind or singularly rising above the rest of humanity. Healthy transcendence is not about being outside of the whole, or feeling superior to the whole, but being a harmonious part of the whole of human existence.... Healthy transcendence involves harnessing all that you are in the service of realizing the best version of yourself so you can help raise the bar for the whole of humanity."

This involves seeing reality as clearly as possible. As noted by Nancy Colier, author of *The Power of Off: The Mindful Way to Stay Sane in a Virtual World*, the point of mindfulness "is to be able to see what is happening inside ourselves, without ownership, judgment or action. And simultaneously, to lose our great belief in and reverence for the productions of our mind.... The dangerous habit is this: The mindful witness itself is becoming yet another form of ego, a new identity, a new somebody that we wear with pride."

Don't get me wrong: I genuinely enjoy looking at all the varied and intricate yoga poses on Instagram. But from my reading of the yoga literature, it doesn't seem as though the theoretical intent of yoga is primarily for physically attractive people to display with pride their ability to twist themselves into a pretzel. Rather it seems that the most growth-oriented benefits of mind-body spiritual practices occur when we aren't using them as a tool for satisfying any of our basic needs—such as our needs for security, belonging and self-esteem. Instead such practices seem to lead to greater maturity, wisdom, compassion, acceptance and unconditional positive regard toward others when we repeatedly attempt to cultivate the ability to be witness to our mind and behaviors so that we can catch when our crafty ego has hijacked the system in a way that is detrimental to our own self-actualization and self-transcendence.

Which has me thinking: Perhaps it is time for all of these yoga and mindfulness centers to chill on all of the extrinsic purported benefits they are claiming ("Better health!" "Better sex!" "Amazing concentration!" "Great success at work!"). Instead focus on the benefits of such spiritual practices for allowing us to realize that these concerns of the ego are just the ego doing its thing. That awareness, in and of itself, is enough of a benefit to last an enlightened lifetime. **M**

The Link between Delirium and Dementia

Delirium is very common on COVID wards. Researchers are testing whether these temporary bouts of confusion could bring on permanent cognitive decline

By Carrie Arnold

FATINHA RAMOS

Carrie Arnold is an independent public health reporter based in Virginia.

In her job as a physician at the Boston Medical Center, Sondra Crosby treated some of the first people in her region to get COVID-19. So when she began feeling sick last April, Crosby wasn't surprised to learn that she, too, had been infected. At first, her symptoms felt like those of a bad cold, but by the next day she was too sick to get out of bed. She struggled to eat and depended on her husband to bring her sports drinks and fever-reducing medicine. Then she lost track of time completely.

For five days, Crosby lay in a confused haze, unable to remember the simplest things, such as how to turn on her phone or what her address was. She began hallucinating, seeing lizards on her walls and smelling a repugnant reptilian odor. Only later did Crosby realize that she had had delirium, the formal medical term for her abrupt, severe disorientation.

"I didn't really start processing it until later when I started to come out of it," she says. "I didn't have the presence of mind to think that I was anything more than just sick and dehydrated."

Physicians treating people hospitalized with COVID-19 report that a large number experience delirium and that the condition disproportionately affects older adults. An April 2020 study in Strasbourg, France, found that 65 percent of people who were severely ill with coronavirus had acute confusion—a symptom of delirium. Data presented last November at the annual meeting of the American College of Chest Physicians by scientists at the Vanderbilt University Medical Center showed that 55 percent of the 2,000 people they tracked who were treated for COVID-19 in intensive care units (ICUs) around the world had developed delirium. These numbers are much higher than doctors are used to: usually about one third of people who are critically ill develop delirium, according to a 2015 meta-analysis.

Delirium is so common in COVID-19 that some researchers have proposed making it one of the disease's diagnostic criteria. The pandemic has sparked physicians' interest in the condition, says Sharon Inouye, a geriatrician at the Marcus Institute for Aging and Harvard Medical School, who has studied delirium for over 30 years.

As clinicians face the immediate realities of confusion and agitation on their wards, Inouye and other researchers are concerned about the future. In the past decade long-term studies have revealed that a single episode of delirium can increase the risk of developing dementia years later and accelerate rates of cognitive decline in those who already have the condition. The reverse is also true: having dementia makes someone more likely to develop delirium. A set of simple steps, such as ensuring a family member is present to help people orient themselves, can reduce the incidence of delirium by 40 percent, but doctors struggle to follow that advice on COVID-19 wards.

But the links between delirium and dementia have been difficult to untangle: researchers need to follow patients for years to get results. The surge in people with delirium produced by the pandemic has focused attention on the condition and provided scientists with a unique opportunity to follow patients and determine if and how delirium might affect long-term cognition. Researchers have launched several studies to explore the long-term neurocognitive impacts of COVID-19, including dementia, and Inouye and others hope that this work will allow them to explore the links between the two conditions in real time.

If the pandemic can be said to have a silver lining, Inouye says, it has been to spur interest in how delirium can lead to dementia—and vice versa. What's more, says Catherine Price, a neuropsychologist at the University of Florida, the spread of COVID-19 "has highlighted the

blurring of the lines between delirium and dementia, especially with more older adults in our populace."

NEGLECTED CONDITION

Inouye's interest in delirium began when she landed her first job as an internal-medicine physician at a Veterans Administration hospital in Connecticut in 1985. In her first month there, she treated more than 40 people for a variety of conditions. Six of them developed delirium during their stay; none seemed to return to their previous level of physical and mental health. To Inouye, the connection between her patients' delirium and their poor prognosis was obvious. When she confessed her suspicions to her bosses, however, they just shrugged. Their attitude, Inouye says, was that delirium was just one of those things that happened.

"Why is it okay for older adults to come in the hospital and lose their minds?" Inouye asked. Answering this question, she says, would be "an uphill battle my entire career."

Shortly after, she began a two-year fellowship to study the condition in depth. Her work showed that delirium occurs when several stressors converge. Preexisting vulnerabilities such as chronic disease or cognitive impairment can combine with precipitating factors, including surgery, anesthesia or overwhelming infection to cause a sudden onset of confusion, disorientation and attention difficulties, especially in older adults.

"Delirium easily occurs when the brain is unable to compensate for a stressful situation," explains Tino Emanuele Poloni, a neurologist at the Golgi Cenci Foundation outside Milan, Italy. Researchers think that the underlying biological causes are inflammation and an imbalance in neurotransmitters—chemical messengers such as dopamine and acetylcholine.

Inouye's mounting clinical experience has taught her that regardless of what precipitates delirium, around 70 percent of those with symptoms eventually recover completely. In the 30 percent who don't, however, an episode of delirium predicts a downward spiral over a period of months that leads to profound cognitive impairment, even to symptoms of dementia.

More formal studies have reinforced the link, to varying degrees. Inouye investigated a group of 560 people aged 70 or older who had undergone surgery and saw that cognitive decline over the subsequent 36 months was three times faster in those who developed delirium than in those who did not have the condition. A 2020 meta-analysis of 23 studies showed that delirium during a hospital stay was associated with 2.3 times greater odds of developing dementia. And work by a team of Brazilian scientists showed that in a group of 309 people with an average age of 78 years, 32 percent of those who developed delirium in hospital progressed to having dementia, compared with just 16 percent of those who did not become delirious.

What's more, the longer a person is delirious, the greater their risk of subsequent cognitive impairment, according to a 2013 study by psychologist James Jackson at Vanderbilt University and his colleagues. Work by Inouye, Jackson and other researchers found that the reverse was also true: even after controlling for age, existing dementia symptoms increased the chances of developing delirium.

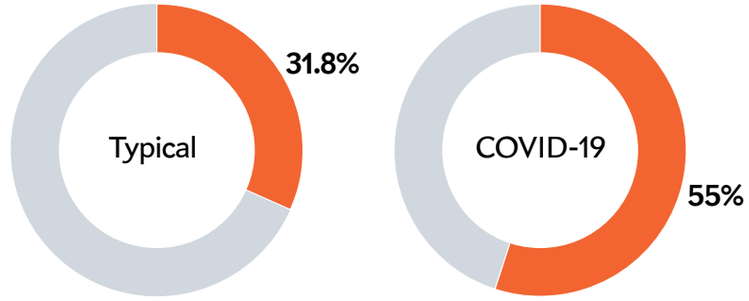
CAUSING CONFUSION

Scientists still don't agree whether the link between delirium and dementia is strong only in those who would have developed dementia anyway or whether delirium increases the risk of cognitive decline even in individuals who are not predisposed to it. Nor can they say precisely what it is about delirium that could provoke dementia. If researchers could identify these connections, then perhaps they could prevent delirium from escalating into dementia.

"We don't understand the mechanisms of delirium at

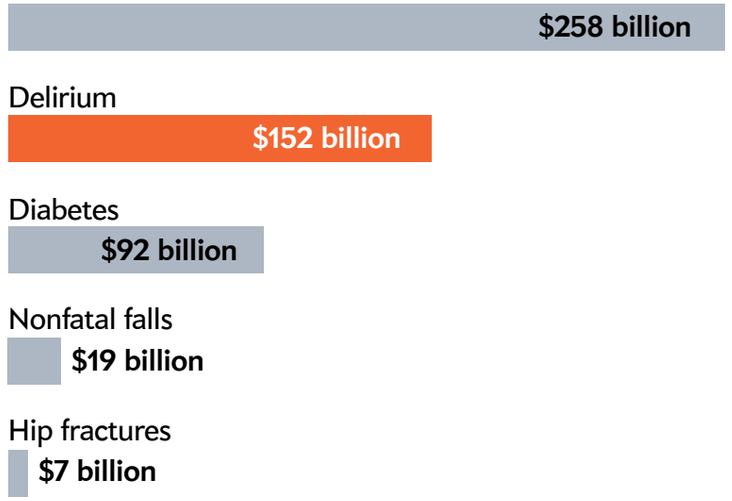
How Common Is Delirium?

Typically, almost one third of people who are critically ill will have an episode of delirium; for COVID-19, the proportion rises to more than half.



THE COST OF DELIRIUM

In the U.S., the annual health-care costs for delirium are higher than those for many other conditions common in older adults.



DELIRIUM AND COGNITIVE DECLINE

People who experience delirium during hospitalization are at increased risk of cognitive decline after discharge, according to a study of 309 patients n Brazil.

"COULD COVID DELIRIUM BRING ON DEMENTIA?" BY CARRIE ARNOLD, IN *NATURE*, VOL. 588; DECEMBER 2, 2020

all—we really don't. And there is no successful management of delirium from a pharmaceutical standpoint," Price says.

Scientists have developed three hypotheses to explain how delirium might provoke dementia. One line of thinking holds that an accumulation of toxic cellular trash in the brain could cause short-term delirium and lead to longer-term damage. The body usually clears this molecular rubbish by way of the bloodstream and the glymphatic system, which is a network of channels filled with cerebrospinal fluid. Damage to vessels from an acute episode of delirium could persist and trigger dementia, or a brain that experiences delirium could become more prone to vascular problems in future.

The second suspect is inflammation, which often troubles people who are hospitalized for infections, respiratory distress or cardiovascular disease. Surgery and severe infections can cause a build-up of cellular detritus in the brain, which triggers more inflammation. This short-term, all-hands-on-deck reaction safeguards the brain because it clears the harmful debris, and the inflammation ultimately dies down. That is not the case for those who develop delirium, Inouye says. Persistent inflammation can trigger an acute episode of delirium and cause neurons and associated cells, such as astrocytes and microglia, to deteriorate, leading to cognitive damage.

The third idea is what is known as the threshold hypothesis. Someone with dementia (even in the earliest stages) has fewer connections between neurons and can show damage to the insulation that wraps them and helps convey signals—known as white matter. This loss strips the neurological reserves that help the person to cope with inflammation or infection, throwing them over the edge not just into delirium but into a more advanced dementia.

Even though the genesis of delirium and its molecular connections to dementia remain unknown, Inouye has

Visits from relatives are a source of comfort for people with delirium, a common symptom of COVID-19, but many hospitals have strict no-visitor policies.

MORTEZA NIKOUBAZ *GETTY IMAGES*

managed to find a way to cut rates of delirium in hospital. She created a program of simple strategies known as HELP (Hospital Elder Life Program), which focus on reducing sedation, even during mechanical ventilation, paying close attention to nutrition and hydration, and ensuring the presence of family members to help reassure and orient patients. A 2015 meta-analysis showed that these steps reduced delirium by around 40 percent. Hospitals around the U.S. began instituting these simple protocols. Then COVID-19 struck and made this all but impossible.

DEMENTIA SURGE

As Crosby endured coronavirus-induced delirium in her Boston bedroom, Poloni was treating delirious people with COVID-19 in Lombardy—Italy's ground zero for the

coronavirus. Many of Poloni's patients already had dementia, and like many physicians, he was watching for common symptoms of respiratory infections such as fever, cough and difficulty breathing. But some of his patients did not show those signs at all. Instead they mostly became "dull and sleepy," Poloni said. Others became restless and agitated—all signs of delirium. It was so prominent that Poloni argued that delirium should be added to the virus's diagnostic criteria. Inouye has made that argument, too, and it is supported by a study she published last November showing that 28 percent of older adults with COVID-19 are experiencing delirium when they present to the emergency department.

> **"Is there going to be an increase in dementia from people who had COVID-19 during adulthood or midlife?"**
>
> ***—Natalie Tronson***

The high numbers of people who developed delirium immediately made Inouye, Price and other researchers worry that the pandemic could lead to a surge in dementia cases in the coming decades, on top of the increase in cases as a result of aging populations. "Is there going to be an increase in dementia from people who had COVID-19 during adulthood or midlife?" asks Natalie Tronson, a neuropsychologist at the University of Michigan. "What happens over the next decades, as the population ages more?"

To begin to find answers, institutes around the world have funded a variety of studies into the long-term cognitive effects of COVID-19, some of which will look at delirium. Already underway in the U.S. is a study tracking people who have been treated in the hospital for COVID-19, many of whom developed delirium during their stay. This study will measure cognitive and psychiatric function in people participating in a trial to assess the safety and efficacy of hydroxychloroquine to treat coronavirus. An international study is planned to measure the prevalence of delirium in people with COVID-19 in ICUs, as well as identifying factors that predict long-term outcomes. A separate study in Germany and the U.K. is also tracking neurocognitive outcomes in people infected with COVID-19 to determine how delirium affects brain function months later. Another research project led by a team at Vanderbilt University is looking for an alternative to commonly used sedatives such as benzodiazepines, which are known to increase delirium. The researchers are testing a sedative called dexmedetomidine to see whether it is a safer option for people hospitalized with COVID-19.

Inouye and Tronson hope that the funding of these long-term studies will lead to ongoing scientific interest in the delirium-dementia connection and that they provide some insight.

"It's going to be, I think, a little bit frightening and a little bit enlightening, both about how illness affects dementia risk but also about what other lifestyle and genetic protective factors can influence risk as well," Tronson says. "We're learning quickly, but there's still a lot of black boxes." **M**

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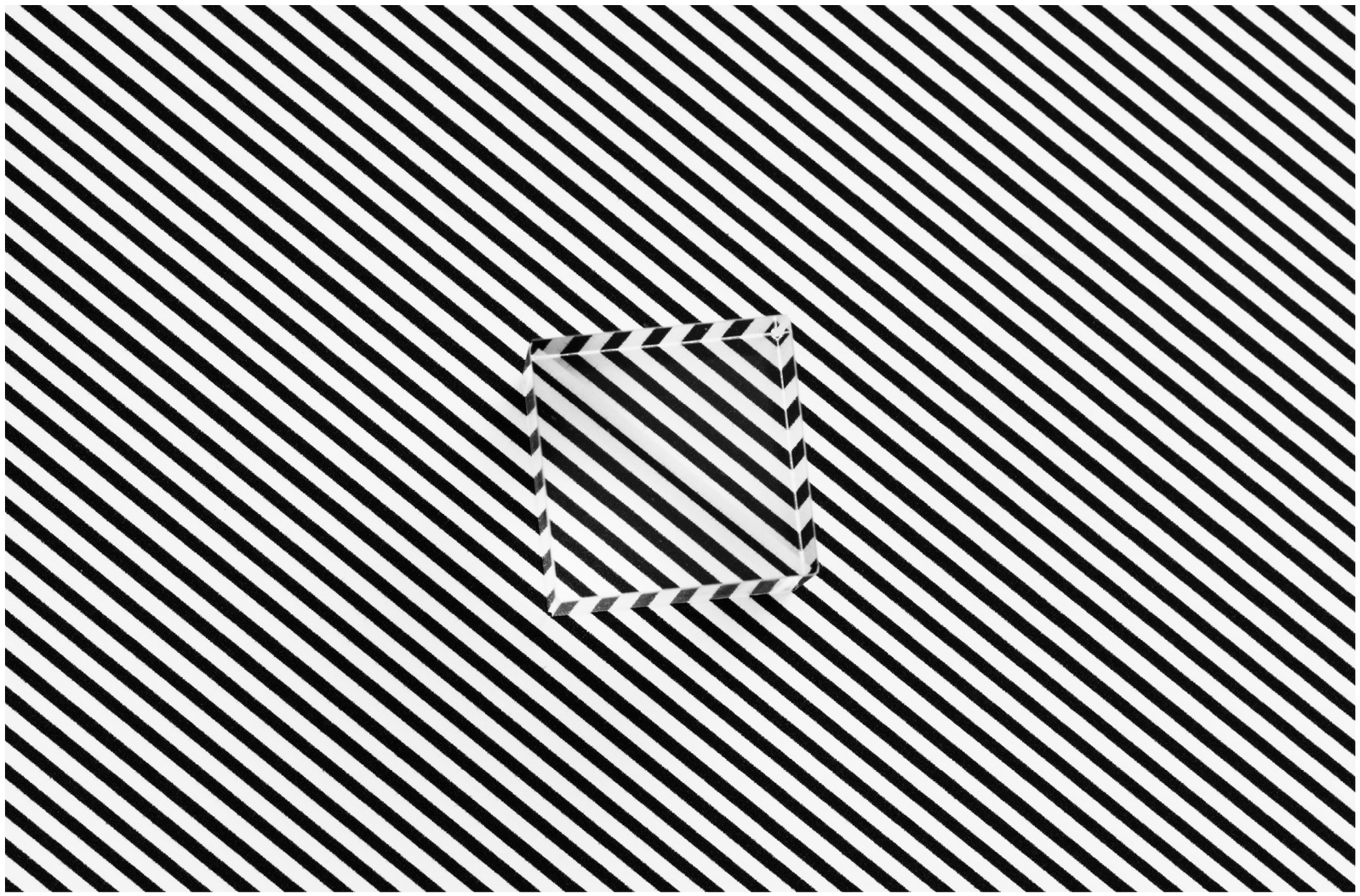
PHYSICS

The Mind-Expanding Power of Complementarity

Embracing divergent perspectives at the same time is a key to understanding reality



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In his *Pensees* ("Thoughts"), Blaise Pascal wrote: "By space the universe encompasses and swallows me up like an atom." In *Leaves of Grass,* Walt Whitman wrote: "I contain multitudes." On the surface, Pascal and Whitman seem to be saying very different things. Pascal says we are small; Whitman says we are large.

Yet both are profoundly correct. Science not only supports but amplifies their famous declarations. Modern cosmology has revealed a universe vastly larger than Pascal could have conceived in 1660. And today we can appreciate the true complexity of Whitman's brain, which incorporates tens of billions of vibrant, interconnected neurons, more clearly than Whitman himself could in 1855.

Complementarity is the realization that a single thing, when considered from different perspectives, can appear to have different, or even contradictory, properties. Complementarity alerts us that answering different kinds of questions can require radically different approaches.

My goal in writing *Fundamentals: Ten Keys to Reality* was to unlock the treasure of what everyone can know about the physical world. That treasure is not an attic crammed with dusty facts—though it contains many surprising facts—but a broad vista, including our best current understanding, the reasons why we trust it, its limits, its meaning—and some guesses about its future.

As a discipline to myself, and to make things easily digestible and memorable for my readers, I decided to follow a long tradition, inspired by the Ten Commandments and the 10-fold lists you find in many modern self-help books, by organizing

the presentation around 10 powerful statements: the "Keys to Reality" promised in the subtitle.

My first key to reality, "There's Plenty of Space," goes deep into the issues raised by Pascal and Whitman, mentioned earlier. That was an obvious starting point. Later choices were not always so obvious, but I settled on a list of nine fairly easily. I hoped that thinking and writing about those nine would suggest another.

And that is what happened. My 10th key to reality, which emerges from but in some ways transcends science, turned out to be "Complementarity Is Mind-Expanding." Complementarity is an attitude toward life that I've found eye-opening and extremely helpful. It has, literally, changed my mind. Through it, I've become larger: more open to imagination and more tolerant.

Let me give two important examples of complementarity in action. The first is the complementarity between analysis and synthesis or, in popular jargon, "reductionism" and "holism."

There is immense satisfaction to be had in describing the world in terms of its most elementary building blocks. It is tempting to say that this is the ideal description, while other, high-level descriptions are mere approximations—compromises that reflect weakness in understanding. That attitude, which makes the perfect the enemy of the good, is superficially deep but deeply superficial.

To answer questions of interest, we often need to change focus. To discover (or invent) new concepts and new ways of working with them is an open-ended, creative activity. Computer scientists and software engineers are well aware that in designing useful algorithms it is important to pay attention to how knowledge is represented. A good representation can make the difference between usable knowledge and knowledge that is there "in principle" but not really available, because it takes too long, and too much trouble, to locate and process. It's like the difference between owning bars of gold and knowing in principle there are vast stores of gold atoms floating dissolved in the ocean.

For that reason, complete understanding of the fundamental laws, if we ever achieved it, would be neither "The Theory of Everything" nor "The End of Science." To do decent justice to reality, we would still need new ideas and complementary descriptions. There would still be plenty of great questions left unanswered and plenty of great scientific work left to do. There always will be.

The complementarity between humility and self-respect is, I believe, the central message of *Fundamentals* as a whole. It recurs as a theme in many variations. The vastness of space dwarfs us, but we contain multitudes of neurons and of course vastly more of the atoms of which neurons are made. The vastness of cosmic history far exceeds a human lifetime, but we have time for immense numbers of thoughts. Cosmic energies outstrip what any human, or even humanity as a whole, commands, but we have ample power to sculpt our local environment and participate actively in life, love and adventures among other humans. The world is complex beyond our ability to grasp and rich in mysteries, but we know a lot and are learning more. In each case, humility is in order, but so is self-respect.

The word "complementarity" was introduced into scientific and philosophical discourse by Niels Bohr, a founder of modern quantum theory. Within quantum theory, complementarity is not merely helpful but essential. It arises in the interpretation of Heisenberg's uncertainty principle, according to which it is impossible to predict both the position and velocity of a particle simultaneously.

In quantum theory, the fundamental description of a particle is given by its wave function. Theoretically, the particle's wave function supplies the answer to any question about the particle that it makes sense to ask. We do not have empirical access to the wave function itself, however, but only to processed versions of it. One way of processing gives us predictions about the particle's position; another way of processing gives us predictions about its velocity. Sadly, those two ways of processing are mathematically incompatible. In this setting, complementarity is a theorem: different questions correspond to different aspects of reality, which do not yield to a single description.

Although Bohr first articulated complementarity in the 20th century, once you're alert to it, you can find many traces of it in the science, literature and art of earlier times. Pascal's quote concludes: "Through space the universe grasps me and swallows me up like a speck; but through thought I grasp it." And Whitman's, in context, is a wonderfully poetic celebration of complementarity:

Do I contradict myself?
Very well then I contradict myself,
(I am large, I contain multitudes.)

Dario Gil is director of IBM Research, one of the world's largest and most influential corporate research labs, with more than 3,000 scientists at 19 locations on six continents. He is the 12th director in its 75-year history. He leads innovation efforts at IBM, directing research strategies in AI, cloud, quantum and exploratory science. He is a founder and co-chair of the COVID-19 High Performance Computing Consortium.

POLICY & ETHICS

The Ethical Challenges of Connecting Our Brains to Computers

We must ensure that companies, policy makers and consumers use neurotechnology in a responsible way

ANDRIY ONUFRIENKO *GETTY IMAGES*

This is neurotech—new, potentially revolutionary technology that promises to transform our lives. With all the global challenges of today, we need revolutionary technology to help the world cope.

Neurotech is our, frankly, mind-blowing attempt to connect human brains to machines, computers and mobile phones. Although brain-computer interfaces (BCIs) are the heart of neurotech, it is more broadly defined as technology able to collect, interpret, infer or modify information generated by any part of the nervous system. Why? To develop therapies for mental illnesses and neurological diseases. Beyond health care, it could soon be used in education, gaming, enter-

tainment, transportation, and so much more.

But there are pitfalls: there are no widely accepted regulations or guardrails yet when it comes to neurotech's development or deployment. We need them—we need them bad. We must have principles and policies around neurotech, technology safeguards, and national and international regulations.

WHAT IS NEUROTECH, ANYWAY?

There are different types of it—some is invasive; some isn't. Invasive brain-computer interfaces involve placing microelectrodes or other kinds of neurotech materials directly onto the brain or even embedding them into the neural tissue. The idea is to directly sense or modulate neural activity.

Such technology has already improved the quality of life and abilities of people with different illnesses or impairments, from epilepsy to Parkinson's disease to chronic pain. One day we might implant such neurotech devices into paralyzed humans, allowing them to easily control phones, computers and prosthetic limbs—with their thoughts alone. In 2017 Rodrigo Hübner Mendes, a paraplegic, used neurotech to drive a racecar with his mind. Recently an invasive neurotech device accurately decoded imagined handwriting movements in real time, at a speed that matched typical typing. Researchers have also showed how invasive neurotech allows users with missing or damaged limbs to feel touch, heat and cold through their prostheses.

There is also noninvasive neurotech that can be used for similar applications. For example, researchers have developed wearables to infer a person's intended speech or movement. Such technology could eventually enable a patient with language or movement difficulties—say, someone with locked-in syndrome—to communicate easier and more effectively.

Noninvasive neurotech is also used for pain management. Together with Boston Scientific, IBM researchers are applying machine learning, the Internet of things, and neurotech to improve chronic pain therapy.

All of this is already quite impressive, but there is also neurotech that really pushes the envelope. Not only can it sense or read neurodata, but it can also modulate—invasively and noninvasively. This research is still in early stages, but it is advancing rapidly.

One astounding example is the work of Rafael Yuste, a neurobiologist at Columbia University. His team has recorded the neuron activity of a mouse that was performing an action, such as licking for a reward. Later the researchers reactivated these same neurons and got the mouse to perform the same action, even if the rodent did not intend to do it at that moment. Other neuroscientists have used similar technologies to transfer learned tasks between two rodents brain to brain and implant false memories into an animal's mind. It's remarkable.

RISKS, ETHICS AND REGULATION

Still, neurotech is at the very dawn of its technological journey. As it becomes more commonplace, we must consider the risks it might present, the ethics around it, and the necessary regulation. We have to anticipate and deal with the implications related to the development, deployment and use of this technology. Any neurotech applications should consider potential consequences for the autonomy, privacy, responsibility, consent, integrity and dignity of a person.

What if someone were to face employment discrimination because the algorithms that power a neurotech application used for hiring misinterpret his or her neurodata? What if a criminal gets ahold of the previous or current neurodata of the secretary of defense and steals top secret information? Ethical concerns increase when we are not just monitoring someone's neurodata but also interpreting it, decoding the person's thoughts—with implications for accuracy and mental privacy.

One tricky aspect is that most of the neurodata generated by the nervous systems is unconscious. It means it is very possible to unknowingly or unintentionally provide neurotech with information that one otherwise wouldn't. So, in some applications of neurotech, the presumption of privacy within one's own mind may simply no longer be a certainty.

As new, emerging technology, neurotech challenges corporations, researchers and individuals to reaffirm our commitment to responsible innovation. It's essential to enforce guardrails so that they lead to beneficial long-term outcomes—on company, national and international levels. We need to ensure that researchers and manufacturers of neurotech as well as policy makers and consumers approach it responsibly and ethically.

Let's act now to avoid any future risks as neurotech matures—for the benefit of humanity.

Debra Lieberman is an associate professor of psychology at the University of Miami, editor in chief of the journal *Evolution and Human Behavior,* and a 2020 Public Voices Fellow with The OpEd Project.

EVOLUTION

The Evolutionary Origins of Friendship

The emergence of this crucial kind of relationship relied on the ability to recognize the unique benefits others have to offer

JUSTIN LEWIS GETTY IMAGES

As awful as 2020 was, its ability to reveal the genuine strengths and weaknesses of our relationships was an unexpected boon. When severe trouble strikes, whether it be a death in the family, divorce, lost fortune, public cancellation or global crisis, true friends rise above the posers.

Strange as it might sound, severe downturns are watershed moments. They enable us to discern fair-weather friends from friends tried and true. Flush times, when all is going well, do not provide the clarifying moments that enable us to see who will come to our aid when the chips are down. In fact, the ironic implication is that during times of good fortune, we might be less certain of who our friends really are and only glean this insight during times of hardship. Indeed, over the past year, I've experienced the gratifying strengthening of relationships with people not previously in close orbit but also the distressing unraveling of relationships I had thought beyond question. Some relationships can withstand intense stress; others break like brittle bones.

As an evolutionary psychologist, I have conducted research on social relationships and emotions for more than 20 years. Friendships are an important class of relationships that evolved in response to the benefits of having additional people beyond family invested in one's welfare. But how do we make other people care—that is, redirect their time, money and social benefits to us

instead of to themselves or to their kin?

The answer: we make ourselves valuable.

The evolution of friendships relied on the ability to recognize the unique benefits other people have on offer. Benefits can include the usual suspects of prestige, status and attractiveness, but there are myriad reasons why you might value another person: they are of the same political party, they like the same kinds of foods, they like to golf, surf or play chess, or they enjoy talking endlessly about *Star Wars.* Friendships tend to begin when one individual perceives value in another and performs a beneficent act: "You can borrow my phone if you need to make a call"; "Can I help you carry that?" These actions serve as a fishing line, cast out to see if the target individual might be in the market for a new friend. Signals of their gratitude are promising indicators of a bite; anger and annoyance are indicators of a lost lure.

What begins as a mere platitude, though, can snowball into a deep engagement. If I demonstrate that I value you, then, all else equal, it pays for you to value me in return. Your increased valuation of me can then lead me to care more about you, and so forth. To the extent we can make ourselves valuable to each other, we will have a vested interest in keeping each other around, which comes in handy during times of misfortune.

The talk of value and benefits on offer sounds calculated and coldhearted. It is. But this jargon refers to the rationale behind why the thoughts and feelings we experience exist. You do not consciously calculate the likelihood that a person values you or the downstream benefits that could result from a relationship—instead the algorithms doing these calculations generate outputs, which percolate up from the unconscious as "liking." Have you ever met someone, talked for hours, and left feeling like you've found a long-lost brother, sister or soulmate? Chances are, you noticed similarities and evaluated the kinds of benefits future interactions might yield, which generated a sense of immediate closeness. Mutual valuation, when intense, can create storybook relationships.

But the tricky part is deciphering which individuals merely say they value us versus those who would be inclined to stand by our side during hardship. Talk is cheap and promises easily spoken: "I'd totally help you out in a pinch"; "You can ask me for money anytime"; "Feel free to stay at my place." Promises cost nothing when friends don't need help, money or a place to stay. As they say, actions speak louder than words. The pandemic has therefore been an unexpected (albeit unwanted) opportunity to test the tensile strength of our relationships.

As 2020 retreats farther into the rearview, it is as good a time as any to take stock of our relationships and to apply the old adage to ourselves and to others: friends in need are friends indeed.

Stephen Macknik and **Susana Martinez-Conde** 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*.

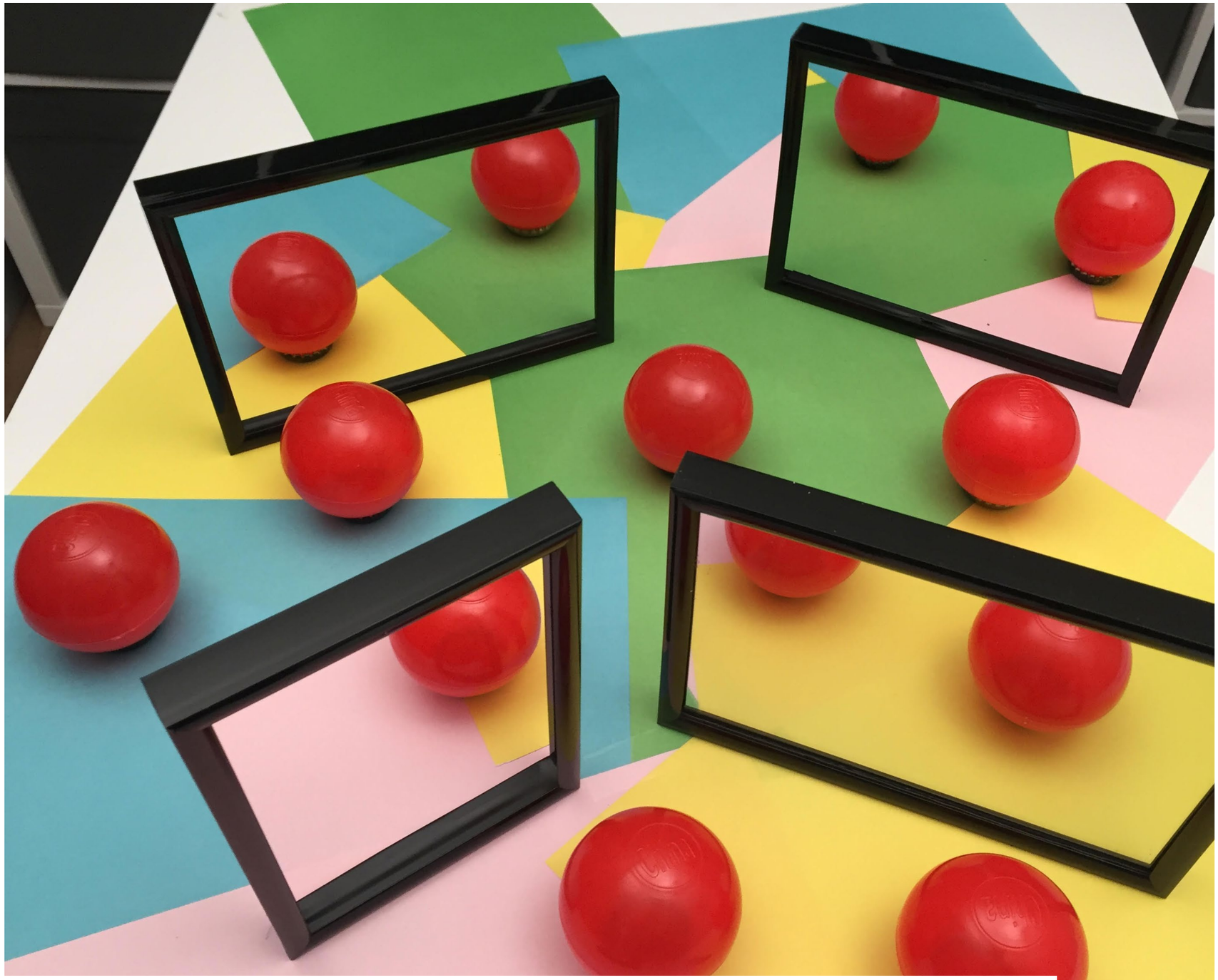
Looking-Glass? Look Again

This illusion turns empty frames into mirrors

The image at the right contains one actual mirror and three empty frames. Can you work out which is which? The visual riddle was created by Matt Pritchard, a U.K. magician. He won second prize in the 2020 Best Illusion of the Year Contest with a related puzzle.

The conundrum highlights our perceptual limitations regarding mirrors. Despite our seemingly unlimited everyday experience with reflecting surfaces, it turns out that most of us understand ordinary mirrors much worse than we think.

Pritchard's discovery was serendipitous. He was handling the frame of a broken mirror when, looking through the empty square, he mistakenly believed that he was looking at a reflection. "It was a lovely reality-twisting moment," Pritchard recalls. The next day he set out to reproduce the effect with the same empty frame, twin cans of soda, and cutouts of colored paper. "The illusions with Coke cans led me down the path of playing with various



In this photograph by Matt Pritchard, one frame is an actual mirror and the other three are empty. The challenge for readers is to distinguish reflection from reality. **Solution:** Only the frame in the lower right corresponds to an actual mirror.

MATT PRITCHARD

mirror-related illusions and exploring various ways to trick the brain."

Pritchard's mind-bending experience might be more common than one might imagine. In 2016, while remodeling their kitchen, psychologist F. Richard Ferraro and his wife, Jacqueline Lee Foster Ferraro, accidentally placed two identical lamps at both sides of a pass-through opening connecting their living room to the kitchen. Although the couple knew that they owned both lamps, they could not help but feel that they were looking at a single lamp and its reflection. In a subsequent paper published in the journal *Perception*, they proposed that their misperception could be explained by the so-called simplicity principle.

According to the simplicity principle, our brains prefer the simplest explanations for the objects in our visual environment. "In everyday life, it's unlikely [we] find symmetry like this, unless there has been an intentional design behind it, or there is a mirror between the two sets," Pritchard explains. In other words, we are more often right than wrong when we guess that a symmetrical arrangement indicates a single object and its reflection, rather than two disconnected objects at either side of a frame.

Pritchard reports that the illusion is largely robust to viewing angle, binocular vision, and even small discrepancies between an item and its "reflection." But several questions remain unanswered. "How did this mirror assumption arise? From an evolutionary perspective … mirrors are a relatively recent invention. At what stage of human development do we learn about mirrors?" Pritchard wonders.

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MIND

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