ANESTHESIA AND THE AGING BRAIN: WHAT ARE THE RISKS? page 60

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THE DARK SIDE OF EMPATHY

WHERE CONSCIOUSNESS LIVES IN THE BRAIN

THE TEMPERATURE OF EMOTIONS

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COVER PHOTOGRAPH AND THIS PAGE: AARON GOODMAN

FROM THE EDITOR

The social sciences offer powerful tools for making sense of the world in which we live. For policy makers, they provide guidance, in the form of study results, for making our world work better. In this edition, two feature articles examine major contemporary issues through the lens of social science theory and research.

First, our cover story on "Getting Preschool Right," written by journalist Melinda Wenner Moyer, sounds the alarm on some unfortunate trends in early childhood education. Between 2002 and 2012 the proportion of American four-year-olds attending preschool doubled. This should be a good thing—especially for kids coming from families stretched too thin economically to provide much enrichment at home. But the expansion has been done on the cheap, with low-quality programs, canned curricula and grossly unprepared teachers. In addition, pressure to perform on standardized tests in primary school has backed up into the pre-K classroom, leading to worksheets and teacher-driven instruction that are a poor match for the developing four-year-old mind. Research shows we should be doing the opposite, writes Wenner Moyer in the story, which starts on page 26. Young kids learn best, she says, "through guided—or 'scaffolded'—play and hands-on, child-led activities, which can help them learn concepts more deeply."

In "How Trump Won," Stephen D. Reicher and S. Alexander Haslam—both members of our board of advisers—analyze the messaging and group psychology dynamics that helped bring Donald Trump to the White House. They deconstruct his carefully staged rallies and explain how they reinforced both a "politics of hope" among his supporters and a sense of us versus them vis-à-vis traditional power elites. Trump, they write in the article, beginning on page 42, presented himself as a prototypical American—a regular guy, despite his billions, whose plain language and sometimes crude or violent imagery were reviled by critics but, to his fans, marked him as someone who could buck the system and bring change.

This issue also includes two articles by top neuroscientists. In "The Footprints of Consciousness" (turn to page 52), advisory board member Christof Koch walks us through science's centuries-old search for the locus of consciousness in the brain, including his own modern-day quest. Starting on page 36, Suzana Herculano-Houzel of Vanderbilt University gives a delightful account of her "brain soup" method of counting neurons in the noggins of dozens of species and the surprising light it sheds on our own "remarkable (but not extraordinary)" human equipment.

Claudia Wallis
Managing Editor
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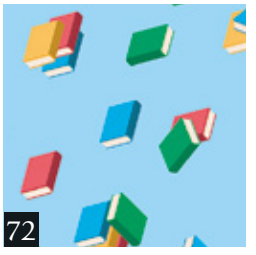

JULIA MUSDOTTER *Getty Images (books)*; JAMIE CARROLL © *iStock.com (brain icon)*

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THE GIVERS

In the article on the caregiver's dilemma, Francine Russo offers research-based advice to help family members and friends maintain their own psychological well-being while tending to a loved one who is elderly or disabled. Some of our readers shared comments on Facebook. Shiby Sahadevan writes, "It takes umpteen hours of thoughtful service to keep up the spirits of those who need constant care. Finding your footing and recuperating are not easy unless you are surrounded by family." Odessa-Nanette Fields notes, "The psychological health of caregivers is so important, especially with the growing numbers of aging baby boomers needing some form of assistance." Elise Kathleen adds, "So glad you're tackling this issue!"

LEARNING TO FORGIVE

I enjoyed Sunny Sea Gold's article "How to Be a Better Forgiver" [Head Lines]. Having done a lot of forgiveness work myself, I found the ideas relevant and useful. I would like to see a longer article that goes into more depth and discusses the work of Robert Enright, a professor of educational psychology at the University of Wisconsin–Madison, who established the International Forgiveness Institute.

I took a seminar with Enright 20 years ago that turned my life around. I was reeling in the vortex of a very nasty divorce, and he showed me a way to take care of myself and stay on the high road. Since then, his teachings have helped me maintain my equanimity in other difficult situations.

I was disappointed to see that Gold didn't mention Enright or the institute. Please share with your readers the name of the organization. There's a wealth of great information that can help people struggling with feelings of resentment and guilt.

Thanks for a great magazine.

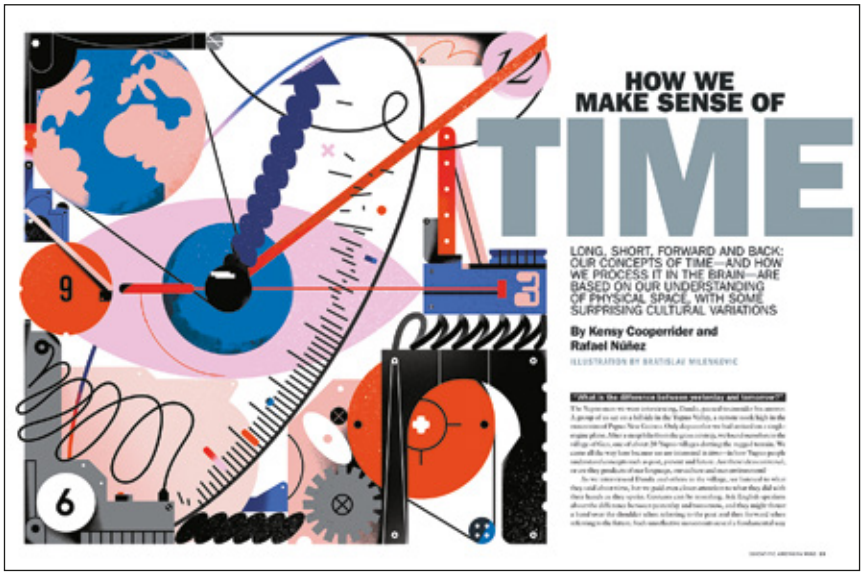
Dave Birren
Stoughton, Wis.

MIND-ALTERING SURGERY

After reading Meredith Knight's story "Weight-Loss Surgery Alters the Brain" [Head Lines] and the hypothesized mechanism responsible for the sudden brain activity (the rapid, novel contact of undigested food hitting the stomach), I couldn't help but wonder how the transmission or activity of the satiety hormone leptin might be altered by bariatric surgery. Are greater levels of this hormone a response to the changes pursuant to the procedure?

Andrea Dasilva
Vancouver, B.C.

KNIGHT REPLIES: *Leptin does appear to play a role in appetite changes after gastric bypass surgery, but the details are far from certain. For instance, some studies have found a decrease in blood levels of leptin after surgery, which is somewhat expected because leptin is generated by fat cells. But other studies showed no change in leptin levels after surgery and resulting weight loss. Intriguingly, genetically engineered mice with disabled leptin systems do not lose weight after bariatric surgery. But the system that regulates appetite is complex, and our knowledge of it is slim. Other substances also play a role for bariatric patients. GLP-1, another hunger-inhibiting gut hormone, is more directly affected. A wealth of studies have shown that its concentration increases after bypass surgery in both mice and humans.*



MATH MEMORIZATION

Jo Boaler and Pablo Zoido's article "Why Math Education in the U.S. Doesn't Add Up" [Perspectives] itself does not add up. The resistance to "memorization" and "rote procedures" and the uncritical privileging of "open, visual, creative inquiry" do not accord with a good deal of research in cognitive and educational psychology. Psychologists have shown that students are at first novices with respect to academic skill and subject matter, but a structured and directional approach helps to build long-term memory and frees up working memory to more effectively tackle a given task or problem. Then as core skills, knowledge, fluency and automaticity develop, students can move on to (guided) open, visual and creative inquiry.

Andrew J. Martin
Professor of educational psychology
University of New South Wales

BOALER REPLIES: *It is a well-known scientific fact that sometimes committing something to memory through automation frees up working memory to tackle problems. What is not established is the timing of such actions or their place in classrooms. Some studies support the belief that automation should precede understanding, but this order is not necessary and has led to unhelpful instruction in schools, in which teachers try to drill students with methods that they do not understand. This can lead to a misunderstanding and dislike of mathematics. Many studies show that when students are introduced to number sense and encouraged to understand numerical relations they can later commit methods to memory and become effective and engaged mathematics students. Mathematics education has suffered from an overemphasis on drill and repetition, and that is shown in the data from the Program for International Student Assessment; it is important to dial this back. The focus of mathematics teaching and learning should be on conceptual understanding, aided, when appropriate, with memorization of what is understood.*

THE SPACETIME CONNECTION

I would argue that the metaphors presented in "How We Make Sense of Time," by Kensy Cooperrider and Rafael Núñez, are directional, not spatial, and that the metaphor "time is like space" introduces a false dichotomy. One of Einstein's great insights was that time and space are not separate. The big bang produced spacetime, not time and space. Scientists define a second as a certain number of complete oscillations of a cesium 133 atom. More generally, the definition of anything involving time (for instance, velocity, day) involves motion.

One of my takeaways from the authors' studies is that there is a universal understanding—without knowledge of modern physics or metrology—that time is perceived and actualized as motion. The examples presented provide culturally different views of the direction in which time moves. They are metaphors about the unified nature of time and space, not about time being like space.

Charles H. Jones
Eugene, Ore.

TROLLEY TEST

Matthew Hutson mentions the trolley or railway switch test of morality in "Why We Love Moral Rigidity" [Head Lines]. The test, as usually posed, involves the decision to push an overweight man off a footbridge to block a trolley from killing five rail workers. Psychologists really should devise a more realistic thought experiment to get meaningful results. Except for employees of the railway company, how could I ever be in a position to know enough to decide that changing a switch might save lives and then to actually do it in time? It is even more implausible that tossing a person onto the tracks will slow a train sufficiently to alter the amount of damage it will do. And are the five rail workers all totally deaf? Fast-moving trains are loud. If I do nothing, all I can be accused of is cowardice. I will accept that rather than risking life imprisonment for murder.

Martin J. Greenwood
Stirling, Australia

THE EDITORS REPLY: *Ethicists have devised many thought experiments that call for even greater leaps of the imagination. The purpose of these thought experiments is not to represent a plausible scenario but rather, through metaphor, to illustrate a particular principle.*

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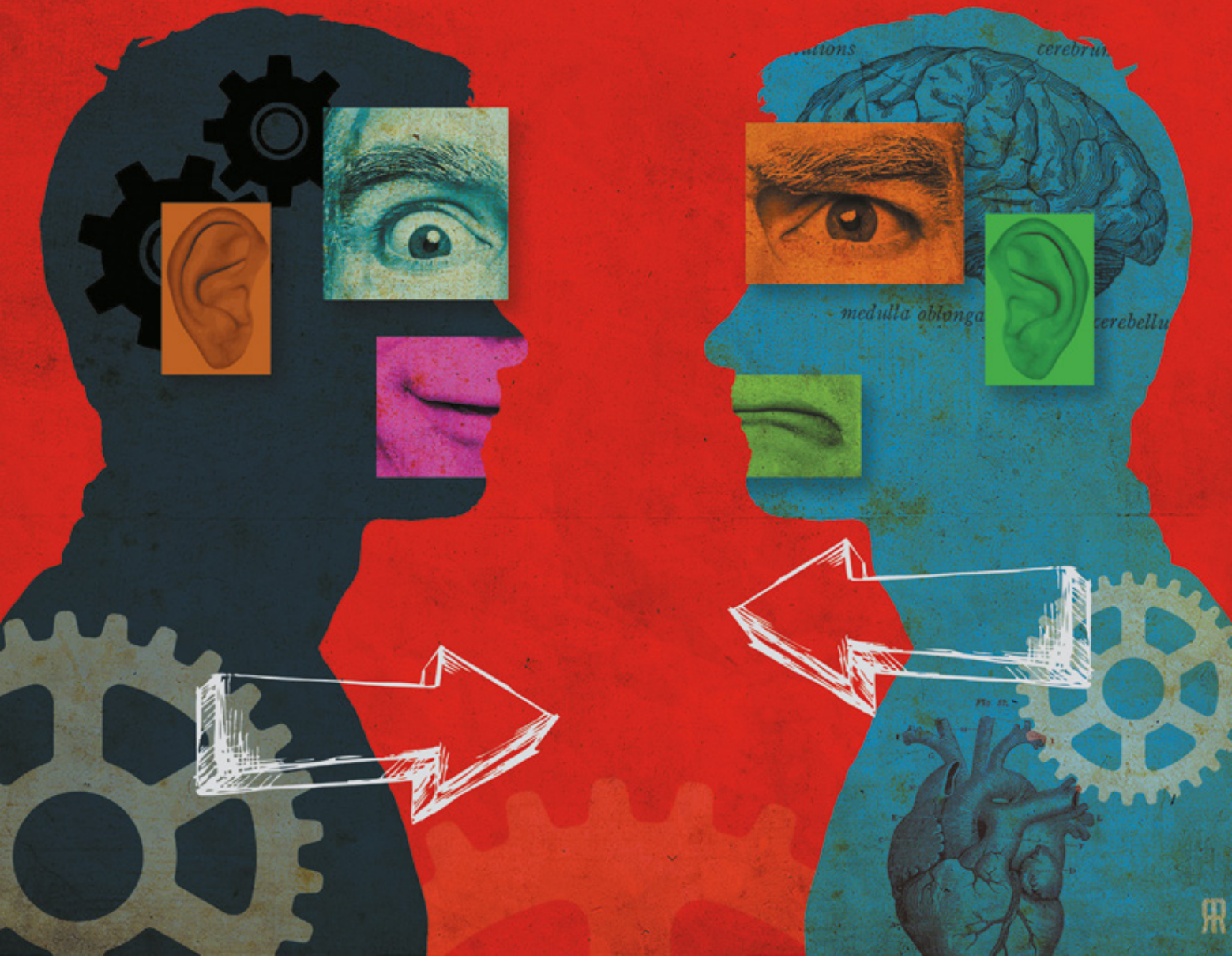
Head Lines

A USER'S GUIDE TO THE BRAIN

How We Read Emotions



Feeling Your Pain

Our ability to read the emotions of other people affects everything from our professional lives to our romantic relationships. New research suggests ways to boost our emotional intelligence—while hinting at some possible downsides to having too much empathy.

ILLUSTRATIONS BY RAFAEL RICOY

Don't Go with Your Gut

When reading people's emotions, careful thinking may pay off

For some things, such as deciding whether to take a new job or nab your opponent's rook in chess, you're better off thinking long and hard. For others, such as judging your interviewer's or opponent's emotional reactions, first instincts are best—or so traditional wisdom suggests. But new research finds that careful reflection actually makes us better at assessing others' feelings. The findings could improve how we deal with bosses, spouses, friends and, especially, strangers.

We would have trouble getting through the day or even a conversation if we couldn't tell how other people were feeling. And yet this ability, called empathic accuracy, eludes introspection. "We don't think too hard about the exact processes we engage in when we do it," says Christine Ma-Kellams, a psychologist at the University of La Verne in California, "and we don't necessarily know how accurate we are."

Recently Ma-Kellams and Jennifer Lerner of Harvard University conducted four studies, all published in 2016. In one experiment, participants imagined coaching an employee for a particular job. When told to help the employee get better at reading others' emotions, most people recommended thinking "in an intuitive and instinctive way" as opposed to "in an analytic and systematic way." When told to make employees worse at the task, the participants recommended the opposite. And yet later experiments suggested this coaching was off base.

For instance, in another experiment, professionals in an executive-education program took a "cognitive reflection test" to measure how much they relied on intuitive versus systematic thinking. The most reflective thinkers were most accurate at interpreting their partners' moods during mock interviews. Systematic thinkers also outperformed intuiters at guessing the emotions expressed in photographs of eyes.

To test for causality, the researchers asked another group of professionals to recall a time when following their instincts paid off—or a time when careful reasoning did—to induce one mode of thought or the other. As predicted, when judging a partner's moods in a mock interview that followed this exercise, individuals primed to reason carefully were more accurate.

Then why do we prize snap impressions of others? "All of us seem to be able to read people on some level," Ma-Kellams says, "so I think it looks a lot easier than it actually is." To judge a person's emotions accurately, we need to take into account context, subtle expressions, personal history and our own biases. Ma-Kellams and her colleagues are now looking into whether intuitive thinking may offer benefits in certain circumstances, such as when you know someone well. But when deciphering other people, especially strangers, Ma-Kellams advises that we "be really wary of our gut instincts and think more critically and effortfully about what this other person is going through before we jump to conclusions." —*Matthew Hutson*

FROM "'BLISSFULLY HAPPY' OR 'READY TO FIGHT': VARYING INTERPRETATIONS OF EMOJI," BY HANNAH MILLER ET AL., IN *PROCEEDINGS OF THE TENTH INTERNATIONAL AAAI CONFERENCE ON WEB AND SOCIAL MEDIA*, COLOGNE, GERMANY, MAY 17–20, 2016. PUBLISHED BY AAAI PRESS (*emojis*)

Emojis: Lost in Translation?

Emojis are a universal language, right? Not necessarily. Operating systems display the same typed characters differently, so what looks like a happy grin to Nexus users (*second from top*) shows up as a grimace to their iPhone-using correspondents (*top*). Yet there is even variation in how people interpret emojis on the same platform: in a 2016 study, researchers at the University of Minnesota found confusion is rife, especially surrounding the "grinning face with smiling eyes" (*all five images*). Asked to rate the emotion portrayed by the Apple version on a 10-point scale from very negative to very positive, subjects were all over the map. Sender and receiver, on average, differed by almost two points. —*Veronique Greenwood*

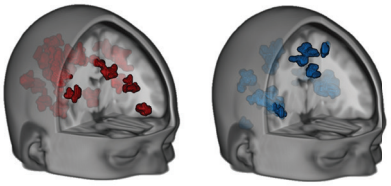
Is Your Happy the Same as My Happy?

The quest to read emotions from brain scans

A number of studies have used functional MRI to see what our brain looks like as we recall pleasant memories, watch scary movies or listen to sad music. Scientists have even had some success telling which of these stimuli a subject is experiencing by looking at his or her scans. But does this mean it is possible to tell what emotions we are experiencing in the absence of prompts, as we let our mind wander naturally? That is a difficult question to answer, in part because psychologists disagree about how emotions should be defined. Nevertheless, some scientists are trying to tackle it.

Emo-Brains

Functional MRI scans show activity corresponding to contentment (*red*) and anger (*blue*).



Contentment *Anger*

In a study reported in the June 2016 issue of *Cerebral Cortex,* Heini Saarimäki of Aalto University in Finland and her colleagues observed volunteers in a brain scanner who were being prompted to recall memories they associated with words drawn from six emotional categories or to reflect on a movie clip selected to provoke certain emotions. The participants also completed a questionnaire about how closely linked different emotions were—rating, for instance, whether "anxiety" is closer to "fear" than to "happiness." The researchers found that pattern-recognition software could detect which category of emotion a person had been prompted with. In addition, the more closely he or she linked words in the questionnaire, the more his or her brain scans for those emotions resembled one another.

Another study, published in September 2016 in *PLOS Biology* by Kevin LaBar of Duke University and his colleagues, attempted to match brain scans of people lying idle in a scanner to seven predefined patterns associated with specific emotions provoked in an earlier study. The researchers found they could predict the subjects' self-reported emotions from the scans about 75 percent of the time.

Not everyone agrees, however, that studying emotions this way—as averages of many people's brains while they undergo a stimulus—makes sense. Psychology professor Lisa Feldman Barrett of Northeastern University and author of *How Emotions Are Made* (Houghton Mifflin Harcourt, 2017), who was not involved in either study, says that so far no one has clearly demonstrated that patterns taken from one study can be used to recognize the same emotion in another group of people provoked by a different stimulus. Such brain patterns, Barrett says, are just statistical summaries, not unique signatures that exist only when someone has a certain experience. And one person's emotions may not look the same in a brain scan as another person's. "Maybe you have five [different] patterns for anger, maybe I have seven, maybe somebody else has two," Barrett adds. "Maybe they overlap, maybe they don't."

Going forward, we are likely to see diverse perspectives on what emotion is and how to study it. "For now," Saarimäki says wryly, "I think we are still safer if you just ask people how they are feeling, rather than trying to read their brain." *—V.G.*

FROM "WHITE-MATTER STRUCTURE IN THE RIGHT HEMISPHERE PREDICTS MANDARIN CHINESE LEARNING SUCCESS," BY ZHENGHAN QI ET AL., IN *JOURNAL OF NEUROLINGUISTICS*, VOL. 33; FEBRUARY 2015 (*brain scans*)

The Dark Side of Emotional Intelligence

Profound empathy may come at a price

Recognizing when a friend or colleague feels sad, angry or surprised is key to getting along with others. But a new study suggests that a knack for eavesdropping on feelings may sometimes come with an extra dose of stress. This and other research challenge the prevailing view that emotional intelligence is uniformly beneficial to its bearer.

In a study published in the September 2016 issue of *Emotion,* psychologists Myriam Bechtoldt and Vanessa Schneider of the Frankfurt School of Finance and Management in Germany asked 166 male university students a series of questions to measure their emotional smarts. For example, they showed the students photographs of people's faces and asked them to what extent feelings such as happiness or disgust were being expressed. The students then had to give job talks in front of judges displaying stern facial expressions. The scientists measured concentrations of the stress hormone cortisol in the students' saliva before and after the talk.

In students who were rated more emotionally intelligent, the stress measures increased more during the experiment and took longer to go back to baseline. The findings suggest that some people may be too emotionally astute for their own good, says Hillary Anger Elfenbein, a professor of organizational behavior at Washington University in St. Louis, who was not involved in the study. "Sometimes you can be so good at something that it causes trouble," she notes.

Indeed, the study adds to previous research hinting at a dark side of emotional intelligence. A study published in 2002 in *Personality and Individual Differences* suggested that emotionally perceptive people might be particularly susceptible to feelings of depression and hopelessness. Furthermore, several studies, including one published in 2013 in *PLOS ONE,* have implied that emotional intelligence can be used to manipulate others for personal gain.

More research is needed to see how exactly the relation between emotional intelligence and stress would play out in women and in people of different ages and education levels. Nevertheless, emotional intelligence is a useful skill to have, as long as you learn to also properly cope with emotions—both others' and your own, says Bechtoldt, a professor of organizational behavior. For example, some sensitive individuals may assume responsibility for other people's sadness or anger, which ultimately stresses them out. Remember, Bechtoldt says, "you are not responsible for how other people feel." *—Agata Blaszczak-Boxe*

Good Relationships Are All in the Family

A decades-long study finds men raised in close families have stronger attachments in old age

A lot can happen during a life—career changes, marriages, divorces, births, deaths, not to mention all the small stuff in between—but childhood lays an important foundation that can last a lifetime. A long-running study published in September 2016 in *Psychological Science* found that men who grew up in warmer, more nurturing family environments had stronger relationships as older adults.

The research is a continuation of Harvard University's Study of Adult Development, a longitudinal study of adult health and well-being that has spanned almost eight decades. At its outset in 1938, researchers enrolled male Harvard students and inner-city Boston teens and used lengthy interviews to rate the quality of the boys' family environments. Different researchers then followed up with the men in midlife to assess how successfully they were able to manage negative emotions. In the most recent study, coauthors Robert Waldinger, a psychiatrist at Harvard Medical School, and Marc Schulz, a psychologist at Bryn Mawr College, conducted in-depth interviews with the men, now in their 80s, to determine their level of attachment to their partners.

Waldinger and Schulz determined that regardless of socioeconomic standing the men raised in warmer family environments used healthier strategies to manage their negative emotions in midlife and were also more securely attached to their partners late in life. These results suggest our childhood environment affects our relationships not only into early adulthood but for the rest of our life.

Chris Fraley, a psychologist at the University of Illinois at Urbana-Champaign who studies attachment but was not involved in the present study, points out that so much can happen between childhood and old age, from financial hardship to illness to divorce. "The fact that the authors found such an association is remarkable," he says, "and raises a number of questions about the factors that explain why it exists."

For Schulz, the findings highlight the need for services such as family

Digital Hypocrisy

To limit kids' screen time, try unplugging yourself

In a world where we are constantly tweeting, texting, Googling and checking e-mail, technology addiction is a real concern for today's kids. Yet parents are often unable to unplug from their own digital devices, research suggests. A recent national survey conducted by Common Sense Media, which included nearly 1,800 parents of children aged eight to 18, found that parents spend an average of nine hours and 22 minutes every day in front of various screens—including smartphones, tablets, computers and televisions. Of those, nearly eight hours are for personal use, not work. (The survey included people from a wide range of socioeconomic classes and fields, who may or may not use computers at their job all day.)

Perhaps even more surprising is that 78 percent of parents surveyed believe they are good role models for how to use digital technology. Multimedia are designed to be engaging and habit-forming, so we do not even realize how much time we spend when we heed the siren call of our devices, says Catherine Steiner-Adair, a clinical psychologist and author of *The Big Disconnect* (HarperCollins, 2013).

This can be a double whammy for children, who not only feel that their parents are ignoring them or do not find them as engaging as the screen but who also learn

GETTY IMAGES (*top*); JAMIE GRILL *Getty Images* (*bottom*)

leave that support parents and allow them to create better family environments. He also stresses the importance of good social services that can intervene when children end up in poor or unsafe family settings. "I think the take-home [message] is that kids may not remember specific events, particularly early in their life," Schulz says, "but the accumulation of loving, nurturing family environments really has an impact over a *long* period."

Waldinger and Schulz also emphasize that there are many ways to overcome having a less than idyllic childhood, such as actively working on developing warmer, more stable relationships as an adult or learning how to use healthier strategies to deal with negative emotions.

"The bottom line," Waldinger says, "is that how we take care of children is just so vitally important."

—Catherine Caruso

to mimic their parents' behavior, Steiner-Adair notes. Studies show that greater use of technology among tweens and teens correlates with shorter attention spans, a preference for digital time over physical activity and worse performance in school. Toddlers and infants also have a harder time learning emotional and nonverbal cues because their parents constantly have what psychologists call "still face phenomenon" from concentrating on mobile devices.

The good news, however, is that if parents use screen time for shared activities with a child—watching a movie or playing an educational game together, for example—it can enhance the child's learning. According to the survey, 94 percent of parents recognize that technology can be used to support their children's education. The key is to limit and track kids' time with technology and set rules for themselves, too. Modeling healthy media habits can start with something as simple as making the family dinner table a device-free zone.

—Knvul Sheikh

NOEL HENDRICKSON *Getty Images*

The Pros and Cons of Being Self-Aware

We value the quality in others—but we don't always like how it reflects on us

Self-awareness is usually considered a virtue. When you are making small talk at a party, it helps to know when your story is getting boring or if you are talking too loudly. Yet being aware of the impression we give off may not benefit us as much as it does other people.

In a pair of studies, psychologist Erika Carlson of the University of Toronto Mississauga had people take part in either a single, brief conversation with a stranger or multiple meetings with an acquaintance. After every interaction, the participants rated one another's level of self-awareness and the overall quality of their relationship. In two other studies, which involved close friends and romantic partners, individuals completed surveys rating their friend's or partner's self-awareness and their self-perceived quality of the relationship. All four studies were published in August 2016 in the *Journal of Personality and Social Psychology*.

Being in tune with how others see us was often a double-edged sword. Across the board, conversation partners generally preferred people who were more aware of how they were coming across—warts and all—whereas self-aware people themselves had the opposite reaction, liking others less when the reflection they saw of themselves was not flattering. The findings comport with past research suggesting that people prefer an idealized version of themselves, and perceiving others picking up on our flaws can be a turn-off.

"There's a common intuition that it's good to know how others see you," Carlson says, adding, "We were surprised to find that it was not always the case. Self-knowledge seems to really benefit the people around us" more than ourselves. It enables us to calibrate our behavior based on others' feedback but does not necessarily make relationships easier to navigate.

One exception to the external benefits of self-awareness may be in short-term romantic relationships. In the study of romantic partners, Carlson compared the survey responses of couples who had been together for two years on average versus couples who had been together for decades. Unlike those in other social pairs, short-term lovers did not rate their relationship as better when their partner was more self-aware. People who had been together for decades, however, did: those with self-aware partners reported higher-quality relationships. The studies "illustrate that context does matter," says Nora Murphy, an experimental psychologist at Loyola Marymount University, who was not involved in the research.

Although we may not value a self-cognizant date in the short term, over the long term it might just make or break a relationship. "In romantic partners, rose-colored glasses are often preferable in the beginning," Carlson says. "And then that shifts." In the long run, you want to be appreciated for who you are.

—Roni Jacobson

PERSONAL EFFECTS

Put a Bird on It

Customizing possessions boosts performance

Soccer star Lionel Messi wears cleats inscribed with his son's name and part of Argentina's flag. The cleats of Austrian star David Alaba have a Nigerian flag in honor of his father and say, "Jesus loves u." But do these personal touches help them play better? Research suggests that may be the case.

In several studies in an upcoming issue of the *Journal of Marketing Research*, students worked and played better when using items they had decorated to portray aspects of themselves. Even though participants did not expect any benefit, they threw customized darts more accurately, they came up with more anagrams using a customized pen, and they played a beer-coaster flipping game better with customized coasters. Across the studies, customization boosted performance by 25 percent.

The trick worked best when people cared about doing well and when the decoration embodied a task-relevant part of their identities (for example, decorating a coaster with a drawing of a competitive athlete will help you more in a flip game than will drawing a picture of people holding hands). "If there is an alignment between the goal and the identity, then you are more motivated to pursue this goal because you can affirm this part of the identity," says Martin Schreier, one of the study's authors and a professor of marketing at the Vienna University of Economics and Business in Austria. Indeed, when people did well with their custom coasters, it actually strengthened that aspect of their personal image—as if player and coaster had become one.

So, Schreier says, first make sure your gear suits you functionally, then put yourself into it expressively. *—Matthew Hutson*

Why We Love Dad's Old Sweater

"Authentic objects" keep us company

Why do people cherish family heirlooms and celebrity memorabilia? We treat them as somehow special, inherently different from items that look identical but do not share the same history. Psychologists call this phenomenon "magical contagion," and research suggests this effect helps to fulfill our need for social connection. In other words, we expect these hand-me-downs to keep us company in lieu of the person who owned them.

Social belonging is a fundamental human need, and George Newman and Rosanna Smith of the Yale School of Management wondered whether the longing for connection might alter how we treat "authentic objects," that is, those with a unique provenance. To find out, they conducted two experiments, reported in the November 2016 issue of *Cognition.*

In the first case, adults played a computer game called Cyberball, which involved passing a ball among several players. Participants were told the other players were controlled by people, when, in fact, they were programmed to pass the ball 10 times to some participants and only three times to others, mimicking social rejection. The participants then completed a "need for belonging" survey, rating their agreement with such items as "I want other people to accept me." Finally, they viewed pairs of objects and imagined that the items—such as sweaters, guitar picks and helmets—were owned by their favorite actor, musician and athlete, respectively, but that only one in each pair had been touched by the owner. Participants who had been rejected in the game reported a greater need for belonging than did the other participants, and they experienced a stronger preference for the touched items.

Did loneliness change people's belief in magical contagion? In a second study, participants imagined either their favorite actor's sweater or the same sweater completely sterilized. They rated their desire for the sweater, how much it contained the actor's "essence," and their own loneliness or need for belonging. The unsterilized sweater was seen by all as having more of the actor's essence, but only the lonely had a strong preference for the unsterilized sweater. Thus, social disconnection does not appear to change people's belief in magical contagion; it simply makes the magic more appealing.

"Authentic objects are in some way thought to actually have a piece of the person," Newman says. So it may seem silly, but on a solitary night, feel free to curl up with that nice, friendly, autographed football helmet. *—M.H.*

STUART BRIERS

Slo-mo Made Him Do It

Watching video in slow motion can lead us to believe actions are more intentional

When a football player clocks an opponent on the field, it often does not look so bad—until we see it in slow motion. Suddenly, a clean, fair tackle becomes a dirty play, premeditated to maim (as any bar full of indignant fans will loudly confirm). But why? A study published last August in the *Proceedings of the National Academy of Sciences USA* suggests that slow motion leads us to believe that the people involved were acting with greater intent.

Researchers designed experiments based on a place where slow-motion video comes up a lot: the courtroom. They asked subjects to imagine themselves as jurors and watch a video of a convenience store robbery and shooting, either in slow motion or in real time. Those who watched the slow-motion video reported thinking the robber had more time to act and was acting with greater intent. The effect persisted even when the researchers displayed a timer on the screen to emphasize exactly how much time was passing, and it was reduced yet still present when subjects watched a combination of real-time and slow-motion videos of the crime (as they might in an actual courtroom). Participants also ascribed greater intent to a football player ramming an opponent when they viewed the play in slow motion.

Werner Helsen, a kinesiologist at the University of Leuven in Belgium, who was not involved in the study, says the findings are in line with his own research on perception and decision making in crime scene interventions and violent soccer plays.

One possible explanation for this slo-mo effect stems from our sense of time, which author Benjamin Converse, a psychologist at the University of Virginia, describes as "quite malleable." He explains that when we watch footage in slow motion, we cannot help but assume that because we as viewers have more time to think through the events as they unfold, the same holds true for the people in the video.

Converse adds that we often accept video as the absolute truth, even when it has been manipulated. "There are a million things that go into how the video is recorded in the first place and an equal number of variables that go into playback," he says.

Currently there are no consistent guidelines about using slow-motion video in legal settings, yet whether or not an action is deemed intentional can have a considerable impact on the severity of a suspect's sentence. "We're rapidly reaching a stage in which almost every trial that has a question about somebody's actions is going to be accompanied by a video of some sort," says study co-author Zachary Burns, a psychologist at the University of San Francisco. "But I think we do need to understand what the limitations are." ***—Catherine Caruso***

"Super Agers" Have Brains That Look Young

Older adults who perform like young people on tests of memory have a shrink-resistant cortex

As we get older, we start to think a little bit more slowly, we are less able to multitask and our ability to remember things gets a little wobblier. This cognitive transformation is linked to a steady, widespread thinning of the cortex, the brain's outermost layer. Yet the change is not inevitable. So-called super agers retain their good memory and thicker cortex as they age, a recent study suggests.

Researchers believe that studying what makes super agers different could help unlock the secrets to healthy brain aging and improve our understanding of what happens when that process goes awry. "Looking at successful aging could provide us with biomarkers for predicting resilience and for things that might go wrong in people with age-related diseases like Alzheimer's and dementia," says study co-author Alexandra Touroutoglou, a neuroscientist at Harvard Medical School.

Touroutoglou and her team gave standard recall tests to a group of 40 participants between the ages of 60 and 80 and 41 participants aged 18 to 35. Among the older participants, 17 performed as well as or better than adults four to five decades younger. When the researchers looked at MRI scans of the super agers' brains, they found that their brains not only functioned more like young brains, they also looked very similar.

Two brain networks in particular seemed to be protected from shrinking: the default mode network, which helps to store and recall new information, and the salience network, which is associated with directing attention and identifying important details. In fact, the thicker these regions were, the better the super agers' memory was.

The results, which were published in September 2016 in the *Journal of Neuroscience,* corroborate previous research that shows these regions are critical communication hubs in the brain. The findings do not explain why super agers have these thicker cortical regions, although most likely it is a combination of genetic factors and a healthy way of life.

If confirmed by other studies, the discovery of shrink-resistant brain regions in super agers could provide a target for future research on aging-related brain changes, says Emily Rogalski, a cognitive neuroscientist at Northwestern University who also studies super agers but was not involved in the new study. She notes that "we will be better able to investigate the cellular, molecular and genetic mechanisms that keep super agers' cortices thicker" and their minds shipshape. *—Knvul Sheikh*

FLYING COLOURS LTD *Getty Images (top);* NICK DODLING *Getty Images (bottom)*

A Trip Inside the Schizophrenic Mind

Researchers are investigating how hallucinogens might be used to model—and develop treatments for—psychosis

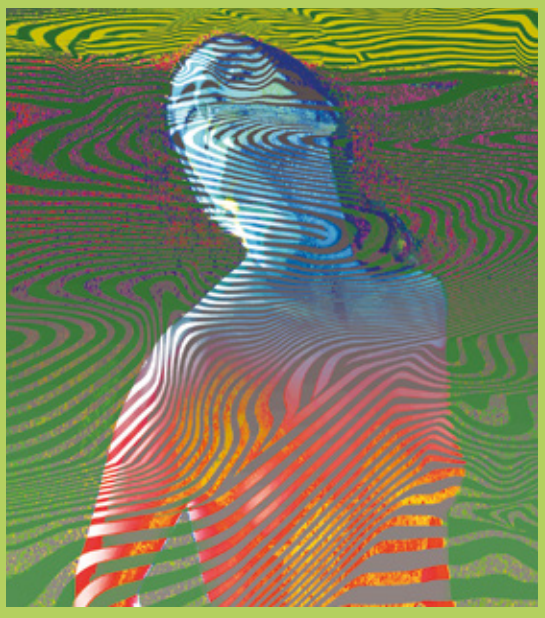
LSD, "magic" mushrooms and mescaline have been banned in the U.S. and many other countries since the 1970s, but psychedelic medicine is making a comeback as new therapies for depression, nicotine addiction and anxiety. The drugs have another scientific use, too: so-called psychotomimetics, or mimics of psychosis, may be useful tools for studying schizophrenia. By creating a brief bout of psychosis in a healthy brain, as indigenous healers have for millennia, scientists are seeking new ways to study—and perhaps treat—mental illness.

"We think that schizophrenia is a group of psychoses, which may have different causes," says Franz Vollenweider, a psychiatrist and neuroscientist at the University of Zurich. "The new approach is to try to understand specific symptoms: hearing voices, cognitive problems, or apathy and social disengagement. If you can identify the neural bases of these, you can tailor the pharmacology."

Vollenweider and his colleagues have found an existing drug for anxiety that blocks specific effects of psilocybin, the psychoactive ingredient in magic mushrooms. When healthy people were given the drug before tripping, they did not report visual hallucinations and other common effects, according to a study published in April 2016 in *European Neuropsychopharmacology*. The effort is part of a burgeoning movement in pharmacology that seeks to induce psychosis to learn how to treat it.

And schizophrenia desperately needs new treatments. Seventy-five percent of afflicted patients have cognitive problems. And most commonly used drugs do not treat the disorder's "negative" symptoms—apathy, social withdrawal, negative thinking—nor the cognitive impairments, which best predict how well a patient will fare in the long term.

Psychedelics such as LSD, psilocybin mushrooms and mescaline (derived from the peyote cactus) all act on serotonin, a neurotransmitter tied to mood. Brain imaging of schizophrenic brains has revealed that networks involved in introspection and those for external attention bleed into one another, as they do in healthy brains on psychedelics. By finding drugs that block this boundary-blurring effect, scientists hope to home in on the biological basis of psychosis and help to prevent it.



GEORGE PETERS *Getty Images*

"If someone is hallucinating, it may not matter if the person is experiencing hallucinations through Parkinson's disease, schizophrenia or a manic episode," says Mitul Mehta, a neuropharmacologist and psilocybin researcher at King's College London, who was not involved in the Swiss study.

The goal of the study was to prevent the deluge of serotonin activation and the resulting hallucinations caused by magic mushrooms, using two nonhallucinogenic chemicals shaped similarly to LSD. The researchers recruited 36 people, each of whom took part in four sessions in the laboratory separated by at least two weeks. They divided people into two groups, each of which tested a different candidate antipsychedelic drug: buspirone, a drug prescribed for anxiety, or ergotamine, one used to treat migraines. The study participants took one of the antipsychedelics followed by psilocybin, a placebo followed by psilocybin, an antipsychedelic followed by a placebo or two placebos in a row. Three hours after taking the drug cocktails, the subjects reported their psychedelic experiences on a standardized questionnaire that measures dimensions of hallucinatory states, including euphoria, visual hallucinations and delusions.

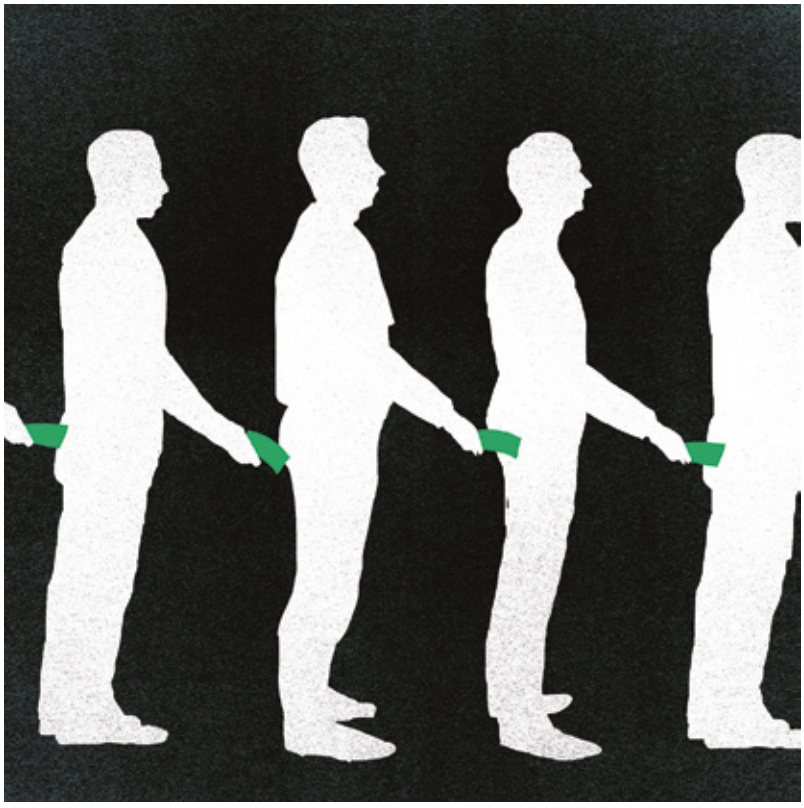
Buspirone prevented some psychotic effects of psilocybin, the researchers found. They hypothesize that by binding to serotonin 1A receptors, which pair with and counteract the serotonin 2A (psilocybin) receptor, buspirone restrained the visual hallucinations, flood of memories and imaginative thinking commonly triggered by psilocybin. The drug had no impact on other psychedelic symptoms such as the anxious sense of ego dissolution or the fear of going insane that some people experience, nor did it prevent decreased alertness during the trip.

The psychotic effects blocked by buspirone are also common in early schizophrenia and Parkinson's. The first approved drug for treating psychosis in Parkinson's, pimavanserin, acts by blocking the serotonin 2A receptor. Vollenweider previously found that a blood pressure drug, ketanserin, blocks the serotonin 2A receptor and prevents virtually all psilocybin effects, but it has not been tested for schizophrenia. Eventually such medicines might not treat the catchall disease "schizophrenia" but alleviate a patient's specific symptoms.

—Taylor Beck

National Corruption Breeds Personal Dishonesty

A shady government influences the moral behavior of its citizens



DAVID SENIOR

One bad apple spoils the barrel, so the saying goes. But what if the barrel itself is rotten?

A number of studies have shown that seeing a peer behave unethically increases people's dishonesty in laboratory tests. What is much harder to investigate is how this kind of influence operates at a societal level. But that is exactly what behavioral economists Simon Gächter of the University of Nottingham in England and Jonathan Schulz of Yale University set out to do in a study published in March 2016 in *Nature*. Their findings suggest that corruption not only harms a nation's prosperity but also shapes the moral behavior of its citizens. The results have implications for interventions aimed at tackling corruption.

The researchers developed a measure of corruption by combining three widely used metrics that capture levels of political fraud, tax evasion and corruption in a given country. "We wanted to get a really broad index, including many different aspects of rule violations," Schulz says. They then conducted an experiment involving 2,568 participants from 23 nations. Participants were asked to roll a die twice and report the outcome of only the first roll. They received a sum of money proportional to the number reported but got nothing for rolling a six. Nobody else saw the die, so participants were free to lie about the outcome.

If everyone were completely honest about their die rolls, the average claim would be 2.5, whereas if everyone were maximally dishonest, all claims would be 5. Participants from nations with a high prevalence of rule violations (PRV)—including Georgia, Tanzania, Guatemala and Kenya—tended to claim more than those from low-PRV countries—such as Austria, the U.K., the Netherlands, Sweden and Germany—and average claims correlated with PRV values. In other words, the more corrupt the country, the more its citizens inflated the number they reported. These values were calculated using data from 2003, and the experiments were conducted between 2011 and 2014 using participants whose average age was 21—too young to have personally influenced PRV ratings but old enough to have been influenced by social norms, implying that national corruption levels influenced participants' honesty, not vice versa.

"These researchers link a simple cheating test to real-world behaviors," says behavioral scientist Amos Schurr of Ben-Gurion University of the Negev in Israel, who was not involved in the study. "This has never been done before."

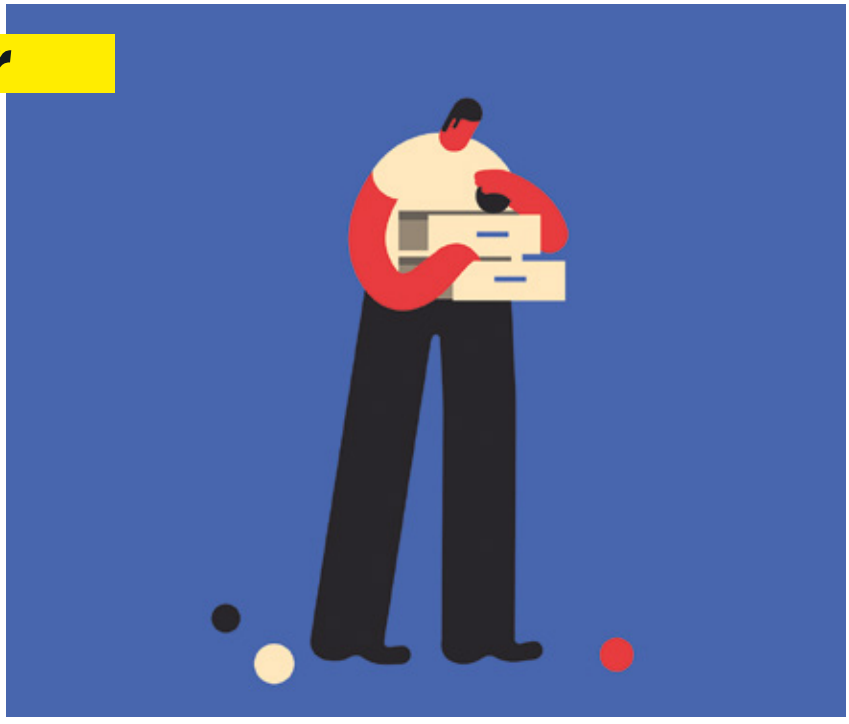
Encouragingly, the researchers found that there was a limit to people's dishonesty, even if they came from profoundly corrupt countries. Claims clustered around the number expected mathematically if, instead of outright lying, people shuffled the facts to report the highest roll instead of the first. "All around the world people are quite honest," Schulz says. They tend to act according to "justifiable dishonesty," but the benchmark of what is justifiable seems to vary slightly according to the level of corruption in one's homeland.

Classic economic theory assumes that people act to maximize their gains, but the finding that they do not lie outright fits with theories suggesting individuals have a psychological incentive to view themselves as honest. "You have competing forces: financial incentives and psychological incentives to keep an honest self-view, which balance out," Schulz explains. "It's easier to keep a good self-image while being more corrupt if you see a lot of corruption around you."

The findings imply that highly corrupt countries may be difficult to change because their citizens have been shaped by norms that permit dishonesty. Yet there is also a positive practical implication. Rather than tackling corruption by targeting institutions, we might do better to aim at young people. "Changing formal institutions will be hard, but institutions rely on people," Schulz says. "It will take a long time, but I think it's a worthwhile path." —*Simon Makin*

A GUIDE TO MASTERING YOUR WORLD

How to Be a Better organizer



When my eldest daughter started school last fall, I realized our family needed a whole lot more order and routine if we were going to survive kindergarten: late-start days, no-school days, "spirit" days (wear pj's!) and avalanches of worksheets. At first, I was petrified. Then I realized this transition was an opportunity to better organize our lives. So I dug into marketing and neuroscience research to find out how to take control of the chaos.

#1 Start a junk drawer. "I'm very deliberate about how I organize my stuff," says Daniel Levitin, a behavioral neuroscientist at McGill University and author of *The Organized Mind* (Dutton, 2014). "It used to freak me out if I didn't have a special place for everything," he says. "But the junk drawer is actually a triumph of organization." In researching his book (which started out as a history of filing cabinets of all things!), Levitin learned it's best not to create *too many* categories for sorting. Imagine having 20 file folders containing just one slip of paper each. That kind of granularity stretches the capacity of your memory, he says. But grouping uncategorizable items together in a miscellaneous folder or drawer makes it easier to recall where they are.

#2 Dial down the visual noise. When I first sat down to write this column, I had 15 digital sticky notes scattered all over my computer desktop. One is my to-do list. The rest are digital detritus—previously important bits of info that I just haven't gotten around to dealing with. Having this type of "noise" in our sight lines takes a mental toll. Multiple studies have found that visual clutter competes for our attention, making it more difficult to concentrate on a task.

But grouping your clutter can help: One 2011 functional MRI study by neuroscientists Stephanie McMains and Sabine Kastner, both then at Princeton University, found that arranging similar bits of visual clutter next to each other made them less distracting. After reading that study, I dragged all my random desktop files into one new, clean blue folder, stacked all the sticky notes in one corner of the screen, and heaved an involuntary sigh of relief.

#3 Prepare yourself to pare down. North America is rife with self-storage facilities packed with an overflow of stuff people can't fit into their homes anymore. There are good reasons why people have a hard time letting go of things: Our possessions accrue meaning and value through their associations with our past and even future aspirations, says Catherine A. Roster, a marketing professor at the University of New Mexico, who studies people's relationships with their stuff. At some level, our things become intertwined with aspects of our own self-image, so getting rid of them can feel like tossing out pieces of ourselves.

But there are steps you can take to prepare yourself for a spring cleaning. Just stick your precious, but unneeded, things in a closet or attic for a while. "When you encounter them again, it becomes more evident that these objects are not as important as you initially imagined," she says. "Creating spatial distance from objects that are infrequently used but still have highly charged meanings can be a sort of cooling-off period."

#4 Restrict your digital diet. Of course, clutter isn't just stuff you can see or touch. Twitter notifications, text pings, floods of e-mails, Facebook updates—all of these compete for our attention and add to the feeling of being overwhelmed. In fact, when your phone buzzes with a text or call, it significantly distracts you even if you "ignore" it and don't pick up, a 2015 study by Florida State University psychologists found. During the experiment, researchers purposely called or texted college students in the middle of a task and found that the students made about 25 percent more errors than when they were left alone. Even though a digital ping is usually over quickly, the wondering and mind wandering it kicks off *isn't,* the researchers wrote.

I have suspected for a while now that too much digital input has been muddying my mental waters—and doing the research for this column confirmed my suspicion. So I recently deactivated my personal Facebook account, unfollowed all but a couple of vital folks on Twitter and limited myself to checking nonwork-related news once a day. Already I feel more clearheaded. "The biggest principle in organizing your life is to be deliberate about how to spend your time," Levitin says. "Time is the scarcest resource that most of us have, so choosing what you do and when you're going to allow yourself to be interrupted is key." —*Sunny Sea Gold*

MAGOZ (*Illustration*); PAUL PANTAZESCU © *iStock.com* (*globe*)

How to Keep the Passion Alive

Couples often lose their mojo after many years together, but research suggests being more responsive could rekindle desire

It's one of Hollywood's classic plotlines: the married couple trying to reignite their passion after years of kids, dirty laundry and, well, life together. Sound familiar? Probably because it echoes a common complaint among real-life couples, who often experience a decline in sexual desire over time. But according to new research, long-term couples can buck the trend and get their groove back if they learn how to be more responsive partners.

The study, published in the October 2016 issue of the *Journal of Personality and Social Psychology,* found that couples can reawaken desire by demonstrating and practicing "responsiveness"—reactions and behaviors that signal a person genuinely appreciates and supports his or her partner and is willing to invest in the relationship.

Lead author Gurit Birnbaum, a professor of psychology at the Interdisciplinary Center in Herzliya, Israel, Harry Reis, a University of Rochester psychology professor, and their colleagues conducted three experiments that were designed to examine whether partner responsiveness and intimacy-building behaviors could rekindle desire for one's partner. In the first study, 153 participants were told they would have an online discussion with their partner about a recent meaningful life event. In reality, they interacted with a researcher who sent either a responsive message (such as "you must have gone through a very difficult time") that indicated attentiveness to the partner's views or an unresponsive message ("doesn't sound so bad to me"). Findings, which were compiled through observation and self-reported questionnaires, showed that women experienced greater sexual desire while interacting with a responsive partner than while interacting with an unresponsive one. Curiously, men's desire was not significantly different in the two responsiveness situations.

In the second study, researchers filmed 178 participants while they discussed a personal event with their partner, finding that the more often one partner displayed responsive behaviors (such as listening, getting facts right that their partner conveyed, making their partner feel respected and communicating feelings of affection), the more desire the other partner reported.

In a final study, 100 couples were asked to keep a daily diary for six weeks documenting their level of sexual desire and perceptions of their partner's responsiveness. The researchers found that both men and women who perceived their partner as responsive had a heightened interest in sex with them, although the effect was stronger for women than for men.

"For a lot of people, feeling an intimate connection and feeling they're understood is a really important part of sexuality," says David Frederick, an assistant professor of health psychology at Chapman University in California, who was not involved in the research. "If you feel your partner is caring and validating, it makes some people want to reach out more, and that validation can lead to sexual desire. It can make someone appear as a better partner and more sexually attractive."

The research was partially inspired by what psychologists call the intimacy-desire paradox—the concept that the greater the intimacy between partners, the less sexual desire they feel. Clinicians have long reported anecdotally that patients say intimacy and closeness quash desire and that novelty and newness are sexually arousing. But Birnbaum and Reis contend that the intimacy-desire paradox does not hold true under certain circumstances. Their findings suggest that what determines whether intimacy stifles or instigates desire is not its mere existence but its contextual meaning. "Responsiveness ignites desire by conveying the message that a partner is valued and worth pursuing. Sex is then seen as promoting an already cherished relationship," Birnbaum says.

Frederick, who is lead author of a study published this year examining sexual satisfaction and dissatisfaction among heterosexual couples in long-term relationships, notes that it may not be familiarity per se that causes sexual feelings to diminish but rather the decline in unpredictability and newness—qualities known to trigger a release of dopamine and a sexual rush. But in some couples, feelings of validation and intimacy foster sexual satisfaction, he says: "There are many ways intimacy and passion can become intertwined."

—Jeanne Dorin

GETTY IMAGES

Battlefield Deceptions

To avoid or at least control conflict, militaries often play tricks on their opponents' perceptions

"*All warfare is based on deception.*"
—Sun Tzu, circa sixth century B.C.

Los Angeles is an illusory place. From the magic of Hollywood to the city's surreal atmospheric light, it's easy to feel like physical reality only sometimes coincides with your perceptions. For that reason, L.A. was the perfect backdrop for a special workshop we attended a few years ago, organized by the Defense Advanced Research Projects Agency (DARPA) to develop illusions that might help the military—itself a surreal topic. In fact, the location was necessary. Among the attendees, only three people, including both of us, were neuroscientists; the rest were high priests and priestesses from the entertainment industry—directors, writers, Foley artists (who reproduce everyday sounds for films), and sound/special-effects engineers. Together we advised DARPA on the technology and research it should invest in to ensure that the U.S. military continues to meet 21st-century scientific standards for tactical camouflage, concealment (or hiding without camouflage), and deception. Perhaps most important, the group explored the role that misperception can play as a deterrent, helping soldiers avoid battle altogether.

Governments are no strangers to military deception—on the contrary. "Misleading one's adversary about the nature, size and location of your military forces—and disguising your tactical or operational intentions—has been part and parcel of military strategy since its inception," said William Casebeer, our DARPA host, who is now research area manager for human systems and autonomy at Lockheed Martin's Advanced Technology Laboratories. Thousands of years ago legendary Chinese general Sun Tzu emphasized the importance of shaping enemy perception to optimize success, either by winning or, even better, by obviating warfare—a point echoed by virtually every prominent military theorist since. Casebeer asserted that illusions—from those affecting basic sensory input to ones shaping high-order cognition and driving judgment and decision making—have helped many nations sidestep the formation of war zones. When conflict was inevitable, illusions also helped soldiers egress from war zones safely.

We cannot discuss the specific secret ideas and approaches developed in the workshop to achieve DARPA's goals—if we told you, we *might* have to kill you!—but this article describes some publicly disclosed illusions that governments and militaries have used to create strategic surprise and save lives in the course of conflict.

DONGYUN LEE (*illustration*); SEAN McCABE (*Macknik and Martinez-Conde*)

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

Stephen L. Macknik and Susana Martinez-Conde are professors of ophthalmology, neurology, and physiology and pharmacology at SUNY Downstate Medical Center in Brooklyn, N.Y. They are authors of the Prisma Prize–winning *Sleights of Mind,* with Sandra Blakeslee (http://sleightsofmind.com).

Send suggestions for column topics to **MindEditors@sciam.com**

FLASH BANG

Flashing bright lights have been used to dazzle adversaries throughout the past century. In World War II, the British mounted carbon-arc searchlights on tanks as a means of blinding Nazi pilots attacking ships on the Suez Canal. The system, called the Canal Defense Light, shot a flickering bright light—which the developers thought was especially disorienting—through a turret slit, aimed at attacking aircraft. It owed its blinding effect to rapid-fire bursts of activity from neurons within the retina and the first several stages of the brain's visual system that respond to lights switching on or off (as we have shown in our own research). Although the tanks were deployed to the canal to deter bombing runs, they were not used.

A related nonlethal tool that militaries and police have used since the mid-1970s is the stun grenade. It produces a very loud explosive sound (greater than 170 decibels, or louder than a shotgun blast) and a coincident bright flash, meant to saturate all the human photoreceptors in the immediate area and temporarily blind the people they belong to. These devices are not meant to physically damage adversaries but instead to reduce the efficiency of their primary sensory systems for about five seconds.

GHOST ARMIES

During World War II, the Allies built a massive army of dummies and inflatable vehicles, used to "strengthen" actual troops on the ground. These fakes were, from the air, similar enough to the real thing to affect Nazi strategy decisions in several different theaters and at various stages of the war. The British army employed a magician, Jasper Maskelyne, to lead their deception development team, called the Magic Gang. They reportedly spoofed German field marshal Erwin Rommel at the Battle of El Alamein by disguising 1,000 tanks in the north as common trucks while "attacking" from the south with 2,000 decoy tanks (plus phony support vehicles).

Today military vehicle and weapons decoys are highly realistic and can go unrecognized to within a few hundred yards. They can be deployed and removed within minutes. This type of mimicry works because the human visual system has limited acuity and thus resolves details of shape as a function of distance (the closer you are, the more detail you see). Decoys are designed with specific minimal viewing distances (and satellite-imaging resolutions) in mind so that analysts cannot easily distinguish the decoy from the real thing. Decoys are much cheaper to make than real weapons. Their strategic use can therefore boost a military's apparent capabilities at a lower cost.

MAGICAL MIGHT

In colonial Algeria in 1856, the imperial French government worried that popular tribal religious overlords, called Marabouts, had undue influence over the populace and the Arab chieftains, who widely believed that the Marabouts could produce miracles. These feats were magic tricks, of course. So French military leaders enlisted the help of famed Parisian magician Jean Eugène Robert-Houdin. They hoped that his illusions—which he performed in a theater in Algiers and later at a series of desert outposts—would rival those of the Marabouts and undermine the public's magical thinking. His so-called Light and Heavy Chest trick proved especially effective in this regard: He would call to the stage a strong man from among the Arab chieftains and ask him to lift a small wood box. Then he would announce that he would render the strong man weak—so weak that he would no longer be able to lift the same box. In fact, the box contained an electromagnet—a force unknown to the Marabouts—that Robert-Houdin used to hold it in place. For good measure, Robert-Houdin would end the act by delivering a painful but harmless electric shock to his unsuspecting Hercules, who inevitably ran from the stage.

MORE TO EXPLORE

- **Memoirs of Robert-Houdin, Ambassador, Author, and Conjurer.** Jean-Eugène Robert Houdin. Translated by Sir Frederic Charles Lascelles Wraxall. Chapman and Hall, 1859.
- **Secret Strobelight Weapons of World War II.** David Hambling in *Wired.* Published online May 17, 2008. **www.wired.com/2008/05/wwii-strobe-t-1**
- **The Ghost Army of World War II: How One Top-Secret Unit Deceived the Enemy with Inflatable Tanks, Sound Effects, and Other Audacious Fakery.** Rick Beyer and Elizabeth Sayle. Princeton Architectural Press, 2015.
- **Decoys in Service of an Inflated Russian Might.** Andrew E. Kramer in *New York Times;* October 12, 2016.

PUBLIC MENTAL HEALTH

Shaping the Urban Brain

Cities shape how we think, feel and behave. Can we create cities that improve our brain health?

By Sandro Galea

Not quite four decades ago the Chinese settlement of Shenzhen was a modest fishing village, with a population of roughly 30,000. Today, thanks to a policy begun in 1979 that encouraged foreign investment, that sleepy community is a manufacturing hub with about 10 million people.

The success of Shenzhen is consistent with the broader development of China's Pearl River Delta. Once mostly agricultural land, it has become, according to a recent World Bank report, the largest urban area on earth. The cities in the region have a combined population of about 57 million—larger than the populations of many countries, including Canada, Argentina and South Africa. The region's development is a dramatic example of the global trend of urbanization. Now more than ever, we are living in an age when the health and fortune of billions are tied to the growth of cities.

In 1800 just 3 percent of the planet's population lived in an urban area. Over the next two centuries that proportion exploded, until, in 2008, it reached 50 percent. This striking demographic shift shows no signs of slowing down. The United Nations has projected that 66 percent of the globe's population will live in urban areas by 2050, with 90 percent of this increase occurring in Africa and Asia.

Shaping economies, the environment and more, the effects of urbanization are tremendous and broad-ranging. This influence is no less true for our physical and mental health. So as urban life becomes the norm for the bulk of humanity, we face a rising tide of mental illness—one we are already seeing in many places, including Shenzhen—but also opportunities to create cities that foster mental health.

Urban Hubs of Risk

From public hygiene, to the living and working conditions of urban residents, to exposure to infectious diseases and dirty air, cities exert a profound influence on all aspects of our health. This has been the case since well before our present era. When the industrial revolution brought a wave of urban expansion, many literary and social commentators, including Charles Dickens in the U.K. and Émile Zola in France, wrote about the dangers of population density, crime and pollution.

The public health community has collected decades of evidence linking urban living with an increased risk of diseases such as cancer, asthma, depression and overall rates of mortality. Among the first to suggest that cities also influence the workings of the brain were sociologists Robert Faris and H. Warren Dunham, who documented a concentration of schizophrenia and other mental disorders in the slums of Chicago. In 1939 they theorized that the social disorganization found in certain parts of cities could produce a sense of isolation in some individuals and lead to psychological distress.

Subsequent research has compared the mental health of urban residents with that of their rural counterparts. A 2010 meta-analysis, for instance, revealed that urban zones were associated with a 39 percent greater risk of mood disorders and a 21 percent greater risk of anxiety disorders.

Cities have also been linked with higher rates of post-traumatic stress disorder (PTSD). While U.S. crime rates have steadily declined in the past 25 years,

CAM FLOYD

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the concentration of violence in some urban neighborhoods has driven up PTSD rates in those areas. The scope of the problem can be breathtaking. When researchers began examining patients at Chicago's John H. Stroger, Jr. Hospital of Cook County, which treats nearly 2,000 patients a year for traumatic injuries such as gunshots and stabbings, they found that more than 40 percent of the patients they screened showed signs of PTSD.

There are several mechanisms through which cities can influence our mental health. For example, by keeping large numbers of people close together, cities make it easier for anxiety to spread through densely concentrated urban populations, almost like an infectious agent. The name for this phenomenon is "social contagion." Although the cause of social contagion is the subject of debate, it may lie in our human tendency to observe and mimic the behavior of others. For example, according to a 2011 review by psychiatrists at Columbia University, many New Yorkers who did not witness the September 11, 2001, terrorist attacks firsthand nonetheless reported anxieties typically seen among people who experience violence and trauma directly.

Although cities tend to have more resources—hospitals, wealth, places to buy food—than rural areas, access to these resources is not evenly distributed among urban populations. Lack of access, combined with stressors such as noise, crime and pollution, can strain urban residents, affecting mental health.

These stressors do not emerge by chance. They are the result of powerful structural forces—among them racism, education level, environmental pollutants and income inequality—that underlie the social, economic and even physical character of cities. Together they shape the conditions that create or curtail all aspects of health. Racist housing practices, for example, led to the residential segregation that concentrates crime in certain urban areas, to the detriment of both physical and mental health. And income inequality, particularly pronounced in cities, is a key driver of mental health problems for many low-resource households.

The Power of Structural Change

Given that more and more of us are living in cities, how do we go about building cities that can improve, rather than detract from, our mental health? The solution lies in rethinking some of the structural conditions that shape the social, environmental and economic aspects of urban life.

In August 2016 former U.S. secretary Julián Castro of Housing and Urban Development (HUD) unveiled a plan very much in line with this approach, proposing a regulation that would lower the permissible level of lead exposure in approximately 128,000 HUD-assisted units of housing in American cities. Lead exposure has been linked to depression and panic disorders, as well as other health conditions; tighter regulation and better monitoring of lead levels stand to help safeguard mental health.

HUD has also taken aim at residential segregation, recently releasing a new rule to bolster the often laxly enforced Fair Housing Act. Given what we know about the link between segregation and stress, changes at the level of policy have the potential to mitigate the effects of the unfair and harmful status quo. Whether such policies will continue with the Trump administration, which has vowed to reduce federal regulations across the board, is something to watch for.

China, home to some of the world's fastest-growing cities, is just beginning to recognize and grapple with the mental health risks associated with urbanization. In Shenzhen, mental health issues account for roughly 20 percent of the city's overall disease burden, according to a 2011 analysis by Dan Zhang and his associates, the highest reported rate of adult mental illness in any Chinese city.

Step one in confronting this issue is to bring mental illness from out of the shadows of stigma, which prevents sufferers and their families from seeking help. Fortunately, China has begun to address this with the enactment of its first national mental health law in 2013, which also calls for a range of reforms focused on better prevention and treatment. China and other urbanizing countries will also need to contend with the impact of pollution, crowding, substandard housing and other problems that come with rapid shifts of population into cities.

The stakes are high. The choices political leaders make now will determine the trajectory of mental health in cities for years to come. And given where most of humanity will be living, healthier cities mean, ultimately, a healthier world. M

URBAN LIVING HAS BEEN LINKED TO A 39 PERCENT GREATER RISK OF MOOD DISORDERS AND A **21 PERCENT ADDED RISK OF ANXIETY DISORDERS.**

MORE TO EXPLORE

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"Doctor, I'm always in the most terrible pain," he said, with closed eyes. "I had no other options. I started using heroin, bought it from my neighbor to help with the pain. I'm scared stiff."

ILLUSTRATIONS BY CHRIS GASH

A Painful Descent into Addiction

How did an educated, elderly engineer wind up with a heroin habit?

By Daniel Barron

It was 4 P.M., and Andrew* had just bought 10 bags of heroin. In his kitchen, he tugged one credit-card-sized bag from the rubber-banded bundle and laid it on the counter with sacramental reverence. Pain shot through his body as he pulled a cutting board from the cabinet. Slowly, deliberately, he tapped the bag's white contents onto the board and crushed it with the flat edge of a butter knife, forming a line of fine white powder. He snorted it in one pass and shuffled back to his armchair. It was bitter, but snorting heroin was safer than injecting, and he was desperate: his prescription pain medication was gone.

I met Andrew the next day in the emergency room, where he told me about

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**Not the patient's real name.*

OPIOID USE: TROUBLING TRENDS

SINCE 1999 sales of prescription opioids in the U.S. nearly quadrupled, as did the number of opioid overdose deaths

78 AMERICANS die every day from opioid overdose; at least half involve a prescription opioid

FOUR OUT OF FIVE new heroin users started out by misusing a prescription opioid

ONLY ONE IN THREE people prescribed opioids says his or her doctor discussed a plan for getting off the medication

the previous day's act of desperation. I admitted him to control his swelling legs and joint pain. He was also detoxing from opioids.

Andrew looked older than his 69 years. His face was wrinkled with exhaustion. A frayed, tangled mop of grizzled hair fell to his shoulders. Andrew had been a satellite network engineer, first for the military, more recently for a major telecommunications company. An articulate, soft-spoken fellow, he summed up his (rather impressive) career modestly: "Well, I'd just find where a problem was and then find a way to fix it."

Yet there was one problem he couldn't fix. "Doctor, I'm always in the most terrible pain," he said, with closed eyes. "I had no other options. I started using heroin, bought it from my neighbor to help with the pain. I'm scared stiff."

For two decades Andrew had suffered serial joint failures from a combination of arthritis, obesity and other factors. Each began as an achy pain and ended in a joint replacement. His right shoulder was the first to go, followed by both hips, a knee and an ankle. Pain always ensued. The new joints kept getting infected: more surgery, more pain. To make things worse, a bathtub mishap broke his right femur. That led to an operation to insert a full-length titanium rod. A perfect storm of complications had left Andrew barely able to hobble around the small apartment he shared with his adult son. (Andrew's wife had left him shortly after he broke his femur, and his son took him in.) Pain became Andrew's all-consuming nemesis, devouring most of his waking hours.

Vitamin O

Andrew was first prescribed an opioid after one of his many surgeries. This was in the late 1990s, around the time when prescriptions for these painkillers began to take off nationally. His doctor began him on Vicodin, a commonly used opioid that combines hydrocodone with acetaminophen (Tylenol).

Pain, like vision, touch or taste, is a sensory signal. The brain has an elaborate network of receptors, neurons and centers dedicated to pain. Opioids exert their effects by binding to mu-opioid receptors, which are densely concentrated in brain regions that regulate pain perception and reward. Activating mu receptors blocks pain signals in the spinal cord and the response to this signal in the brain. Mu receptors also cause the release of dopamine in reward pathways, which is why opioids cause both analgesia and euphoria.

Surgery after surgery, opioids became Andrew's vitamins, as vital to his pain control as blood pressure drugs are for hypertension. Yet in 2005 Andrew noticed he was feeling anxious about his pill supply. "You start out with a bottle of 30 pills, then there's only 20, then only 10. It's scary when you run out."

Months after his surgeries, after his scars were healed, he still struggled with deep, biting pain. It had spread throughout his body and required more pills to

SOURCES: CDC (*opioid sales and deaths*); U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES (*new heroin users*); *WASHINGTON POST*/*KAISER FAMILY FOUNDATION SURVEY OF LONG-TERM PRESCRIPTION PAINKILLER USERS AND THEIR HOUSEHOLD MEMBERS*, BY BIANCA DIJULIO ET AL. KAISER FAMILY FOUNDATION, DECEMBER 2016 (*doctors discussing opioids*)

tame. Andrew had transitioned from what is called acute pain (pain from his surgical wounds) to chronic pain (pain in the absence of an obvious cause). He had also developed a tolerance to the opioids. On a cellular level, this means that his neurons expressed fewer mu receptors, so he needed to flood his system with higher doses to get the same effect as before. (Andrew, ever the engineer, appreciated the irony of wrangling yet another network, this time with drugs.)

Possibly, the opioids had contributed to Andrew's spreading pain. Some patients on these drugs have been known to develop increased pain sensitivity known as opioid-induced hyperalgesia.

From Prescription Meds to Street Drugs

As his tolerance for opioids grew, Andrew found that even 15 milligrams of oxycodone no longer worked for him. After he relocated to his son's apartment, he no longer had a primary care provider familiar with his history and could not refill his medications.

With nowhere to turn, Andrew mentioned his situation to his neighbor, who sold him diverted opioids—prescription medications hawked on the street. When these ran out, his neighbor sold him heroin. Andrew's dependence on heroin terrified him, and at $100 a day, it threatened to bankrupt him as well.

This trajectory is by no means unusual, according to Andrew's lead doctor, William Becker, an addiction medicine specialist and assistant professor at the Yale School of Medicine: "Chronic pain is the new initiation to heroin. We're finding that it's older and older patients, who start on the path to chronic pain, then on to opioids, then on to heroin." Andrew's case is a "classic example," he said. "The numbers are controversial, but as tens of millions of people taking opioids for pain age, we think 10 percent and maybe more will develop at least a mild opioid use disorder. And their pain isn't going away. We have to become more fluent in managing the co-occurrence of chronic pain and addiction."

His words and recent warnings from U.S. surgeon general Vivek H. Murthy about the "urgent health crisis" caused by our lax approach to opioids now come to mind every time I consider writing a prescription for one of these painkillers. I also think of Andrew standing at his kitchen counter, hands trembling as he forms a line of heroin.

> "CHRONIC PAIN IS THE NEW INITIATION TO HEROIN," SAYS ONE SPECIALIST. OLDER AND **OLDER PATIENTS ARE STARTING DOWN THIS PATH.**

Relief and Release

Luckily for Andrew, Becker runs the Opioid Reassessment Clinic, which is pioneering strategies to taper patients with chronic pain from high-dose opioid use to Suboxone, a clever sublingual tablet that combines buprenorphine and naloxone. Buprenorphine activates the mu-opioid receptor. When taken under the tongue, it provides pain relief and prevents withdrawal. Naloxone is added as a safeguard to keep abusers from injecting the drug. When taken sublingually, naloxone has no effect. When injected, it blocks the mu receptor and causes acute withdrawal, a physiological inducement to use Suboxone in the prescribed manner.

At a dollar a day, Suboxone is affordable. In combination with intensive psychosocial therapy, it is a safe and highly efficacious treatment for opioid use disorders. And, as Andrew attested, it actually controls pain better than heroin. Instead of being strung out on heroin, Suboxone allowed Andrew to meaningfully interact with our medical team. He undertook a program of proved therapies for chronic pain that included physical therapy, mindfulness training and psychosocial therapy. Andrew left the hospital after nearly three weeks with a clear plan: weekly check-ins at Becker's Suboxone clinic and continued physical and psychosocial therapy tailored for pain. The last time I saw him in his hospital room, he was excited at the prospects: "The plan is to continue with Suboxone and to stay with it. And hopefully I won't have any more surgeries. It's been a rough decade, a long haul, but I'm making slow progress."

Andrew will be managing pain and addiction for the rest of his life, but now he has a variety of tools for doing so that are safe, legal and effective. M

MORE TO EXPLORE

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Getting Preschool Right

The push for rigorous prekindergarten education has overlooked the evidence on how young kids really learn best

By Melinda Wenner Moyer

PHOTOGRAPHS BY ANNABEL CLARK

Two students build together at the Randolph School, a private school that runs from prekindergarten through fifth grade. High-quality preschool programs balance freewheeling playtime with structured activities and guidance from teachers.

The block room at the Randolph School in Wappingers Falls, N.Y., is bustling with preschool builders. One boy places a tall, wood, cross-shaped block under a newly erected archway, explaining to onlookers that it is a revolving door. On a nearby wall hang drawings the children have made of past creations; sometimes the students build over several days, creating miniature, interconnected cities.

"Thomas wrecked my building!" one child complains. Evan Miklos, his teacher, has been observing the children, occasionally piping in with open-ended questions or suggestions. "Why don't you tell Thomas how that makes you feel?" Miklos suggests. "Sometimes this kind of thing happens by accident, but it's okay to tell him you're frustrated."

The boy follows his advice, and tension quickly diffuses. Moments later recess begins. The children keep all-weather gear in their cubbies so that they can play outside every day—even when it is raining or snowing. All the kids clean up and head outside for an hour, crossing a red brick patio that they built last year as a group. They did most of the measuring, designing and bricklaying themselves. "Kids love real work," Miklos says.

According to the latest research in early childhood education, Randolph, a private school, is doing a lot of things right. Its child-centered curriculum encourages students to learn math, literacy and critical thinking via hands-on activities and play, making their education largely self-directed. Teachers are warm, responsive and skilled—they help kids navigate their emotions, they encourage and value the students' perspectives, and they guide playtime to make it more meaningful. Young children learn best, says the nonprofit National Association for the Education of Young Children (NAEYC), in precisely these kinds of environments.

Over the past two decades policy makers in many states have come to recognize the foundational importance of preschool—especially for lower-income children—and have earmarked funds to support it. In 2013 President Barack Obama unveiled a plan to provide universal preschool to all low- and moderate-income four-year-olds across the country, citing it as a way to narrow the vast achievement gap that persists between wealthy and poor kids. In 2012 28 percent of American four-year-olds attended preschool, twice the percentage that did in 2002. But even as more and more preschools—many state-

FAST FACTS

THE PROBLEM WITH PRESCHOOL

1. Poor funding, ill-prepared teachers and a premature emphasis on academics put many pre-K programs out of alignment with what researchers recommend.
2. Many programs sideline recess and exploration in favor of teacher-led instruction; other schools rely too much on unstructured play. Both approaches are problematic.
3. "Scaffolded" play, in which teachers prompt and guide children at play to help them learn, may be uniquely effective in helping preschoolers master new concepts.

funded—open around the country, an ever shrinking percentage of them resemble Randolph.

Only 18 percent of low-income American children, versus 29 percent of high-income kids, are getting a high-quality preschool education, according to the Center on Enhancing Early Learning Outcomes, an arm of the U.S. Department of Education. Many children attend mediocre schools that provide few, if any, lasting benefits.

Why are America's preschools failing? For one thing, few states fund their pre-K programs well. Public and private spending on preschool amounts to 0.4 percent of the U.S. gross domestic product (GDP), less than half as much as is spent by Spain, Israel or Denmark. In part as a result, preschool teachers are woefully underpaid and underskilled. Annually they earn between $10,000 and $30,000 less than historically undersalaried public school elementary teachers, driving a turnover rate so high it is rivaled only by the fast food industry. Until these funding and workforce problems are addressed, "we can come up with the best strategies for teaching in the world," says Deborah Stipek, a professor at the Stanford University Graduate School of Education, "but they're not going to be implemented."

Preschool curricula remain subpar for other reasons, too. Because of the push for greater rigor and accountability in public education, kindergarten preparation and readiness have become a national priority. In the 2010–2011 school year 73 percent of rising U.S. kindergartners were administered readiness tests that have, unsurprisingly, also created "pressure downward into the early childhood education space," explains Susan Hedges, the NAEYC's director of program quality research.

This pressure is not in itself a problem, but how preschools are handling it is: they are changing their pedagogical approaches, replacing play and exploratory activities with teacher-driven instruction, which, ironically, is less effective for learning in the long term and stifles curiosity and creativity. New research suggests we should be doing precisely the opposite: teaching kids through guided—or "scaffolded"—play and hands-on, child-led activities, which can help them learn concepts more deeply. "Somehow, somewhere, we decided that success for our children is how well they do on math and reading tests," says Kathy Hirsh-Pasek, a psychologist at Temple University who studies how children learn. "We kind of forgot that what's really important is raising humans."

The Devil Is in the Details

The seeds of our country's vast reconceptualization of preschool were sown in 1983, when President Ronald Reagan's National Commission on Excellence in Education published a report entitled *A Nation at Risk*. It asserted, among other things, that if "an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war." The report demanded that the country dedicate greater resources to education to make public school more rigorous.

Fast-forward to 2002, with President George W. Bush's signing of the No Child Left Behind Act (NCLB), and public schools were suddenly being held accountable for educational outcomes in consequential ways. "Passage of NCLB made for the greatest amount of standardized testing this country has ever seen," says Samuel Meisels, founding executive director of the Buffett Early Childhood Institute at the University of Nebraska.

Accountability itself is not a bad thing; it is important for schools to assess whether their programs are effective. But high-stakes standardized tests are not always reliable, and they can have unintended downstream effects. For one thing, there has been little evidence to suggest that scores on early elementary school standardized tests predict academic success later on. Yet under NCLB, public schools that did not meet targeted scores for multiple years could suffer serious sanctions, including losing funding or being shut down entirely—so administrators and teachers have found themselves under enormous pressure to ensure that students test well. "We saw an increase in expectations for what children would be able to do early on in school," Meisels says, "and that resulted in a downward extension of these academic demands through the primary grades and then, eventually, into early childhood."

Amid a growing emphasis on math and reading tests, "we kind of forgot that what's really important is raising humans," says Kathy Hirsh-Pasek, a Temple University psychologist.

At the same time, policy makers began to recognize the need for publicly funded prekindergarten programs. If kids from low-income homes were doing poorly in school, the thinking went, then educating them earlier might help.

There were impressive precedents, such as the Abecedarian Project, a long-term research study undertaken by researchers in North Carolina starting in 1972. They randomly assigned 111 babies, deemed "high risk" because of factors that included low family income and education, either to get no intervention or to receive high-quality child care and preschool for eight hours a day, five days a week, from infancy through age five. In elementary school, those in the intervention arm had stronger cognitive and academic skills than the control group; by age 30 they were 3.8 times more likely to have gone to college.

But today's state-funded pre-K programs look very little

Preschool by the Numbers

ILLUSTRATION BY PETER HOEY

Who Goes?

44% of rural four-year-olds attend vs. **79%** of urban and suburban kids

About 60% of preschoolers (at any age) attend a public preprimary school

Public vs. Private

29% of all four-year-olds attend a pre-K run by the state

25% attend a private preschool

9% attend the federal Head Start program

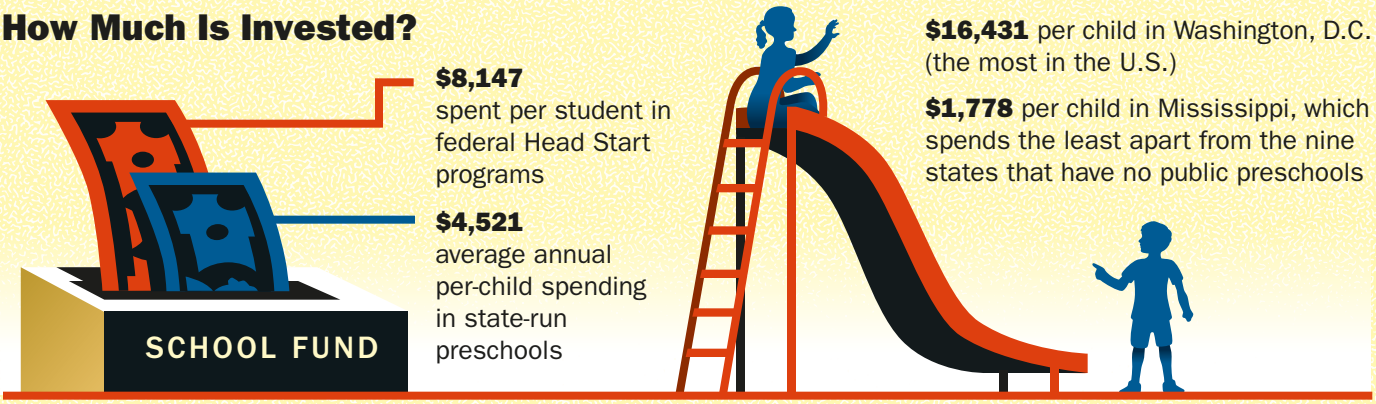
Attendance

77% of kids from high-income homes attend vs. **57%** of kids from low-income homes

How Much Is Invested?

$8,147 spent per student in federal Head Start programs

$4,521 average annual per-child spending in state-run preschools

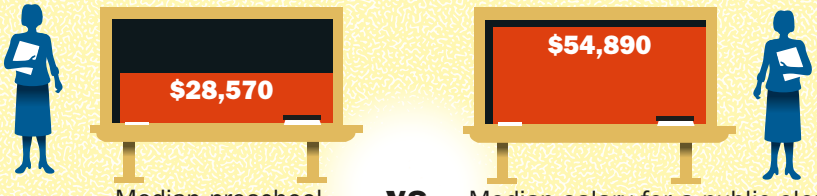


$16,431 per child in Washington, D.C. (the most in the U.S.)

$1,778 per child in Mississippi, which spends the least apart from the nine states that have no public preschools

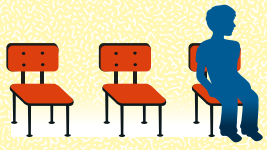
How Do Teachers Fare?

30%–37%: Annual turnover among pre-K and child care staff, driven by low wages, limited training and instability in management

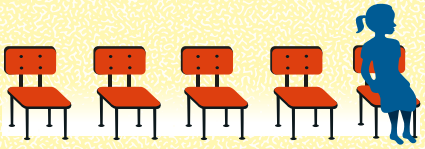


Median preschool educator's salary **vs.** Median salary for a public elementary school teacher in the U.S.

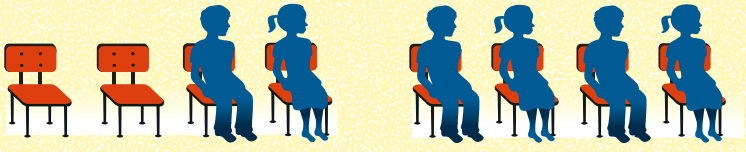
Who Gets a High-Quality Start in School?



1 in 3 affluent four-year-olds

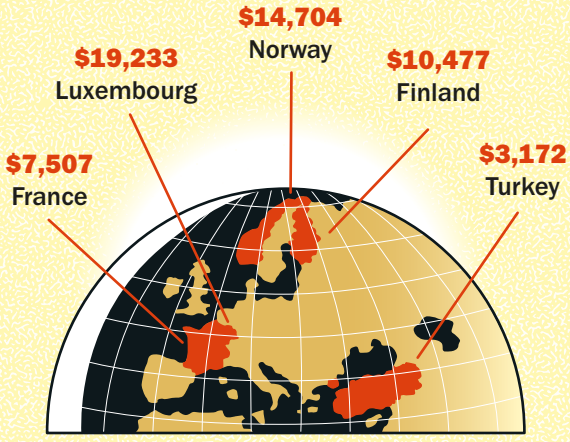


1 in 5 poor kids



Rural kids are only half as likely as others to get this exposure

Average Annual Spending per Preschooler in Other Countries



like Abecedarian. They do not serve kids from infancy to age five, nor do they last all day. Funding is also much less generous. Abecedarian spent an estimated $18,648 per child a year in 2016 dollars. In contrast, state spending on pre-K in 2015 averaged just $4,489 per enrolled child.

Abecedarian was also pedagogically distinct from today's preschool programs. The curriculum was more akin to that of the Randolph School (which, not incidentally, has similar costs—$15,200 tuition a year for a full-day student, although most receive financial aid). Its program largely comprised "learning games" that the children frequently played with teachers, along with lots of shared reading and responsive care-

Recess is an invaluable part of the pre-K experience, although many programs are cutting unstructured time. Randolph students participate in a spontaneous drumming session during an outdoor break (*1*). Indoors, a pair of four-year-olds discuss a building project with a teacher (*2*).

giving. Many of today's state-run pre-K programs rely more on direct instruction. They instruct and drill kids on math, vocabulary and literacy skills rather than letting children learn these skills through play and other self-directed activities.

There are many potential reasons for this curriculum shift. First, state-run programs are usually formally connected to the public school system, so they tend to adopt the same teaching strategies. Second, preschool teachers may not have the time or resources to devote to creative curriculum development, so they rely instead on "curriculum kits" that often lead to scripted, teacher-led instruction. "Preschools worried about not meeting expectations—typically the lower-performing programs and those serving disadvantaged students—embrace these products and comprehensive curriculum packages in the vain hope that they've landed on the magic bullet that will cover the standards and lift achievement scores without any guesswork," writes early childhood educator Erika Christakis in her 2016 book *The Importance of Being Little*.

Finally, because children who enroll in state-run programs are at high risk for future academic problems, administrators and teachers may feel they have to provide more formal instruction to give them an edge—even if this approach is not actually supported by science. "You go out to middle-class preschools, and they're so much more relaxed—they take time for children to enjoy childhood, they do exciting fun things, they have projects," explains Jeffrey Trawick-Smith, an early education researcher at Eastern Connecticut State University. "Then you go into Hartford, where there's real concern about kids and their learning, and it's just so rigid, and the focus is on direct instruction." (These trends continue into elementary school: schools that serve low-income kids typically have less recess time than those serving more affluent kids.)

Although few would argue with the need for some direct instruction in the preschool classroom, most researchers say it should not be the primary means for learning. Young children find it boring and have difficulty paying attention; others may find it stressful. Many preschools have prescribed "literacy lessons," for instance, in which kids are asked to sit quietly on the floor and listen to the teacher talk about the sound a letter makes and what it looks like. Occasionally the children are asked to participate in a contrived exercise, such as shaping their hands like an "O" or sounding out a word as a group. But these scripted, teacher-led lessons limit the amount of spontaneous, one-on-one conversation kids can have with one another and with their teachers—and, ironically, research has shown that frequent opportunities for extended discourse are what boost literacy and language skills the most.

More fundamentally, these kinds of curricula can interfere with crucial facets of preschool teaching. "A lot of times a politically driven agenda derails teachers from being emotionally and socially present, which is a really core part of their value," says Lesley Koplow, director of the Center for Emotionally Responsive Practice at the Bank Street College of Education in New York City. In other words, for young children rigid academic curricula can influence the character and atmosphere of the preschool classroom in ways that ultimately stifle learning.

In a 2002 study, Rebecca Marcon, a developmental psy-

THE AUTHOR

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chologist at the University of North Florida, published a study showing that fourth graders who had attended academic pre-K programs had lower grades than those who had attended schools with a child-centered focus. Stipek's research at Stanford has shown that kids who attend academic preschools rate their own abilities as lower, have stunted expectations of their own success, and are less motivated than kids who go to more child-centered preschools like Randolph.

In a randomized controlled trial released in 2015, researchers at Vanderbilt University compared how 773 disadvantaged children who had attended a Tennessee-run pre-K program fared in elementary school compared with 303 similar students who had been wait-listed for the program but did not attend. They found that although the pre-K attendees initially performed better than the control group on six measures, including work-related skills and social behavior, by the second grade they actually began performing worse. In first grade, teachers also rated the pre-K attendees as having poorer work skills and feeling more negative about school compared with the control students, most of whom had not gone to any pre-K.

Ample research suggests that kids from well-off families do not benefit as much from a good preschool as low-income children do, because they have so many rich interactions and experiences at home, and yet these are also the kids who tend to enroll in the best programs. Put another way: the youngsters who need high-quality preschools the most are the least likely to get them.

For decades researchers have been touting the benefits of free, unstructured play for children. "Play is critical learning in the way that's developmentally appropriate for young children," NAEYC's Hedges says. Kids learn about physics when they play with marbles, levers and ramps; they learn about math and geometry when they play with blocks. Make believe teaches self-regulation: If you are playing the patient and not the doctor, you do not get to use the stethoscope, even if you really want to.

But the science on play has evolved in recent years, and today many researchers believe that play can be even more educational for young kids when it is not free and unstructured but rather when it is guided by skilled adults. "Good teachers set up play experiences, a variety of them," Hedges says. "When you see there's a time to introduce complexity to their play and enrich that for them—either verbally or through getting down and playing with them—you do that."

Free play certainly has a time and a place, scientists say, but it also has limits—when similarly aged kids play together, they can get into a rut and act out scenarios over and over again. I saw this happen when I visited a preschool in Westchester County, New York: The teachers never engaged with the students while they played, and after a while some of the play routines turned stale, and the kids lost interest.


1


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Enhancing Playtime

A number of scenes unfold as the Randolph students frolic outside during recess. Some traverse a rope bridge; others play in a sandbox; a few bang makeshift drums made of overturned plastic buckets. But what seems most extraordinary is the sight of Randolph's teachers playing along with the students—a pedagogical technique that many researchers believe is a hallmark of high-quality preschool education.

Scaffolded play is more important and useful than it used to be, researchers say, because kids are not having the same types of rich play experiences that they had in decades past. Generations ago kids spent hours a day outside playing with mixed-age groups of neighborhood children. The oldest boys and girls modeled and taught the younger ones more sophisticated forms of play. Today such romps are much less frequent because of parental safety concerns and the takeover of more structured activities such as sports and music lessons. When kids do play, it is typically with kids their own age, who do not provide the same prompts and challenges. But teachers can. During recess, one Randolph preschool student explained that

she was making "sand smoothies" for anyone who might be hungry. A nearby teacher piped up and asked how much they cost, prompting a discussion about money and math.

Research suggests these kinds of play prompts help kids learn important concepts. In a 2016 study, Trawick-Smith and his colleagues recorded interactions between 47 teacher-student pairs in preschool and found that the students whose teachers scaffolded their play by introducing mathematical ideas and discussions later scored better on tests that measure math ability. "We have found that interactions that are respectful of children's play but enhance children's thinking are really powerful and lead to all kinds of positive outcomes," he says.

In a 2013 study, Johns Hopkins University psychologist Kelly Fisher, then at Temple, and her colleagues divided 70 children ages four and five into three groups. Some were given the opportunity to learn about geometric shapes through guided play, and others played freely with the shapes. A third group was taught about the shapes using direct instruction. The kids who engaged in the guided play learned the most, by far, about the shapes, and they remembered what they had learned a week later. Kids in the direct instruction and free-play groups, in contrast, had trouble recognizing shapes presented in different ways and orientations. As the researchers concluded, the guided play "helps direct children's attention to key defining shape features and prompts deeper conceptual processing."

Research shows that kids get more out of playing when teachers guide, or "scaffold," imaginative activities, enriching story lines or adding math concepts. At Randolph, teachers participate as students build an outdoor habitat (*1*) and make observations at a brook near the school (*2*). Warmth and emotional responsiveness have also been shown to be crucial factors in teaching young learners (*3*).

Guided play has also been shown to help with literacy. In a 2010 study, researchers at the University of Delaware had two groups of low-income preschoolers participate in a vocabulary activity twice a week for 30 minutes. One group was taught two vocabulary words using direct instruction the entire time. The teachers in this situation read a book containing the words, showed the children the words in the book, explained what they meant, asked the kids to repeat the definition and did a word-related action to help solidify their understanding. A second group was given similar direct instruction for 20 minutes and then participated in a guided-play activity for 10 minutes related to the two new words. For instance, when the kids were learning the word "bake," they were given a mixing bowl, oven mitt and timer and told to play-bake.

After four months, the researchers tested the preschool students. The children who participated in the guided play performed much better on standardized vocabulary tests designed to assess verbal ability: 62.5 percent of the kids who did guided play met age-appropriate benchmarks compared with only 44 percent of those who got only direct instruction.

Scaffolded play encourages kids to engage with materials and concepts in meaningful ways—far more than when they hear a lecture. Indeed, many researchers note that child-directed activities that are not technically "play" can still be highly educational. "Children can be engaged in, for example, looking at a pile of sand or a leaf under a microscope," Yale's Christakis says. "It's not necessarily play, but it's very engaging and requires active, hands-on and usually social experiences."

Of course, ample play or exploratory time is not all that a preschool classroom needs, either—more important, in fact, may be the warmth and emotional responsiveness of the teacher. This is often lacking in programs with poor resources. At a private preschool I visited outside of New York City, one that allowed hours of free play each day, the lead teacher did not invite her students to speak up or share thoughts during circle time or when she was trying to teach new concepts. One child who wanted to add her perspective to a discussion was admonished and told to be quiet. At snack time a boy who said he did not like his snack was told that he was not "being nice."

In a 2001 study, researchers at the University of Virginia found that the quality of children's relationships with their kindergarten teacher predicted various academic and behavioral outcomes in eighth grade. "Whatever happens in children's first

What Makes a Good Preschool

When choosing a pre-K program, look for signs that the school is employing best practices:

- Kids have ample time to explore, play and be creative using a variety of materials.
- Teachers are warm and responsive and encourage conversation and participation.
- Kids feel safe and secure.
- Teachers set limits about acceptable behavior but also work with students to help them label, understand and cope with emotions.
- Teachers read to the children regularly—not just as a class but individually and in small groups.

Evan Miklos, a preschool teacher at Randolph, uses finger counting to help students solve simple math challenges. The lesson brings several groups of children together for a collaborative, interactive learning experience.

educational experiences sets the stage for receptivity for what comes later—so if you inherit a nurturing and interesting environment in preschool, that's what school becomes for you," Bank Street's Koplow says. Randolph's students clearly adored their teachers, and it was not hard to see why—the teachers were all encouraging, responsive, playful and warm. There were more hugs in one day than you could count.

Valuing the Invaluable

Considering everything that goes into making preschools good, it is not too surprising that our country has so few of them. High-quality curricula require a lot of money and planning to create; they take a tremendous amount of skill to implement. Yet "it's hard to demand a lot of education and preparation when you're going to earn a salary as low as preschool teachers [get]," Stipek says. Indeed, the median preschool salary in the U.S. is $28,570, according to a June 2016 report co-published by the U.S. Department of Education and the U.S. Department of Health and Human Services. Janitors and hairdressers are paid more.

Why are these crucial jobs—roles that shape the lives of our future generations—so underpaid? In large part, Nebraska's Meisels blames sexism: 97 percent of preschool teachers are women, so it is "seen to be women's work, and—I hate to say it—even unskilled work," he says. In fact, as of 2015, 16 states did not require their preschool teachers to have bachelor's degrees. And four of those states—Texas, Florida, Arizona and Massachusetts—did not require them to have specialized training in early childhood education.

Preschool could be a way to help every American child, regardless of background, reach his or her fullest potential. But first, researchers say, the country needs to stop valuing universal preschool in and of itself and recognize that it is only high-quality preschool that can accomplish this feat. Then the country needs to be honest about what separates the good from the bad. We need to invest much more richly in our preschool workforce, understand the research on how young children learn, and stop worrying so much about tests and other useless proxies. It is time to put aside the worksheets and curriculum kits and let our nation's preschoolers learn the way they do best—by engaging meaningfully with others and the world around them. M

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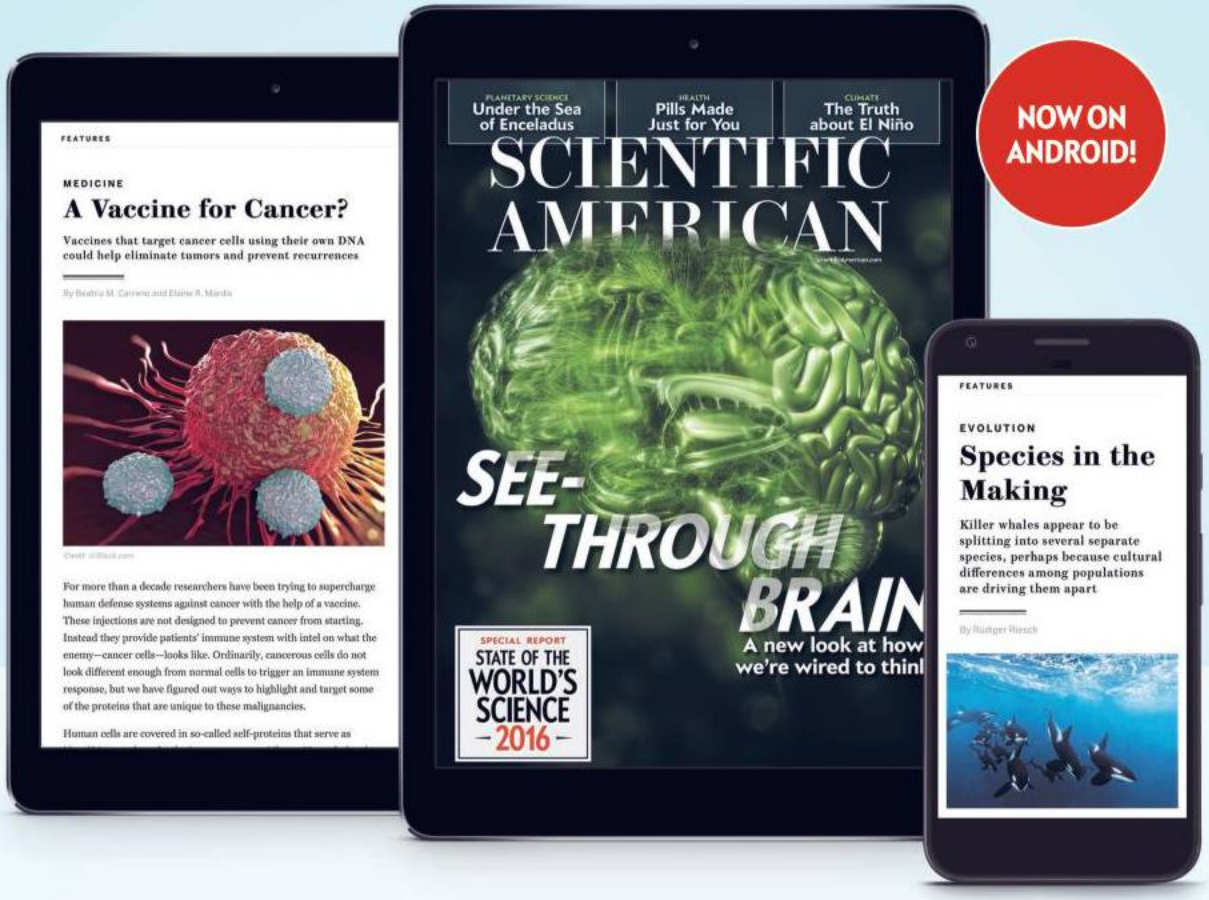

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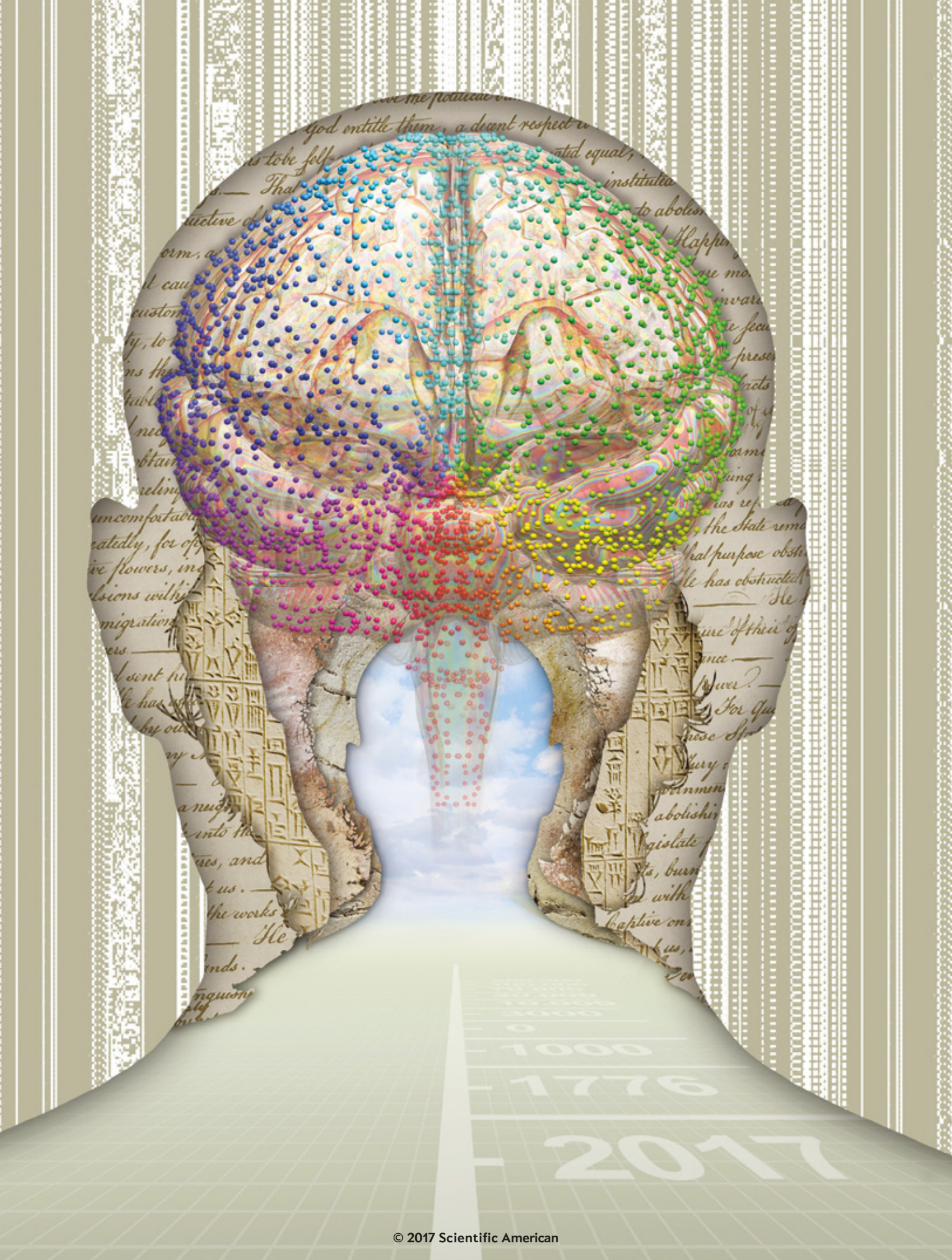
The Remarkable *(But Not Extraordinary)* Human Brain

A novel technique for counting neurons is changing our appraisal of just how special the human brain really is

By Suzana Herculano-Houzel

ILLUSTRATION BY JEAN FRANÇOIS PODEVIN



The custom officer's eyes opened wide. She was viewing an x-ray image of my two suitcases. Both were packed with plastic containers small and large, all double-wrapped individually and each carrying a soft mass in clear liquid. "Are you bringing fresh cheese?" she asked me. It was June 2012, and I was returning from South Africa to Brazil through the international airport in São Paulo. A Portuguese couple ahead of me had just been caught sneaking in prohibited fresh cheese, which could contain live pathogens harmful to local cattle.

"No, it's just brains," I replied. I had no fear of having those precious organs confiscated. I knew I had done everything correctly, and so I waited patiently, sitting by my still unopened suitcases, while she went to fetch the appropriate officer. Somebody would have quite a story to tell that evening at dinner.

As the confused officials tried to remember what to do when someone brought brains into the country, I presented the customs agent with a thick stack of permits in several languages—including documentation that declared my specimens posed no biological threat and had no commercial value. I was bringing in brains of giraffes, various antelopes, lions, hyenas, one minke whale and dozens of smaller African rodent species that my collaborator had collected in South Africa, the Democratic Republic of the Congo, Saudi Arabia, Denmark and Iceland. I handed the agent my paperwork, and she let me go without ever opening my suitcases. Part of me was sorry: I wished she had seen my cool collection.

I have been in the business of importing animal brains for about 10 years now, carrying them from the laboratories of collaborators in many countries. My research interest is finding out how many neurons each contains, how that relates to brain size and how it compares with the human brain in particular.

Fourteen years ago, while at the Federal University of Rio de Janeiro, I developed a method that has allowed me to count neurons from creatures large and small, human and otherwise, something that could not be done before in vertebrate brains. My procedure? Turning brains into soup. The numbers we have obtained have overturned some of the old myths of human exceptionality and revealed that our brains are both uniquely powerful and surprisingly predictable in the context of other primates. In fact, comparing us with our evolutionary cousins suggests that it was technology rather than anatomy that allowed us to fully realize our neuronal capabilities.

How to Make Brain Soup

For more than 50 years scientists have been trying to number the brain's cells. Pioneered by anatomist Hans Elias in the early 1960s, the classic and most widely used approach to unbiased counting was stereology: one would "fix" brain tissues, turning them hard in formaldehyde, and then slice them finely. Chemical stains would then make the cells visible under a microscope, and a careful sampling scheme allowed scientists to extrapolate the total number of cells in a brain structure in just a few counts.

The problem with counting cells in this way was that it could only be done properly in well-defined, homogeneous brain regions. The procedure was painstaking and time-consuming. Although it was very accurate if used properly, it was also prone to user errors. Applying that procedure to whole brains, and particularly to large brains, would take forever.

In the 1970s some researchers observed that because there is a set amount of DNA content associated with each brain cell's nucleus—and there is just one nucleus per cell—it should be possible to extract all the DNA in a brain and use it to calculate the total number of cells. This idea inspired me: What if instead of extracting DNA from the nuclei, I were to extract the nuclei themselves?

I figured that nuclei could be freed from cells, like pits out of peaches, and once liberated, one could mix them in a known volume of liquid until they were distributed evenly, then count them under the microscope without an elaborate sampling scheme. As I learned later, I was not the first person to count free nuclei. In 1963 comparative anatomist John Zachary Young counted and stained brain tissue in liquid to estimate the number of neurons in the brain and arms of an octopus. His tally: 500 million.

We now know that figure is likely too low. The reason my kind of brain soup worked accurately, whereas others missed cells, is that I started from fixed, not fresh, tissue, which hardened the nuclei and made them resistant to the process of liquefaction. Of course, it did not work at first. I initially borrowed from biochemists a common method to free nuclei: flash-freezing brain tissue in liquid nitrogen, then cracking it in a blender. Predictably I had frozen pieces of brain hurled around the lab. My mother advised: "You have to keep the lid on,

FAST FACTS

LESSONS FROM BRAIN SOUP

1. The human brain includes 16 billion neurons in the cortex—an area associated with sensation, behavior and cognition.
2. Although we have more cortical cells than any other species, the numbers are in line with smaller primates—suggesting we are simply "scaled-up" versions of our evolutionary relatives.
3. Yet we do have more neurons proportional to body size than gorillas and orangutans, possibly because innovations such as cooking allowed our ancestors to efficiently feed our energy-hungry brain cells. Great apes–like all other animals–are stuck with a raw diet.

Although the brain represents only 2 percent of our body mass, *it chugs about 25 percent of all energy* required to operate the body every day.

silly." But it was still no good; there were too many bits and pieces stuck to the walls of the blender. I had to make sure I could collect every last nucleus.

In 2003 I struck gold using detergent to dissolve brains that had been well fixed. Sloshing the tissue around in detergent inside a glass tube, I turned heterogeneously distributed neurons into a soup of evenly distributed free cell nuclei.

I could then easily and quickly count free nuclei under a microscope and—because of the one-nucleus-per-cell rule—that was as good as counting cells. For a rat brain, I needed only about half a cup of liquid to suspend all the nuclei and then tally them up. I could do that in a morning. Even an elephant brain can be enumerated in about six months through a few gallons of elephant brain soup.

Since 2003 research teams at both Vanderbilt University and the University of Nevada, Reno, have shown that brain soup gives comparable results to traditional stereology where both methods can be easily applied. Researchers in Canada, Australia, Germany, Hong Kong, the Czech Republic, Brazil and the U.S. have studied brain soups from birds, fish, mammals and invertebrates.

Are Humans *Really* Special?

Very quickly my method began yielding insights. I discovered that the numbers of neurons in the mammalian cerebral cortex, the brain's outer layer of tissue, is enormously variable—from just a few million to several billion neurons—in different species. These cells are responsible for sensory integration, movement generation, personality, temperament, pattern finding, logic reasoning and planning for the future, making behavior more than simple reactions to stimuli.

Further, in the dozens of studies my colleagues and I have conducted to date, we have not found a single, universal relation between the size of a cerebral cortex and the number of neurons therein. In a 2014 review of our findings thus far, we concluded that different rules apply to primate and nonprimate animals, with much larger numbers of smaller neurons fitting inconspicuously in the cortices of primates than in, say, rodents or ungulates of similar size.

A baboon cortex, for instance, has 10 times more neurons than the similarly sized cortex of an antelope. The number of neurons, therefore, could not be surmised simply from the size of a cortex. The human cortex, meanwhile, has a whopping 16 billion neurons, which may seem out of the ordinary for our brain size—but only when we are compared with nonprimates.

The human brain has long been seen as an evolutionary outlier: too big for its body by the largest amount for any species. But according to my numbers, the human brain is actually just a scaled-up primate brain.

In 2014 we took a look at the elephant cortex, which is twice as large as ours, and found it has only about a third as many neurons: 5.6 billion. Even the largest whales, by our accounts, do not have much more than three billion to five billion cortical neurons. Most mammals have less than one billion.

For many years scientists also suspected that humans have a disproportionately large prefrontal region, the part of the cerebral cortex that deals with complex, associative functions beyond simply integrating sensory information and generating movements. Yet in 2016 we found evidence to the contrary. My colleagues and I looked at the distribution of neurons along the cortex of eight primate species and discovered that the human prefrontal cortex has only about 8 percent of all cortical neurons—the same proportion as in other

COURTESY OF SUZANA HERCULANO-HOUZEL

Herculano-Houzel (*left*) with her packed suitcase full of specimens in 2012. She has studied hundreds of brains, including those of African elephants (*right*), to examine how the number of neurons varies across animal species.

THE AUTHOR

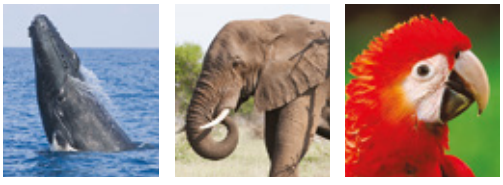
SUZANA HERCULANO-HOUZEL is a biologist who specializes in neuroscience and science writing. After 14 years as a researcher in Brazil, she is now an associate professor of psychology and biological sciences at Vanderbilt University.

What if it was *great apes that had brains too small* for their bodies rather than humans having brains that were too big?

primates. But because our cortex has the most neurons overall, that 8 percent translates into the largest number of such neurons in any primate.

The jury is still out on the number of prefrontal neurons in other brains, particularly in elephants and whales. These species have a lot of gray matter but a comparatively small number of neurons in the cortex when compared with us. Furthermore, their prefrontal cortex appears to amount to just a sliver of the brain, whereas it takes up proportionally more space in humans, making it likely that the human brain has the most higher-order, prefrontal neurons.

Related animals, such as ungulates, primates or rodents, have similar brain architecture but can have different numbers of neurons.



Bigger is not always better. Whales and elephants are large-brained but appear to have relatively few of the cortical neurons that assist humans in higher-order thinking. Parrots and songbirds, meanwhile, pack neurons more densely than mammals.

What does that matter? If neurons are the basic information-processing units of the brain, then the more neurons in a cerebral cortex, the more capable it should be, regardless of the overall size of the structure. We have, by far, the most cortical neurons of any single brain on earth. That, I believe, is the simplest explanation for our remarkable cognitive abilities, given that our brain's overall connectivity and distribution of functions are actually pretty typical for a mammalian brain.

Food for Thought

Brain cells are costly, so it is impressive that we can afford so many cortical neurons. Although the brain represents only 2 percent of our body mass, it chugs about 25 percent of all the energy required to operate the body each day.

Yet here again our brain is just a scaled-up primate's. By dividing estimates of how much energy different brains cost by our calculations of the number of neurons therein, we have found that rodent and primate brains alike cost about six kilocalories per billion neurons a day, regardless of their size. With 86 billion neurons on average, the human brain has an expected cost of 516 kilocalories a day, very close to its actual measured daily cost of about 500 kilocalories.

Humans have just the number of neurons and precisely the brain mass one would expect, given our bodies. In many Old and New World monkeys, as well as smaller primates, the brain represents 2 percent of body mass—just as in humans. It is great apes that stand out, with brains that amount to less than 0.5 percent of body mass. Gorillas, in particular, are animals that can weigh up to three times as much as humans. Because larger animals tend to have bigger brains, we would expect the biggest primates to have larger brains than us. Yet, to the contrary, the human brain weighs about three times more than the gorilla or orangutan brain.

Gorillas, with their large, expensive bodies, may have reached a point where they cannot afford the energy to support as many neurons as we do. With these findings, I could turn a key question of comparative neuroscience on its head: What if, because of energetic constraints, it was great apes that had brains too small for their bodies rather than humans having brains too large for their bodies?

Whatever energy is available to support brain and body, it has to come from what an animal eats. In 2012 Karina Fonseca-Azevedo and I published a paper—based on work done when she was my undergraduate student—with a few calculations, including how much energy different primate brains and bodies require, how much they receive from their natural diets, and how long it takes them to find and ingest that energy.

We found that at their current body mass, gorillas and orangutans could not afford any more neurons in their brains than they already have. These are animals that forage and eat for about eight hours a day, and they lose weight when the food they pick and ingest for eight hours is not enough, for example, during the dry season.

Eating longer hours to afford more neurons is not an option for a primate that also has to sleep for seven to eight hours daily and take care of other business, such as defending territory or enforcing social status. There is not much time left for anything else. A college education is an impossible dream for someone who needs to forage and eat for that long. Because energy intake is limited, there is a trade-off between body mass and number of neurons. In the case of great apes, their brain is only as large as the body still allows.

A similar limitation applies to us: On a comparable diet as other primates, our ancestors should have spent almost 9.5 hours a day looking for food and eating—something that would be prohibitive for a larger primate. If they, and we humans, still fed like other primates do, we could not have survived.

And yet here we are. If our ancestors did not skimp on neurons, did not have inordinately cheap brains and could not

IGNACIO PALACIOS *Getty Images (ungulate)*; ANUP SHAH *Getty Images (orangutan)*; GETTY IMAGES (*chipmunk* and *whale*); ANNICK VANDERSCHELDEN *Getty Images (elephant)*; FRANS LANTING *Getty Images (parrot)*

Great apes such as gorillas and orangutans need to spend hours foraging to have enough energy to sustain their large frames. Under similar constraints, we would need 9.5 hours of seeking and consuming calories from raw plants. Cooking gives us a higher caloric yield from the same foods and also makes it easier to consume meat, which allows our body to afford a larger number of neurons.

spend most of their waking lives eating, the only way out of the energetic limitation to brain cells was a radical change in diet. My colleagues and I argue that our ancestors found a way around that limitation about three million years ago. They improved on the lucky evolutionary innovation of bipedality—which extends the range that one can roam looking for food—by creating tools to cut, slash, dice, mince, crush and pound.

In 2016 research by paleoanthropologist Daniel E. Lieberman and his group at Harvard University showed that modifying food prior to eating—by my definition, cooking—increases its energetic yield. Lieberman's team conducted a series of experiments, including a setup in which participants had to gnaw on raw goat meat, that demonstrated how Paleolithic technologies, such as stone tools for slicing and pounding, altered food enough to make energy-rich, chewy meats easy to swallow.

Simply put: our ancestors, and ours alone, cooked. *Homo culinarius,* I like to call them—and maybe that would be a better name for our modern selves rather than the presumptuous and improbable *sapiens,* which implies that no other species thinks or knows. To the list of technological implements that could modify food before it was eaten, our ancestors later added fire, about one million years ago. Primatologist Richard Wrangham, also at Harvard, has previously proposed cooking with fire as a watershed in human evolution.

Our research shows that had there not been a radical change in diet that tremendously increased the caloric intake of our ancestors, we could not feed our brain and therefore would not be here. Cooking, first without fire and later with it, was most likely that change.

The Legacy of *Homo culinarius*

Like any technology—by definition, objects, systems or procedures that help to solve problems—cooking freed time for our ancestors. They could put those now affordable extra neurons to other uses.

Once free time was no longer a rare commodity, our ancestors could develop technological innovations and share these discoveries with others. New tools begot further progress. Our species grew in culture and complexity. In the process, we probably pushed our brain ever further toward more neurons, and with them, we expanded our mind's capabilities.

Yet capabilities are not abilities. Judging from cranial size, our modern 16 billion neurons or so have been with us for at least 200,000 years. Our amazing cognitive feats—building, writing, investigating ourselves and the universe—are much more recent.

It takes a lifetime to sculpt a newborn human brain into a learned, mature brain of impressive abilities. In modern times, our collective wisdom and achievements are no longer within the grasp of a sole individual. Without enough people to hold that knowledge collectively and without cultural transmission, all our hard-earned gains could vanish in a single generation, despite the fact that we would remain capable of these deeds. We therefore *must* cultivate, document, and pass on knowledge and crafts through culture and formal education to ensure that our capabilities will give rise to the abilities of future generations.

Our species' achievements are many, and the potential of our collective thinking is tremendous. We have certainly distinguished ourselves from all other animals. But we have never stopped being primates. **M**

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HOW TRUMP WON

Behind his unforeseen success in the 2016 election was a masterful use of group psychology principles

BY STEPHEN D. REICHER AND S. ALEXANDER HASLAM

Adapted from *Why Irrational Politics Appeals: Understanding the Allure of Trump,* edited by Mari Fitzduff, with permission from ABC–CLIO/Praeger. Copyright © 2017.

DAMON WINTER/*NEW YORK TIMES Redux Pictures*

Editors' note: All but the last section of this article was written before Donald Trump's victory in the U.S. presidential election, making its insights all the more remarkable. It was updated for Scientific American Mind.

It is easy and common to dismiss those whose political positions we disagree with as fools or knaves—or, more precisely, as fools led by knaves. Indeed, the inability of even the most experienced pundits to grasp the reality of Donald Trump's political ascendency in the 2016 presidential race parallels an unprecedented assault on the candidate and his supporters, which went so far as to question their very grip on reality. So it was that when a Suffolk University/*USA Today* poll asked 1,000 people in September 2015 to describe Trump in their own terms, the most popular response was "idiot/jerk/stupid/dumb," followed by "arrogant" and "crazy/nuts," and then "buffoon/clown/comical/joke." Similarly, Trump's followers were dismissed in some media accounts as idiots and bigots. Consider this March 2016 headline from a commentary in Salon: "Hideous, Disgusting Racists: Let's Call Donald Trump and His Supporters Exactly What They Are."

Such charges remind us of Theodore Abel's fascinating 1938 text *Why Hitler Came into Power,* but first let us be absolutely explicit: We are not comparing Trump, his supporters or their arguments to the Nazis. Instead our goal is to expose some problems in the ways that commentators analyze and explain behaviors of which we disapprove. In 1934 Abel traveled to Germany and ran an essay competition, offering a prize for autobiographies of Nazi Party members. He received around 600 responses, from which he was able to glean why so many Germans supported Adolf Hitler. Certainly many essays expressed a fair degree of anti-Semitism and some a virulent hatred of Jews. In this sense, party members were indeed racists or, at the very least, did not object to the party's well-known anti-Semitic position. But this is very different from saying that they joined and remained in the party primarily or even partially *because* they were racists. Abel discovered that many other motives were involved, among them a sense of the decline of Germany, a desire to rediscover past greatness, a fear of social disorder and the longing for a strong leader.

We would argue that the same is true of those who supported Trump. Some, undoubtedly, were white supremacists. All were prepared to live with his racist statements about Muslims, Mexicans and others. But are racism, bigotry and bias the main reasons people supported Trump? Certainly not. We argue instead that we need to analyze and understand the way he appealed to people and why he elicited their support. Moreover, we need to respect those we study if we want to understand their worldview, their preferences and their decisions.

To understand *how* Trump appealed to voters, we start by looking at what went on inside a Trump event. For this, we are indebted to a particularly insightful analysis by journalist Gwynn Guilford, who, acting as an ethnographer, participated in Trump rallies across the state of Ohio in March 2016. We then analyze *why* Trump appealed to his audience, drawing on what we have referred to as the new psychology of leadership. Here we suggest that Trump's skills as a collective sense maker—someone who shaped and responded to the perspective of his audience—were very much the secret of his success.

Anatomy of a Rally

A Trump rally involved much more than just a Trump speech. Important though his words were (and we will look at them in some detail), it is even more essential to look at the event as a performance of a particular worldview. Once again, the charge of irrationalism can serve to obscure because if we view Trump's crowds as mindless mobs led by primitive urges and stirred up by a narcissistic demagogue, as many critics have done, it impairs our ability to appreciate what his events tell us about how those who attended them see the world.

In simple terms, a Trump rally was a dramatic enactment of a specific vision of America. It enacted how Trump and his followers would like America to be. In a phrase, it was an identity festival that embodied a politics of hope.

A rally would start long before Trump's arrival. Indeed, the long wait for the leader was part and parcel of the performance. This staged delay affected the self-perception of the audience members ("If I am prepared to wait this long, this event and this leader must be important to me"). It affected the ways audience members saw one another ("If others are prepared to wait this long, this event and the leader must be important to them"). And it thereby set up a norm of devotion in the crowd and a sense of shared identity among crowd members ("We are joined together in our devotion to this movement").

The wait also provided time for other ritualized acts that helped to shape the audience's worldview. As Guilford described it, Trump's security procedures were more rigorous than those of any other candidate. At every venue, the audience had to pass through a metal detector. Inside, highly visible se-

FAST FACTS

NEW PSYCHOLOGY OF NEW LEADERSHIP

1. Donald Trump's rallies enacted how Trump and his followers would like the country to be. They were, in essence, identity festivals.
2. Trump succeeded by providing a categorical grid—a clear definition of groups and intergroup relations—that allowed many Americans to make sense of their lived experiences.
3. Within this framework, he established himself as a prototypical American and a voice for people who otherwise felt voiceless.
4. His rivals did not deploy the skills of identity leadership to present an inclusive narrative of "us." In that context, Trump had a relatively free run.

At a Trump rally, like those in Kinston, N.C. (*above*), and Radford, Va. (*right*), elements such as tight security and group rejection of protesters reinforced a shared sense of identity among participants.

curity agents abounded. They fanned out, their backs to the stage, and purposefully made eye contact with audience members, checking for intruders. Audience members joined in the exercise. A person did not have to express overt opposition to be deemed suspect; just failing to show sufficient enthusiasm could draw others' hostile attention.

About an hour before Trump would speak, a message broadcast over the PA system instructed crowd members not to touch any protesters they spotted. Rather they were told to notify security by chanting, "Trump! Trump! Trump!" Though often a false alarm, this cry would go up repeatedly. When it happened, the entire audience was alerted to possible enemies in their midst. As a result of these various tactics, crowd members were induced to act as if they were under threat—and observing themselves and others behaving in this way only served to reinforce the presumption that they truly were under threat, from enemies both without and within.

As identity festivals, Trump rallies succeeded in large part thanks to an audience that enthusiastically performed its devotion to Trump and to an audience and security apparatus that acted as a community under threat. Yet there is one more set of actors who—perhaps unwittingly and certainly unwillingly—played a key part in the drama: members of the media, who were generally kept segregated from the crowd, positioned as a visible presence to be derided when he maligned them as the voice of a hostile establishment. Guilford described one such incident:

> Trump scowls at the media cattle pen in the back of the room and calls the press the "most disgusting" and "most dishonest" people he's ever seen, pantomiming his disdain with an elaborate sneer before goading his supporters to turn and glare, too. On cue, the crowd turns and boos.

In this moment, the tables are turned. The media and establishment are no longer big and powerful. They are small and cowed by Trump's legions.

Trump on the Stump

Just as Trump's rallies brought to life a powerful representation of social relations, his speeches confirmed and fleshed out this representation. In this regard, his rhetoric was largely con-

STEPHEN CROWLEY/*NEW YORK TIMES Redux Pictures (top)*;
DAMON WINTER/*NEW YORK TIMES Redux Pictures (bottom)*

JEFF KOWALSKY *Getty Images*

Trump's rhetoric followed a form known as the "American jeremiad," which extols the idea that America has an exceptional mission in the world but is falling short. Trump laid blame with the political class.

sistent from rally to rally and presented a particular example of a general form that the late cultural critic Sacvan Bercovitch called the "American jeremiad." By definition, this form of rhetoric extols the notion that America has an exceptional mission in the world but is falling short and therefore needs to change to fulfill its original vision. What distinguished Trump's version from the original Puritan one is, first, that the failings are a matter of power and wealth rather than of moral purpose and, second, that they are caused by the depredations of others rather than the weaknesses of the in-group (that is, his supporters).

Trump's standard argument had three key elements. The first asserted that America, once great, is now weak and repeatedly humiliated by others. Thus, in the speech that announced his candidacy, given at Trump Tower in New York City on June 16, 2015, he asserted, "Our country is in serious trouble. We don't have victories anymore. We used to have victories, but we don't have them. When was the last time anybody saw us beating, let's say, China in a trade deal? They kill us."

The second element was that America's decline was framed as resulting from the actions of its enemies. These enemies are in part external: China and Mexico and other countries that, in his view, cheat, are corrupt, and take the jobs and wealth of ordinary Americans. Again, we can see this stance in Trump's presidential announcement, in which he opined: "Our real unemployment is anywhere from 18 to 20 percent. Don't believe the 5.6. Don't believe it. That's right. A lot of people up there can't get jobs … because there are no jobs, because China has our jobs, and Mexico has our jobs. They all have jobs."

More important, though, the argument went on to assert that these external enemies thrive only because of the actions of many enemies within. Sometimes Trump just labeled these enemies as incompetent, having an inability to do deals that favor America. Sometimes he targeted specific individuals (Barack Obama, Hillary Clinton, his Republican rivals), and sometimes he targeted the political class as a whole. This line of attack is exemplified by the following passage, also from his announcement speech: "I've watched the politicians. I've dealt with them all my life. If you can't make a good deal with a politician, then there's something wrong with you. You are certainly not very good. And that's what we have representing us. They will never make America great again. They don't even have a chance. They're controlled fully—they're controlled fully by the lobbyists, by the donors and by the special interests, fully."

This statement suggested another reason why other politicians act as enemies: they are controlled by enemies to the American people. The point was made even more explicit in Trump's economic policy speech, given on June 28, 2016, in Monessen, Pa., in which he pilloried his chief Democratic rival: "The people who rigged the system are supporting Hillary Clinton because they know as long as she is in charge, nothing is going to change. The inner cities will remain poor. The factories will remain closed. The borders will remain open. The special interests will remain firmly in control. Hillary Clinton and her friends in global finance want to scare America into thinking small." In short, the analysis proposed that America is losing out because the enemy within is colluding with the enemy beyond.

After identifying the problem and its cause, the third part of Trump's argument went on to identify the all-important solution: himself. Throughout his speeches, Trump insisted that he is not like other politicians. He knows how to make a deal. He insisted that he has been so successful and become so rich that he cannot be bought. For instance, in one of many anecdotes, Trump recalled: "One of the big banks came to me and said, 'Donald, you don't have enough borrowings. Could we loan you $4 billion?' I said, 'I don't need it. I don't want it.' "

As a consequence of these nonpolitical attributes, Trump positioned himself as being able to restore what America has lost. Accordingly, when, in his announcement speech, he asserted that China beat the U.S. in trade deals, in his next line he observed: "I beat China all the time. All the time." To this, the audience applauded and chanted, "We want Trump! We want Trump!" In closing that speech, he said, "If I get elected president, I will bring it back bigger, and better, and stronger than ever before, and we will make America great again." By using the term "we" here, he included his audience and thereby significantly extended his argument—insisting that it is not just Trump but the Trump movement that will restore greatness.

This invocation of the crowd bookended the speech, and we can conclude our analysis by rewinding from the closing words to the opening words: "Wow. Whoa. That is some group of people. Thousands.... This is beyond anybody's expectations. There's been no crowd like this." Here we come full circle and see how the rhetorical and the performative come together: the crowd is reflected back to itself as a demonstration of its power to achieve change. In this, the relationship between the crowd, Trump and threatening enemies within the event is translated into a vision of the world in general: ordinary Americans have fallen from their rightful place in the world because of attacks from without and betrayals from the political class within, but they have the power, united behind Trump, and the will to employ it to restore the American people to this place.

Everything coheres. Everything that was used as evidence of pathology—from the rough language and baying at foes to the devotion and reverence for one who violates all the rules of politics—makes sense within the terms of this vision. It is a vision realized in its very telling. It is an enactment of Trump's new America. It is not only a politics of hope but the lived experience of all that is hoped for.

The Entrepreneur of Identity

As we have seen, Donald Trump made much of his economic entrepreneurial skills and his ability to make deals—although these claims have come under some critical scrutiny. Indeed, Tony Schwartz, the ghostwriter of Trump's book *The Art of the Deal,* has described them as a work of fiction and said, "I feel a deep sense of remorse that I contributed to presenting Trump in a way that brought him wider attention and made him more appealing than he is." And an article published online in *Fortune* on August 20, 2015, suggested that Trump would have made more than four times as much money if he had simply invested his money in an index fund. Whatever the truth of the matter, our argument is that Trump's political success derived not primarily from his acumen as a business entrepreneur but rather from his skills as an entrepreneur of identity—in essence, his ability to represent himself and his platform in ways that resonated with his would-be followers' experience of their world.

A Trump rally involved much more than just a Trump speech. It was a dramatic enactment of a specific vision of America—of how Trump and his supporters would like America to be.

There has been much controversy over the demographics of Trump's followers. For instance, they have been described as uneducated, white and poor. The percentage of Trump supporters with college degrees in the primaries was around 20 percent—about half the overall percentage of Americans who are college graduates. But in many primaries, most Republicans with college degrees did vote for Trump. Equally, it is true that, on average, Trump supporters earned less annually than those who backed his main GOP rivals ($72,000 versus $91,000 for Governor John Kasich of Ohio), but at the same time, they earned considerably more than the U.S. median wage ($56,000) and supporters of both Clinton and Senator Bernie Sanders of Vermont ($61,000 each). What does seem to hold, however, is that Trump supporters were primarily white, and, as Neil Irwin and Josh Katz reported in the *New York Times,* they lived in areas of "long-simmering economic dysfunctions" even if they themselves were not poor. To quote further from Irwin and Katz: "One element common to a significant share of his supporters is that they have largely missed the generation-long transition of the United States away from manufacturing and into a diverse, information-driven economy deeply intertwined with the rest of the world." That is, Trump's constituents were largely people who are part of a declining sector of an economy

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that is, at best, stagnating and who have been hit especially hard by trade deals that have opened the U.S. to competition from low-cost manufacturing elsewhere in the world.

The second reliable characteristic of the members of this constituency was their lack of trust in politics, politicians and political institutions. In this distrust, they were not alone. In 2015 a Pew Research Center report showed that overall trust in government had fallen from 73 percent in 1958 (rising to a peak of 77 percent under President Lyndon B. Johnson in 1964) to a mere 19 percent in 2015. Only 20 percent of Americans in this survey thought government programs were well run. Less than 10 percent of Republicans had trust in government. And even for Democrats, that same figure was only a little more than 30 percent. Moreover, if people feel distanced from government and believe that the government does not represent them, there is good reason to conclude that this is rooted in their actual experience. For example, a 2014 analysis by Martin Gilens, a professor of politics at Princeton University, and Benjamin I. Page, Gordon Scott Fulcher Professor of Decision Making at Northwestern University, showed that whereas economic elites and business groups have considerable influence on U.S. government policy, average citizens and mass-interest groups have virtually none.

Trump's accomplishment was to take these inchoate feelings of decline and marginalization and to provide a perspective that not only made sense of them but also provided a solution. In so doing, he acknowledged the real problems of his audience (while others ignored them or even contributed to them); he understood them and empowered them to participate in the process of resolving those problems. But he also did one more thing: for his narrative was not only about the world and the place of his audience within it, it was also about him, his own place and his relationship to his audience.

A Prototypical "Ordinary American"

Trump clarified his own position in the world with reference to a classic populist confection in which that world is divided into two groups: the common people and a privileged elite. Here the people were defined in national terms—as Americans—and the elite primarily in political terms. Trump's claim to leadership was then rooted largely in the work he did to position himself firmly among the former (and his rivals among the latter). This division indeed was at the heart of his successful identity entrepreneurship.

To start with, Trump has construed himself as prototypical of the "ordinary American" in-group. Not typical. Trump is far from typical. How many ordinary Americans are worth billions and have their own towers, golf courses and jets? No, he is *proto*typical, which means that he represents the key values and attributes that distinguish the in-group from out-groups. This is how journalist and author Andrew Sullivan put it in *New York Magazine:* "He did not hide his wealth in the late-20th century—he flaunted it in a way that connected with the masses. He lived the rich man's life most working men dreamed of—endless glamour and women, for example—without sacrificing a way of talking about the world that would not be out of place on the construction sites he regularly toured. His was a cult of democratic aspiration."

In keeping with this, here is how Donald Trump, Jr., described his father in his speech at the 2016 Republican National Convention: "We didn't learn from M.B.A.s. We learned from people who had doctorates in common sense.… It's why we're the only children of billionaires as comfortable in a D10 Caterpillar as we are in our own cars. My father knew that those were the guys and gals who would teach us the dignity of hard work from a very young age. He knows that at the heart of the American dream is the idea that whoever we are, wherever we're from, we can get ahead, where everyone can prosper together."

Likewise, the way Trump dresses (always immaculate in tie and expensive suit, never dressing down, signifying his wealth), the way he talks (the crude, undiplomatic, violent forms of expression) and what he says are not incidental. They are part of his performance as an exemplary American. In addition, they distinguish him from the typical (or prototypical) politician. What was thought to be a weakness (lack of political experience) is touted as a strength. Here, then, Trump's constant violations of political rules, so often seen as presaging his decline, actually served to consolidate his ascendancy. Furthermore, the lack of support from heavyweights of the Republican establishment—including Mitt Romney and George H. W. Bush—only helped to increase his poll ratings. His failure to follow the rules of politics and his rejection by the political class validated his in-group status in the eyes of an antipolitical audience. Supporters confirmed that he is "one of us," not "one of them." All this helps to explain what the *Guardian* newspaper called "the paradox that has been at the heart of the Trump phenomenon"—that is, "How can a billionaire businessman from New York be the one who 'gets' the struggling working class?"

Trump's use of crude and even violent language signified that he is not a typical politician. Breaking the rules of the game added to his appeal.

But it is not enough to be "one of us." As we note in our 2011 book, with Michael J. Platow, *The New Psychology of Leadership,* success also depends on being seen to "do it for us," acting for the in-group interest. This claim is one of Trump's constant refrains, and again his wealth acts for him, not against him. He says he is not acting to enrich himself; he does not need any more money. Equally, he cannot be bought to serve the interests of others, such as the international (that is, non-American) elite. Clinton was paid to speak to Wall

Street, but Trump proclaimed that he was free to "tell it like it is"—something regularly cited as a source of his strength and a reason why people voted for him.

Finally, even "doing it for us" is not enough if a leader lacks the support or ability to be successful in advancing the group interest. The effective leader must, above all, "make it real," turning group values into lived experience. Although it is difficult for an aspirant to power to achieve anything before he or she has been elected, Trump rose to this challenge by making much of his previous successes and his credentials as an inspired business leader and deal maker. Also, as we have seen, by so carefully choreographing his rallies, he created a simulacrum of reality within the very movement designed to change reality.

In sum, Trump's campaign was all about creating a particular sense of "us" (articulating a sense of "them" is critical but secondary) and then establishing how he himself is representative of the group in both a symbolic and a practical way, able to represent the group at the political level. The skill, complexity and subtlety with which he accomplished this feat (even when it came to his use of crudity) helps us understand why Trump proved so appealing to his audience.

We contend that Trump succeeded by providing a categorical grid—a clear definition of groups and intergroup relations—that allowed many Americans to make sense of their lived experience, to understand their problems and to entertain the hope of being able to deal with them. Within this framework, he established himself as a champion and as a voice for people who otherwise felt unchampioned and voiceless. Ironically, too, in a politics controlled by wealth and privilege, his wealth freed him of the charge that he was in hock to the money men. Above all, Trump had an intuitive grasp of how to establish himself as the voice of America in both his words and his actions.

What is more, Trump's successes must be seen in light of others' failures. In particular, his rivals did not succeed in providing an alternative grid, based on alternative categories, to make sense of the experiences of many Americans. They did not deploy the skills of identity leadership to present an inclusive narrative of "us" that dealt with the real problems people face. They did not elaborate an alternative politics and an alternative set of solutions. In that context, Trump had a relatively free run.

President Trump

The presidential campaign went through many twists and turns after we first wrote this piece in the summer of 2016. If anything, Trump became even more extreme. The Billy Bush tapes, in which he boasted about assaulting women, seemed sure to disqualify him from the presidency. But for all that, on Election Day, he prevailed in the Electoral College, though not in the popular vote. Even though this was a scenario we had imagined on the basis of our theoretical and empirical observations, it still came as a surprise—not least because it was an outcome that almost no pundits or pollsters had forecasted.

So how could the commentators have gotten it so wrong? Why did Trump not suffer for his "gaffes" while Clinton seemingly did—most notably through renewed focus on her use of a private e-mail server during the last days of the campaign? As this article goes to press, there are important unresolved questions about Russian interference in the election, the role of FBI director James Comey's eleventh-hour announcements about Clinton's e-mails, and the influence of "fake news." We are not in a position to assess their true impact. But we can examine evidence from election night, which tells us much about why Trump prevailed in 30 out of the 50 states.

We can start by invoking Trump's closing pitch in the campaign—the televised *Donald Trump's Argument for America*. This two-minute advertisement started with the candidate intoning, "Our movement is about replacing a failed and corrupt political establishment with a new government controlled by

How Trump dresses and speaks have long been part of a carefully crafted image as an exemplary American, which helps to explain how the privileged billionaire businessman could win the support of the working class.

BEN BAKER *Redux Pictures (left)*; HARRY HAMBURG *Getty Images (right)*

In exit polls, Trump trumped Clinton on just one measure: voters' perceptions of who could bring about change.

you, the American people." Then it built on this basic opposition between the establishment and the people. It asserted that the establishment is an international conspiracy with national allies (cue pictures of Clinton)—people who "don't have your good in mind." The categories could not be starker, nor could the way in which Trump overlaid himself on "the people" (us) and his rival on "the establishment" (them). From the start to the end of the campaign, Trump was nothing if not consistent in driving home this framework.

The question regarding the impact of any specific event is then tied to whether it strengthened or subverted this categorical appeal. And the fact is that here—perhaps especially here—the so-called gaffes can be seen as having strengthened it. Even the Billy Bush tape allowed Trump to emphasize his "locker-room" credentials. Rough? Yes. Crude? Yes. But even more obviously, not the cultured talk of those slick establishment insiders.

In this regard, one wonders what might have happened had Trump's critics played their hand differently. What if they had emphasized the elitist rather than the sexist dimension? After all, Trump was boasting that, as a star, he could take advantage of ordinary folk. He was expressing contempt in direct violation of his claims to be a leader of and for the people. But it was not on this that he was called into account. Instead he was mainly faulted for the deficiencies of character that this episode revealed.

In contrast, one can argue that the reason Clinton suffered for her e-mail indiscretions was because they worked directly against her own appeal, which was based on her long experience and proved commitment to working for the American people. To use a private server for state business seemed an elementary error, one designed to make her less accountable to the people. Moreover, even if not illegal, the content of the e-mails pointed to a self-serving and self-perpetuating Washington oligarchy. Illegality was the least of it. The e-mails suggested that Clinton was simply not of us or for us.

Finally, then, what did the election night results tell us? There is a welter of information here. It showed that the great majority of black and Latino people voted Democratic but less so than in 2012, that women overall voted for Clinton but that working-class women favored Trump, and that the poorest sections of the population (those earning under $30,000 a year) also voted for Clinton (albeit in smaller proportions than they had for Obama). Those in the declining middle classes (earning $50,000 to $100,000) leaned toward Trump.

The story is complicated. But two things were abundantly clear from the *ABC News* exit polls. First, on every measure of character and suitability for the presidency, Clinton had a clear lead. She was seen as better qualified than Trump (53 versus 37 percent), as having the right personality and temperament (56 versus 34 percent), as being less dishonest (59 versus 65 percent) and as being less unpopular (54 versus 61 percent).

Second, there is just one measure on which Donald trumped Hillary—and did so by a country mile: voters' perceptions of who could bring about change. Here Trump won out by 81 to 13 percent. And across the electorate as a whole, the ability to bring change was identified as the key issue (by 38 percent of respondents, compared with the next most important issue identified by 22 percent). It was particularly important to Trump's people, of whom a massive 93 percent saw the U.S. as seriously on the wrong track (whereas the corresponding figure for Clinton voters was a mere 31 percent).

When we put it all together, these figures tell us something important about leadership in general and about the 2016 leadership contest. They underline the point that leadership is never about the character of individuals *as individuals*. This is the "old psychology of leadership" that our own theoretical and empirical analysis has called into question. Instead leadership is about individuals *as group members*—whose success hinges on their capacity to create, represent, advance and embed a shared sense of "us."

Reflecting on the implications of this analysis for the specifics of this election, we can see that many Trump voters knew full well that their man was a reprobate, that they deplored his crudities and that they saw him as a risky choice. And yet in a world where the system is seen to be against "us" and where things appear to be driven in the wrong direction by "them," the really irrational thing to do is to vote for the conventional candidate who represents sticking with that system. M

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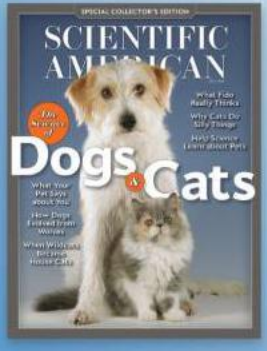

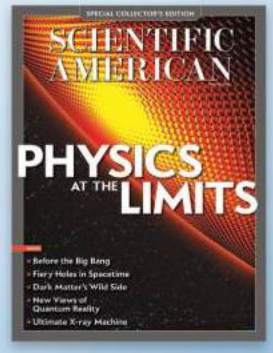

The Footprints of Consciousness

The bits and pieces of the brain that render us conscious reside in places few suspected

By Christof Koch

ILLUSTRATION BY ARMANDO VEVE

"It is in the brain that the poppy is red, that the apple is odorous, that the skylark sings."
—Oscar Wilde (1854–1900)

We moderns take it for granted that consciousness is intimately tied up with the brain. But this assumption did not always hold. For much of recorded history, the heart was considered the seat of reason, emotion, valor and mind. Indeed, the first step in mummification in ancient Egypt was to scoop out the brain through the nostrils and discard it, whereas the heart, the liver and other internal organs were carefully extracted and preserved. The pharaoh would then have access to everything he needed in his afterlife. Everything except for his brain!

Several millennia later Aristotle, one of the greatest of all biologists, taxonomists, embryologists and the first evolutionist, had this to say: "And of course, the brain is not responsible for any of the sensations at all. The correct view [is] that the seat and source of sensation is the region of the heart." He argued consistently that the primary function of the wet and cold brain is to cool the warm blood coming from the heart. Another set of historical texts is no more insightful on this question. The Old and the New Testaments are filled with references to the heart but entirely devoid of any mentions of the brain.

Debate about what the brain does grew ever more intense over ensuing millennia. The modern embodiment of these arguments seeks to identify the precise areas within the three-pound cranial mass where consciousness arises. What follows is an attempt to size up the past and present of this transmillennial journey.

The field has scored successes in delineating a brain region that keeps the neural engine humming. Switched on, you are awake and conscious. In another setting, your

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body is asleep, yet you still have experiences—you dream. In a third position, you are deeply asleep, effectively offline. What is more, I and others have labored on discovering critical brain regions that imbue us with specific forms of conscious experience: perceptions of the orange hues of a sunset, pangs of hunger or the stabbing pain of a toothache. Those are in the neocortex, the brain's outer surface, which generates the particular *content* of experience as it plays out from one moment to the next.

From Heart to Head

By and large, classical Greece and Rome were in thrall to cardio-centric thinking. The brain proper looked too mushy, coarse and cold to host the sublime soul. Yet some clinicians and anatomists had already deduced that the brain was intimately tied to sensation and movement. Two remarkable examples are the fourth-century B.C. work by Hippocrates—*On the Sacred Disease*—that combines a rejection of superstition in treating brain disorders with an accurate clinical description of epilepsy. Later, in second-century A.D. Rome, the renowned Greek physician Galen became, in essence, the first experimental neuroscientist by testing the hypothesis that the brain controls all muscles by means of the nerves. Famously, Galen argued that the vital spirit that animates humans flows up from the liver to the heart and into the head. There, inside the ventricles—the brain's interconnected fluid-filled cavities—the vital spirit becomes purified and gives rise to thought, sensation and movement.

For more than 12 centuries afterward, the world plunged back into dogma, mumbo jumbo, exorcism and mysticism until the beginning of the European Enlightenment. The publication of *Cerebri anatome* in 1664 by English doctor Thomas Willis heralded the beginning of today's neuro-centric age. It featured meticulous drawings (by the young Christopher Wren, England's most acclaimed architect) of the brain's convolutions that transcended previous renditions, which greatly resembled a tangle of intestines.

Neuroscience has always retained a creative tension between holists, who argue that mental activity and other brain functions cannot be tied to a specific region in the brain, and locationists, who claim that specific loci, hot spots in the language of brain imagers, are responsible for carrying out specific functions. Locationism rose to dominance after 1861, when French neurologist Paul Broca presented the landmark case of a patient unable to speak except for a single word. The patient's brain exhibited widespread damage to the left inferior frontal gyrus, part of the neocortex that crowns the top part of the brain. An analysis of a second patient reinforced Broca's conclusion that this small region was responsible for productive speech (touch the bottom of your left temple to get an idea of where it is). The identification of this region, which has been named Broca's area, also fortified the view of the neocortex as the jewel in the crown of the central nervous system, the region most closely associated with higher-order cognitive functions, including consciousness.

In those early days during the Second Empire in France, doctors depended on keen observations of symptoms and on dissection of the brains of patients who had died to reliably infer the site of a lesion and connect it to its likely function. Today neurologists can make these connections by directly peering inside the heads of their living patients using x-ray computed tomography, magnetic resonance imaging and other powerful imaging techniques.

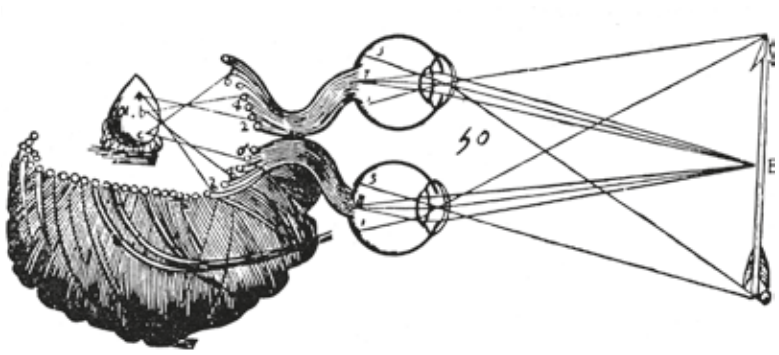
Damage to the brain comes in many forms: strokes, hemorrhages, tumors, viruses, bullets and blows. Examining such destruction, when limited in size, can illuminate the link between the brain's complex structure and what happens when a particular region shuts down. Interpreted carefully, such clini-

FAST FACTS

WHERE CONSCIOUSNESS LIVES

1. Until the 17th century, widespread beliefs held that the heart was the seat of sensation, volition and the soul.
2. It took until the 1980s for studies on the nature and physiology of consciousness to become more than a theoretical exercise.
3. Research has demonstrated that a region in the lower brain—the brain stem—is necessary for switching on activity in areas devoted to higher cognitive functions.
4. A posterior area of the brain appears to be key for conscious seeing, hearing and feeling.

DEA/C. SAPPA *Getty Images* (1); DEA/A. DAGLI ORTI *Getty Images* (2); WORLD HISTORY ARCHIVE *Alamy* (3); INTERFOTO *Alamy* (4)



The quest for the seat of consciousness began in all the wrong places. Embalming procedures in ancient Egypt (*1*) discarded the brain because it was thought that the heart, liver and other organs hosted the soul. Hippocrates and Galen, physicians from antiquity depicted in a 13th-century fresco (*2*), realized that the brain controlled our thoughts and actions. During the Renaissance, Andreas Vesalius, credited as the father of modern anatomy, captured details of the brain's surface (*3*), a prelude to René Descartes's speculation that the pineal gland (*onion-shaped structure, 4*) is where consciousness resides.

4

cal studies have by far been the most fecund source of knowledge concerning the relation between the physical brain and the conscious mind.

The Brain's Light Switch

Some areas of the brain are more instrumental than others in generating a conscious state. The brain stem at the top of the spinal cord is one of them. If the brain stem is damaged or compressed, consciousness will flee the victim. Indeed, even a small injury to parts of it can lead to a profound and sustained loss of consciousness. The patient can go into stupor and can only be partially aroused after vigorous and prolonged stimulation. Worse, the patient can lapse into a coma, an enduring, sleeplike state of immobility with closed eyes, from which arousal may prove to be difficult.

During and after World War I, a remarkable wave of "sleepy sickness," or encephalitis lethargica, swept the world. The condition helped to point to the brain stem as a mediator of sleep and wakefulness. This form of encephalitis induced in many of its victims a state of almost permanent and statuelike sleep, from which they would awaken only for a few hours at a time. It was the astute observation by Austrian neurologist

A Guided Tour

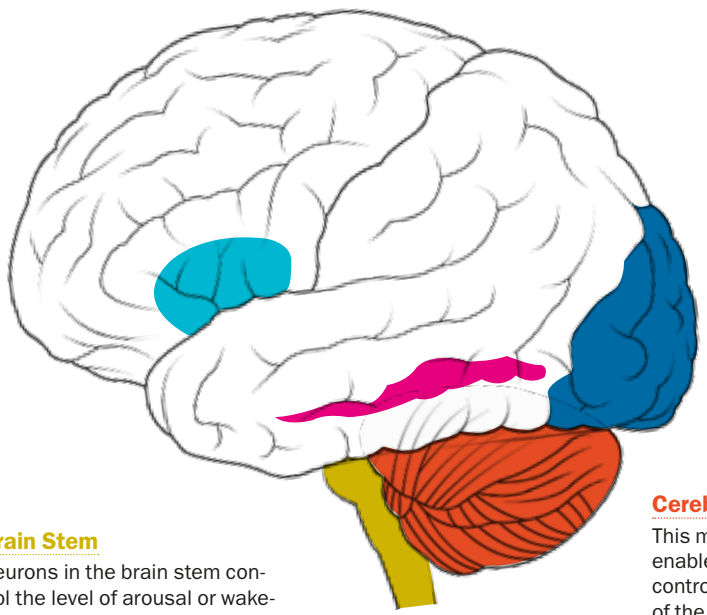
Scientists fall into two camps when discussing the brain. Holists argue that consciousness is generated by the entire three-pound mass made up of 170 billion cells, of which half are nerve cells. Locationists support the idea that specific neural circuits are responsible for specific functions, including consciousness. On closer inspection, neuroanatomists have realized that one confined area, the brain stem, ensures that we do not lapse into a coma or suffer from a sleeping sickness. Meanwhile rear areas on the surface of the brain are needed to generate mental imagery and other specific conscious experiences, such as recognizing your grandmother.

Broca's Area

In 1861 Paul Broca discovered a small region at the brain's surface that is responsible for producing speech.

Occipital Cortex

Visual information about form and motion gets processed in this area at the back of the brain.



Fusiform Gyrus

Parts of this structure play a critical role in recognizing faces, among other visual tasks. Damage to it causes face blindness.

Brain Stem

Neurons in the brain stem control the level of arousal or wakefulness. If these do not properly function, the patient lapses into stupor or a coma or may die.

Cerebellum

This mini brainlike structure enables precise motor control. Lesions in part of the cerebellum do not appear to lead to a loss of conscious experiences.

Baron Constantin von Economo of victims of this epidemic that led to the hypothesis that a brain center in the hypothalamus actively promotes sleep, whereas another in the upper brain stem produces wakefulness.

A more precise localization came from classical experiments by Italian Giuseppe Moruzzi and American Horace Magoun in the late 1940s, demonstrating that a brain stem region known as the midbrain reticular formation modulates the level of wakefulness ("reticular" here refers to the mesh or netlike appearance of this part of the brain).

When we began this labor of love in the late 1980s, consciousness was viewed as a fringy subject, a sign of a scientist's cognitive decline.

In more recent years this notion of a monolithic system that activates consciousness has given way to a recognition that 40 or more nuclei are housed within the brain stem, all of which exhibit a specific neurochemical identity. These conglomerations of neurons are profoundly different in structure from the layered organization of the cortex. Cells in different nuclei manufacture, store and release different neurotransmitters or neuromodulators at their synaptic terminals—acetylcholine, serotonin, noradrenaline, GABA, histamine and orexin. Many of these brain stem nuclei monitor and modulate our conscious state, including wake-to-sleep transitions. Collectively they transmit signals that control internal bodily processes, such as breathing, thermal regulation, muscle tone, heart rate, and so on and process signals relating to the working condition of the body's organs.

Brain stem neurons promote consciousness by suffusing the cortex with a cocktail of these neurochemicals to keep cortical neurons in an aroused state. These substances alone are incapable of producing an experience. Rather they form the background—a neural palette—on which any conscious experience occurs, and this chemical mix acts as a "switch." But if the cortex is severely damaged, it cannot receive the signals that maintain the light of conscious experience. Patients who have brain stem function that has been relatively spared but who have widespread cortical destruction typically remain in a vegetative state, permanently unresponsive but with eyes open, experiencing or feeling nothing.

Where Consciousness Resides

At this point, the story gets personal. In the late 1980s, as a freshly baked assistant professor at the California Institute of Technology, I started having regular conversations with Francis Crick about the mind-body problem. Crick was the physical chemist who, together with James Watson, discovered in 1953 the double-helical structure of DNA, the molecule of heredity. In 1976, at age 60, when Crick's interests shifted from molecular biology to neuroscience, he left Cambridge, England, in the Old World to establish his new home in La Jolla, Calif. Despite an age difference of 40 years, Crick and I struck up an easy friendship and a collaboration that would last for 16 years and result in two dozen scientific papers, essays and two books. All of them focused on the anatomy and physiology of the mammalian brain and its connection to consciousness.

When we began this labor of love in the late 1980s, writing about consciousness was viewed as a fringy subject, a sign of a scientist's cognitive decline. Retired Nobel laureates did it, as did philosophers and mystics, but not hard-core scientists. When the topic arose, graduate students, always finely attuned to the mores and attitudes of their elders, rolled their eyes and smiled indulgently. Betraying an interest in consciousness was ill advised for a young professor, particularly one who had not yet attained the holy state of tenure.

Those attitudes have since changed. Together with a handful of colleagues, Crick and I gave birth to a science of consciousness. Its physical basis in the brain is now investigated worldwide, and questions concerning what makes any system, biological or man-made, exhibit a conscious state are hotly debated. Consciousness is no longer the unspoken taboo.

Our goal from the outset was to identify the mechanisms in the brain that, at a minimum, are needed to create a specific conscious experience: seeing the setting sun, recognizing your grandmother or feeling that god-awful toothache. We called these the "neuronal correlates of consciousness," or NCC. The definition of an NCC was by no means clear. Must, for instance, some nerve cells vibrate at a particular magical frequency? And if that is true, what is it about the biophysics of particular bits and pieces of highly excitable brain matter vibrating at a specific frequency that is able to produce the glorious surround sound and Technicolor that constitute the sounds and sights of life? Are these special consciousness neurons all located in a particular part of the brain, as René Descartes famously postulated back in the middle of the 17th century for the pineal gland, probably the first hypothesized neuronal correlate of consciousness?

It is important to stress the "minimal" in defining the NCC. Without that qualifier, all of the brain could be considered a correlate: after all, the brain does generate consciousness, day in and day out. But Crick and I wanted to find the

THE AUTHOR

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specific synapses, neurons and circuits that generate—that, in fact, *cause*—an equally specific conscious experience. Being careful scientists, we used the more cautious "correlates" in place of the more definitive "causes" of consciousness.

Based on our knowledge of the highly sophisticated nature of cortical nerve cells and their response to stimuli in the external world, we set our sights on the cortex, the gray matter on the brain's outer surface. The cortex is a laminated sheet of nervous tissue about the size of a large pizza. Two of these sheets are crammed into the skull, side by side, making up the left and right cortical hemispheres. The cortex is subdivided into the neocortex—a defining hallmark of mammals—and the evolutionarily older archicortex. All available evidence points toward certain key regions within the 11 ounces of highly structured neocortical tissue as the location of content-specific NCCs.

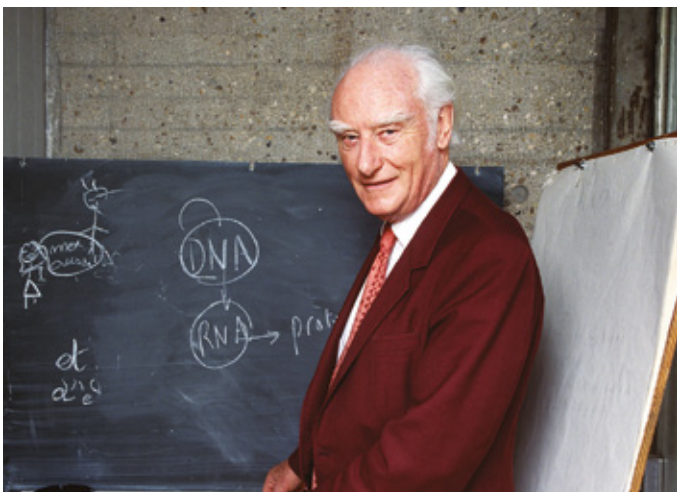
Lesions to the rear section of the neocortex—for instance, from a stroke or some other damage—demonstrate what happens when activity in the back of the brain shuts down. A patient so afflicted cannot recognize a set of keys on a chain dangling in front of her. She looks at them and sees texture and lines and colors but not keys. Yet if she grasps them or if they are jingled, she immediately knows what they are. Poetically termed *Seelenblindheit* in German (literally, "blindness of the soul"), this condition was rechristened agnosia by Sigmund Freud, a term that persists. The late neurologist Oliver Sacks brilliantly wrote about patients with agnosia and how their loss shaped the way they experienced the world.

Consider A.R., who suffered a blockage to the cerebral artery that damaged a small region on one side of his occipital cortex. The stroke briefly blinded him. He eventually recovered sight but permanently lost color vision in the upper left quadrant of his field of view, corresponding to the site of a pea-sized lesion in his right occipital visual cortex. A.R.'s low-level vision—detection of brightness, lines, and so on—and his motion and depth perception were normal. The only other deficit was a difficulty distinguishing—he could not read text—but this problem was confined again, to the upper left quadrant.

Functional MRI and EEG are some of the most common ways to look for neural correlates of consciousness in healthy volunteers. These techniques can identify a bevy of brain areas related to face recognition in volunteers within regions of the ventral temporal cortex, called the fusiform gyri (bottom area toward the back of the head). Found bilaterally, the regions are referred to as the fusiform face area and respond more strongly to pictures of faces, compared with scrambled faces or other objects and scenes.

Epileptic patients have played an outsized role in consciousness research. This is especially true of those who had electrodes implanted to control their seizures. A study of 10 such patients conducted in 2014 at Stanford University used the electrical signals recorded by implanted electrodes to confirm that both the left and the right fusiform gyri responded selectively to faces, compared with pictures of body parts, cars or houses. These electrodes could also directly excite the underlying cortical tissue using electrical pulses. Stimulating the right fusiform gyrus led to reports of perceiving faces. In one study, a patient who looked at his neurologist remarked: "You just turned into someone else. Your face metamorphosed. Your nose got saggy and went to the left. You almost looked like somebody I'd seen before but somebody different. That was a trip" [*see box on page 59*].

When the left fusiform gyrus was



The brain stem (*left, highlighted in yellow*) serves as an engine of consciousness. When injured, it may extinguish all conscious activity. The modern search for key brain loci that imbue us with consciousness began with Francis Crick, the author's mentor (*above*), decades after he had co-discovered the structure of DNA.

GETTY IMAGES (*left*); DANIEL MORDZINSKI *Getty Images* (*right*)

stimulated, patients either did not make such reports, or they were restricted to simple, nonface imagery, such as twinkling and flashing lights or traveling blue and white balls.

This study underscores the truth behind the oft-repeated mantra that correlation is *not* causation. Just because the left fusiform gyrus is selectively activated by a sight, sound or action does not imply that the area is essential for vision, hearing or movement. These patients also teach us that electrically stimulating the right ventral temporal cortex can give rise to imagined faces. Indeed, this region is the best candidate we have for a content-specific NCC like "seeing" a face. Its activity correlates closely and systematically with facial perception. Stimulation of it induces or alters the perception of faces, and, crucially, people become face-blind when this region is destroyed.

Sometimes not finding something where you expected it can be as important and revealing as finding it. This observation applies to the cerebellum, tucked below the cortex at the back of the brain, and even pertains to parts of the cortex.

If the cerebellum is damaged, both animals and people have difficulty making precise movements, and the movements they do make lose precision and become erratic, jerky and uncoordinated. Yet patients with cerebellar lesions do not complain of being unable to see, hear or feel. Nor do they experience transient or permanent loss of consciousness. Their subjective experience of the world appears intact and normal. Consider the rare, and extreme, case of a 24-year-old woman born without a cerebellum.

Although she has mild mental impairment and moderate motor deficits and talks with a slight tremor, she can speak clearly about her daily experiences, her likes and dislikes, and her life with a young daughter. This is surprising given that her brain scans [*see 2 below*] show she has only a fluid-filled cavern where her cerebellum should be.

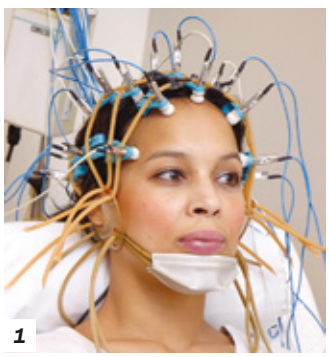
This absence is remarkable because the cerebellum contains Purkinje cells, whose fan-shaped structures are among the most beautiful and complex of all neurons. And astonishingly another cell type in the cerebellum—the granule neuron—outnumbers cortical ones by a factor of four. Despite this intricate physiology, neural activity in the cerebellum does not give rise to consciousness.

Even more intriguing than the cerebellum are the frontal lobes of the neocortex. Traditionally they are thought to be the key hallmark of our species, having expanded more in *Homo sapiens* than in all other higher primates. Functional MRI has also shown them to be involved in tasks that involve planning, short-term memory, language, reasoning and self-monitoring. Yet more than a century of reports describing electrical brain stimulation carried out during neurosurgery while the patient is awake suggest that it is difficult to directly elicit sensory experiences from stimulation of frontal sites.

> Large portions of the front of the brain can be excised without having a major impact on conscious experience.

Indeed, it is common surgical knowledge that removing much of the front of the cortex causes no apparent major deficit! This surprising realization stems from insight gained from hundreds of neurosurgeries for tumors, epileptic seizures and other neurological conditions during the first half of the 20th century, when neurosurgeons routinely excised large swathes of frontal or prefrontal cortex on both sides. What is remarkable is how unremarkable these patients appear from their clinical description.

The most dramatic example is Mr. A, a patient of neurosurgeon Walter Dandy in 1930. Because of Mr. A.'s massive tumor, the surgeon had to amputate the patient's frontal poles, the protruding sections at the front of the brain. The patient survived this bilateral frontal lobectomy for 19 years and continued to speak. A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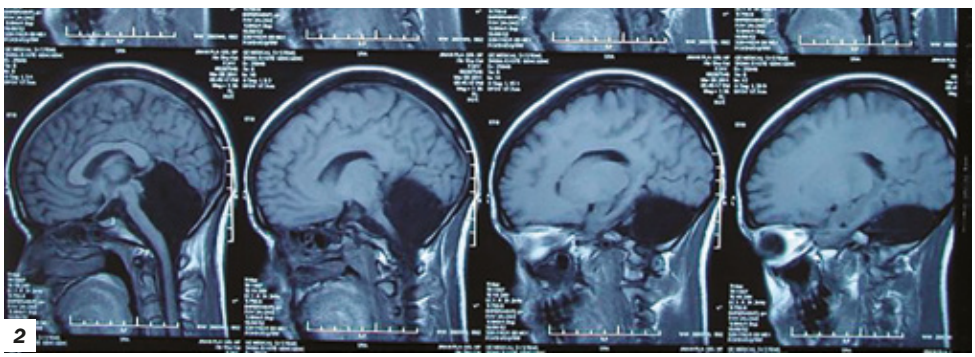
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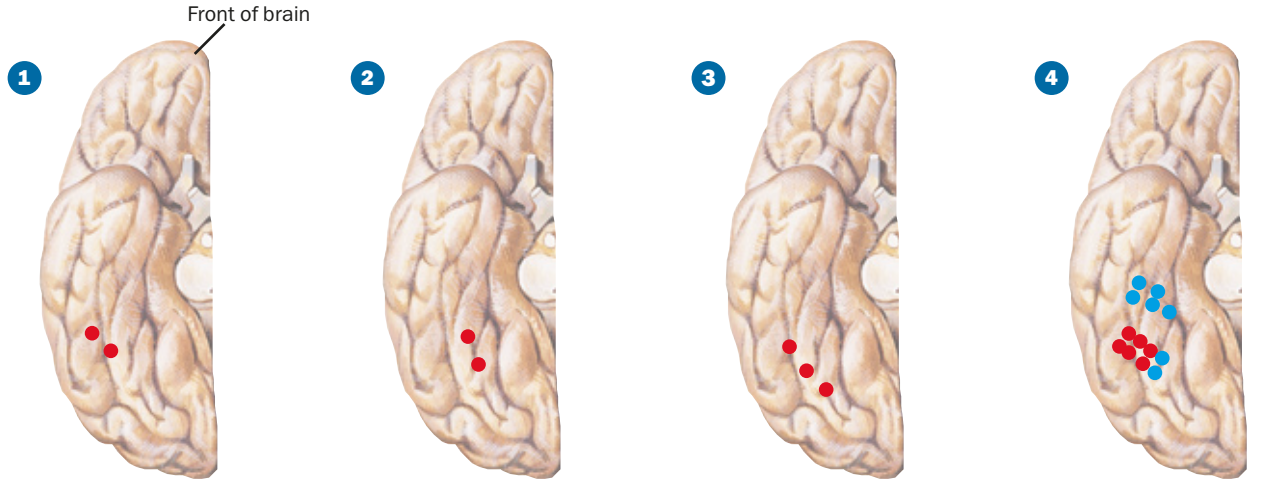
Tools in the hunt for consciousness include EEG (*1*) and MRI brain scans (*2*). These scans show a woman with an empty space where her cerebellum should be.

AJ PHOTO *Getty Images (1)*; FROM "A NEW CASE OF COMPLETE PRIMARY CEREBELLAR AGENESIS: CLINICAL AND IMAGING FINDINGS IN A LIVING PATIENT," BY FENG YU ET AL., IN *BRAIN*. PUBLISHED ONLINE AUGUST 22, 2014 (*2*)

Now You See Me, Now You Don't

Electrical stimulation of the right fusiform gyrus, seen from below, in four epileptic patients undergoing surgery caused distorted perception of faces. The red dots represent electrodes that produced distorted views, whereas the blue ones did not do so in one patient.



1 "Like you weren't you. You were a different person. I noticed the eyes. I was able to see almost your whole body on your right side."

2 "You turned into someone else. Your face metamorphosed.... Your nose got saggy and went to the left."

3 "That orange part looked like a person ... like a face and a body.... Like a hallucination of the curtains."

4 "[The eye] looked like a circle and then changed to a rectangle shape."

SOURCE: "ELECTRICAL STIMULATION OF THE LEFT AND RIGHT HUMAN FUSIFORM GYRUS CAUSES DIFFERENT EFFECTS IN CONSCIOUS FACE PERCEPTION," BY VINITHA RANGARAJAN ET AL., IN *JOURNAL OF NEUROSCIENCE*, VOL. 34, NO. 38; SEPTEMBER 17, 2014; DE AGOSTINI PICTURE LIBRARY *Getty Images (brain)*

note in his file observed that "one of the salient traits of Mr. A's case was his ability to pass as an ordinary person under casual circumstance." When he toured the Neurological Institute in the company of distinguished neurologists, "no one noticed anything unusual." Mr. A. did exhibit some of the behaviors associated with frontal lobe removal, such as childlike behavior, lack of inhibition and a need to tell jokes. Neither he nor other patients who submitted to similar surgeries were robbed of conscious behaviors. Their capacity to see, hear or experience the world remained intact, despite the drastic surgical intervention.

That the anterior cortex may not be necessary for sensory consciousness does not imply that it does not contribute directly to any given aspect of consciousness. After all, being self-conscious (reflecting on what one perceives) is different from perceiving something, yet both are subjective experiences. Perhaps reflection, effort, and so on are generated by the anterior cortex, although no firm evidence exists yet. The prefrontal cortex might then be involved in unconscious planning, strategizing, forming memories and focusing attention.

The Hot Zone

Since the modern quest for the NCCs at the end of the 20th century, progress has been rapid compared with previous millennia. First, conceptual work has clarified the importance of investigating the neural correlates of both specific conscious contents and consciousness as a whole. Second, some parts of the brain have been identified as contributing little to conscious experience. The areas of the brain that make us conscious appear to be centered on a more restricted hot zone in the posterior part of the neocortex, with some possible additional contributions from some anterior regions.

These findings raise the question of why the seats of consciousness are so circumscribed. Is there something so different in the wiring or behavior of neurons in the back of the cortex from those in the front? Future investigations will be needed in the decades—maybe centuries—ahead to further illuminate the types of neural activity that underlie the infinite varieties of human experience. **M**

MORE TO EXPLORE

- **Brain of Patient A. after Bilateral Frontal Lobectomy; Status of Frontal-Lobe Problem.** R. M. Brickner in *AMA Archives of Neurology and Psychiatry,* Vol. 68, No. 3, pages 293–313; 1952.
- **Electrical Stimulation of the Human Brain: Perceptual and Behavioral Phenomena Reported in the Old and New Literature.** A. Selimbeyoglu and J. Parvizi in *Frontiers in Human Neuroscience,* Vol. 4, Article 46, pages 1–11; May 2010.
- **The Neural Correlates of Consciousness: Progress and Problems.** C. Koch, M. Massimini, M. Boly and G. Tononi in *Nature Reviews Neuroscience,* Vol. 17, pages 307–321; May 2016.

From Our Archives

- **The Face as Entryway to the Self.** Christof Koch; Consciousness Redux, January/February 2015.
- **Sleeping While Awake.** Christof Koch; Consciousness Redux, November/December 2016.

The Risk of Going Under

Research paints a complex picture of how surgery and anesthesia might harm the brain, particularly in the elderly

By Andrea Anderson

William Sieber was working in his garden. Wasn't he? He was sure he had been picking tomatoes just moments ago. Now he appeared to be in some kind of rehabilitation hospital. And weren't people looking at him a little strangely? What on earth were they up to?

Sieber, a then 88-year-old retired pediatric surgeon, knew that something was not right. As he told his son, Fritz, a few months later, he was unable to shake the frightening fog of confusion and paranoia that enveloped him.

This delirium lasted about a week. It had started after a fairly routine spinal surgery to relieve nerve pressure caused by stenosis, the narrowing of space around the spinal cord. The 45-minute procedure went according to plan. His anesthesiologist had sedated him using a typical cocktail of drugs.

Before the operation, Sieber had not experienced any noticeable cognitive difficulties. He was living independently with his wife in a retirement community near Pittsburgh, still drove his own car and read a book a week on his favorite topics, history and gardening. But his experience in recovery "scared the daylights out of him," Fritz recalled. "He knew that he was acting, in his words, 'crazy.' He couldn't do anything about it, and that's what bothered him."

It bothered his son, too. As director of anesthesiology at the Johns Hopkins Bayview Medical Center, Fritz took a professional interest. Not long after his father's 2007 surgery, he joined the ranks of researchers studying the impact of surgery and anesthesia on the brains of elderly patients. For decades physicians have anecdotally reported mental changes, from short-term disorientation to outright dementia, in older patients following surgery. Only more recently, though, have they begun to seriously investigate the prevalence of these changes, their duration, and an array of potential causes, mechanisms and possible solutions.

So far these efforts have not turned up any definitive proof that anesthesia or surgery, or both, is directly responsible for postsurgical cognitive problems. But the circumstantial evidence is building. Several questions loom large: If the connection is real, is the main culprit consciousness-zapping drugs, the stress of surgery or the brain inflammation that can accompany it? Are specific types of anesthesia more harmful than others? Are certain patients more susceptible to surgery-related cognitive decline? And perhaps most critical, are there ways to ward off any potential negative effects?

To date, a few guideposts have emerged—among them, the importance of offering counseling and evaluating patients' cognition before they get wheeled into the operating room—but definitive answers cannot come soon enough. Every year more than 17 million seniors in the U.S. undergo surgery. With more than 75 million baby boomers hitting their golden years, the number of Americans facing hip replacements, heart repairs and all manner of other procedures is sure to rise. Soon many more seniors and their families will face tough decisions as they try to balance the best treatment options against potential risks to their cognition and quality of life.

From Delirium to Dementia?

Researchers began exploring the potential cognitive effects of surgery and anesthesia in earnest in the 1990s, focusing largely on two outcomes: postoperative delirium, marked by temporary disorientation, hallucinations and memory problems, and postoperative cognitive dysfunction. The latter, known as POCD, encompasses a range of lasting deficits, among them problems with learning, memory, attention and abstract thinking. These studies suggested that postoperative delirium is remarkably common, occurring in up to half of patients older than 65, with even more patients displaying some milder confusion. They also found that POCD affected at least a third of elderly patients, although it has proved trickier to pinpoint because there is no standard way to measure or diagnose it.

In 2001 a pivotal study in the *New England Journal of Medicine* documented even higher rates of delirium and POCD—and an apparent overlap between the two. A Duke University–led team measured neurocognitive function in 261 patients, all older than 50, both before and after coronary artery bypass graft surgery. Among the tests they ran were some that measured how well these individuals remembered details from a story and a series of digits and shapes, as well as their speed at drawing lines through sequential numbers or letters.

At discharge, typically a week after surgery, more than half of the participants showed at least a 20 percent drop in at least one of the cognitive areas tested. Many improved quickly. After six weeks, 36 percent still struggled; after six months, less than a quarter did. But for a significant number of these subjects, their cognitive problems persisted or reappeared: Five years after surgery, 42 percent of the 172 patients who returned for testing exhibited signs of cognitive decline. In patients with cognitive decline at discharge, these losses were two to three times those seen among nearly 6,000 Medicare patients tracked for five years in a separate study.

Levels of Consciousness

The bispectral index (*below*)—a value based on the brain's electrical activity, measured with electrodes on the scalp (*left*)—helps doctors to monitor how deeply sedated patients are during surgery.

100
- **Awake:** Fully alert

80
- **Light/Moderate Sedation:** Remains somewhat responsive to loud voices and physical prodding

60
- **General Anesthesia:** Unconscious, unresponsive to most outside stimuli

40
- **Deep Hypnotic State:** Completely sedated, no awareness

20
- **Burst Suppression:** Mostly no brain function, punctuated by flurries of activity

0
- **Flatline EEG:** No neural activity

FAST FACTS

STAYING SHARP AFTER SURGERY

1. For decades physicians have anecdotally reported mental changes, from short-term disorientation to outright dementia, in older patients following surgery.
2. Recently scientists have started to investigate an array of potential causes for these changes—including anesthesia, the stress of surgery and brain inflammation.
3. Some evidence links the depth of sedation to the risks for postoperative cognitive problems, but other studies suggest that deep sedation may shield the brain from trauma.
4. A few guideposts have emerged: among them, it is critical to assess a patient's cognition before surgery and to make sure he or she understands the risks.

PRECEDING PAGES: GETTY IMAGES; THIS PAGE: JUANA ARIAS *Washington Post/Getty Images*

In the years since, a growing body of research has shown that seemingly temporary postoperative deficits can resurface months, even years, after surgery. "We do know that patients having procedures in hospital have a very high rate of delirium, and we know that that puts patients at increased risk of cognitive decline down the track," says Lisbeth Evered, an anesthesia researcher at St. Vincent's Hospital Melbourne in Australia.

Last year investigators at Beth Israel Deaconess Medical Center and elsewhere sought to quantify that risk. They tracked 560 individuals, all older than 70 and initially shown to be dementia free, undergoing total hip replacement or another major surgery. They found that 134, or about 24 percent, experienced postoperative delirium. Compared with the participants who did not have delirium, those who did were significantly more likely to show mental deterioration years down the line. Although both groups on average experienced some cognitive decline, the rate was nearly three times faster in the group who had suffered from delirium. What is not clear, however, is if the decline is caused by the delirium, or if the delirium is indicative of some underlying brain vulnerability, or if something else entirely is to blame.

Dose vs. Depth

Several months after Sieber's back surgery, he faced a knee operation. His spell of postoperative confusion had completely dissipated, but he still felt apprehensive. "I just can't have that happen to me again," he told his son. So Fritz asked his father's anesthesiologist to consider using a regional anesthetic, which can produce lighter sedation and might, he reasoned, have less of an effect on his father's thinking. She agreed, and the strategy paid off (although it is not always an option for longer surgeries). Sieber experienced no delirium and went home from the hospital after only two days, "clear as a bell," Fritz remembers. "It really got me thinking about whether there are issues with drug dosing in the elderly."

To try to find out, in 2010 Fritz and his colleagues evaluated delirium in 114 otherwise healthy elderly patients undergoing surgery for hip fractures. Instead of general anesthesia, the doctors administered varying doses of propofol via the spine. To estimate how deeply the patients went under, the researchers used a so-called bispectral index (BIS) monitor. The device gauges levels of consciousness based on the brain's electrical activity, measured with electrodes placed on the scalp. They found that after surgery, the patients who had been only lightly sedated as measured via BIS—regardless of how much anesthesia they received—experienced half the rate of postoperative delirium compared with the rest. In other words, sedation depth and not anesthetic dose had predicted whether or not someone experienced delirium.

Other studies, however, do link anesthesia dose to delirium. In 2013 researchers at the Chinese University of Hong Kong evaluated 921 elderly patients undergoing major surgery, only some of whom received BIS monitoring to make sure they stayed minimally sedated. Compared with the group that was not monitored, BIS-monitored patients received, on average, 21 percent less propofol when it was administered intravenously and 30 percent less via inhalation. They were also more than 30 percent less likely to have postoperative delirium or to have POCD three months after discharge. The lower exposure to anesthesia may have been the "crucial factor," says Duke anesthesiologist Miles Berger, who was not involved in the work.

Complicating this picture, though, additional evidence hints that deep sedation may sometimes protect patients' brain function. In 2015 Mount Sinai Hospital anesthesiology, geriatrics and palliative medicine researcher Stacie Deiner and her colleagues reanalyzed BIS measurements from 105 older individuals undergoing major surgery with intravenous or inhaled general anesthesia. They found that patients who spent 50 percent more time in deep anesthetic states had lower POCD rates, on average, three months after surgery. Those who were deeply sedated for longer also displayed more burst suppression, a type of neural activity characterized by almost no brain function, punctuated by flurries of activity. Deiner's team suspects that sustained periods of burst suppression, brought on by deep sedation, may shield the brain from trauma.

Her study highlights a central question about whether anesthetics harm or protect the brain. This uncertainty persists, in large part, because researchers still do not fully understand how anesthetics work. In general, these drugs slow nerve firing throughout the brain. But as Imperial College London biophysics and anesthetics researcher Nick Franks explains, some also boost neural activity along the pathways that make us sleepy. On another level, research suggests that anesthetics disrupt the way in which neurotransmitters typically interact with their receptors. Many common anesthetics, including sevoflurane and propofol, bind to receptors that regulate memory, attention and concentration and may even rewire connections essential to these functions, according to researcher Laszlo Vutskits of the University of Geneva.

Up to half of older patients suffer from delirium after major surgery. Perhaps a third have postoperative cognitive dysfunction, which may resolve, persist or vanish and then resurface.

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Animal studies consistently show that some general anesthetics injure neurons, alter the branchlike dendrites that allow nerve cells to communicate and trigger learning problems. But they also show that other drugs may safeguard the brain from damage. It may be that an animal's age helps to determine the permanence of any neuronal changes. Vutskits argues, for instance, that young, developing brains are flexible enough to compensate for or reverse anesthesia-induced modifications [*see box below*]. The likelihood that postoperative cognitive problems stem from more than one factor is "one of the things that makes understanding human models so confusing," Deiner says.

The Link to Inflammation

Sieber recovered quickly from his second surgery but started to show signs of dementia a few years later. His mental capacity continued to deteriorate until his death in 2015. Sieber's trajectory—cognitive difficulties that emerge after surgery, then dissipate and ultimately return—matches that of many patients. Given the slew of unanswered questions concerning anesthesia, his son, like many other experts, began to consider factors such as surgery itself and a presumed consequence: neuroinflammation.

Inflammation is our body's natural response to a trauma—immune cells release chemicals to help heal damage, keep intruders at bay and protect us from further harm. But sometimes this defense mechanism goes awry, launching a full-fledged war when only a small surge is warranted. Many investigators now believe that surgery *can* trigger brain inflammation, which in turn produces cognitive problems. "You get an inflammatory insult as a result of the surgery that is then redirected at the brain," says anesthesia researcher Roderic Eckenhoff of the University of Pennsylvania.

A series of studies have shown that rodents display robust inflammatory responses to surgery, which increase their risk of POCD-related brain damage. In 2016 one mouse study found that surgery triggered inflammation in the brain's memory center, which impaired the animals' powers to recall a familiar mouse, among other tests. In contrast, when the animals received just anesthesia, without surgery, they showed no memory problems. The same study reported that mice that were engineered to lack a normal inflammatory response or that received an anti-inflammatory drug during surgery could also sidestep these cognitive costs.

Unfortunately, the findings are less straightforward in humans. If, for instance, neuroinflammation leads to cognitive issues, then brief, relatively noninvasive surgeries should probably be less risky. But in a 2015 pilot study, chief of geriatrics Cynthia X. Pan and her colleagues at NewYork-Presbyterian/Queens Hospital compared mental outcomes in dozens of older individuals undergoing either laparoscopic colon surgery, involving small incisions, or more invasive colon surgery. They found that almost half of all patients experienced POCD, and its occurrence in both groups was essentially the same. Also confounding was a Chinese study in which investigators ran-

What about the Risks for Kids?

GETTY IMAGES

Do children who need surgery face the same cognitive risks as older patients? Some epidemiological studies suggest that early exposure to surgery and anesthesia might lead to neurodevelopmental problems down the road, but the most robust research tends to show no long-term cognitive consequences.

In 2016 Andrew Davidson, an anesthesia and pain management researcher affiliated with the Murdoch Childrens Research Institute and Royal Children's Hospital Melbourne in Australia, and his colleagues looked at cognitive outcomes in more than 700 children who had inguinal hernia surgery as infants. The babies randomly received spinal or general anesthetic for just under an hour. When the researchers reassessed the tots a year or so later, both groups performed equally well on tests of cognition, language, motor skills, behavior, and social or emotional skills. "At the age of two, there's no difference whatsoever," Davidson says. "That doesn't mean that there isn't some impact in some other neurocognitive domain," he adds, noting that the children will be assessed again when they are older.

In another study published last year, Lena Sun, a pediatric anesthesiology researcher at Columbia University, and her co-workers tracked down 105 children who had elective hernia surgery before their third birthday and received a general anesthetic for a median of 80 minutes. Five to 12 years later the investigators compared these children with their unexposed siblings in terms of IQ, memory, attention, learning, motor function and language. Again, cognitive scores were similar in both groups.

Sun says this study should be "very reassuring to parents with healthy children having brief procedures." Children needing multiple or lengthy procedures, however, may experience more lasting neural changes. Indeed, the FDA recently issued a safety warning that prolonged or frequent use of general anesthesia in very young children could harm their brain. Sun says that in such cases, "we cannot make a blanket statement that there are no problems," but current research is tackling the potential risks. —*A.A.*

The stress of surgery or resulting inflammation may play a role in cognitive decline. Another possibility: those most affected are already slipping, and surgery pushes them over the edge.

domly assigned elderly knee surgery patients to receive either paracoxib, an anti-inflammatory drug, or saline with general anesthesia. They found that the paracoxib group exhibited fewer inflammatory markers and half the rate of POCD one week after surgery. Three months out, that gap closed, casting doubt on how much inflammation harms cognition in the long run.

Other research implicates ailments such as chronic heart disease, hypertension and Alzheimer's disease, which is associated with neuroinflammation. In people with these conditions, who are already more susceptible to cognitive decline, triggering additional inflammation with surgery or drugs may hasten an ongoing process. In 2013 Eckenhoff and his colleagues at the University of Pennsylvania explored this idea, studying the effects of surgery and anesthesia on normal mice versus mice genetically engineered to develop Alzheimer's-like dementia. They found that surgery led to dramatic learning and memory problems in the genetically altered mice. But surgery in the normal mice and anesthesia in both groups had no significant impact on cognition.

Last year Katie J. Schenning and her colleagues at Oregon Health & Science University retrospectively analyzed data from two studies and compared 182 elderly individuals who had one or more surgeries under general anesthesia with 345 of their peers who had never had surgery or had at least avoided general anesthesia. They found that the group who received general anesthesia displayed significantly worse cognitive abilities over the course of seven years, on average, and showed brain shrinkage and ventricular enlargement—an expanding of brain cavities that is associated with dementia. These changes were most pronounced among surgical patients who carried the *APOE4* allele, a gene variant that increases the risk of developing Alzheimer's.

"Perhaps the people most affected are already at risk for having this cognitive decline and perhaps are already declining," says Schenning, an anesthesiology and perioperative medicine researcher. "Maybe it's gone unrecognized until they have a major life stress, such as surgery, that sort of pushes them over the cliff."

Reducing Your Risk

Did Sieber's surgeries ultimately contribute to his dementia? His son cannot rule out the possibility that his father was always at risk and would have deteriorated anyway. "Part of the issue with older adults is that what you're observing is part of a longer trajectory of decline," Deiner says. "So understanding whether the person is having just normal age-related changes versus having an actual problem related to surgery and anesthesia can be a bit thorny to figure out."

Whatever the cause, cognitive problems postsurgery present serious challenges to patients and their families. Esther Oh, co-director of the Johns Hopkins Memory and Alzheimer's Treatment Center, describes one all-too-common scenario: an elderly person has routine surgery and winds up either dependent on family members or needing an assisted living facility. Before that happens, experts are recommending several strategies that may help reduce the risk of postsurgical delirium and POCD.

First, elderly patients and their families should be advised of possible risks in a frank manner and be made aware of any nonsurgical options. For those facing surgery, Sieber advocates preoperative screening for subtle cognitive impairment. Those who show signs of cognitive change would benefit from adhering to evidence-based guidelines, such as Enhanced Recovery after Surgery, which aim to decrease surgical complications through counseling, to reduce physiological stress and to standardize anesthetic protocols, such as using lower doses or less sedation. Even simple tactics—such as making sure older patients always have their glasses or hearing aids at their bedside—can help reduce disorientation. Similarly, patients may feel less disconcerted if they are allowed to wake up on their own in recovery rather than being roused.

Investigators emphasize that the possible links among surgery, anesthesia, POCD and dementia should not scare anyone away from procedures that can improve health or quality of life. Instead they want to maximize patient outcomes. It is not acceptable to say, "Grandma was never quite right" after surgery, says Beverley Orser, an anesthesia researcher at the University of Toronto: "Survival's not good enough—we want them to thrive." M

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The Warmth of Friendship, The Chill of Betrayal

Thanks to some evolutionary hardwiring in the brain and body, our physical and psychological temperatures are linked

By Marta Zaraska

ILLUSTRATION BY GONCALO VIANA

The hot cup of tea. Its powers to soothe are as legendary as the supposed antiviral properties of chicken soup. Examples abound in literature. For instance, after Mrs. Inglethorp quarrels with her husband in Agatha Christie's 1920 novel *The Mysterious Affair at Styles*, the maid is quick to suggest, "You will feel better after a nice hot cup of tea, m'm." In real life, too, many of us turn to a piping-hot panacea—be it chamomile or cocoa—when we feel in need of comfort.

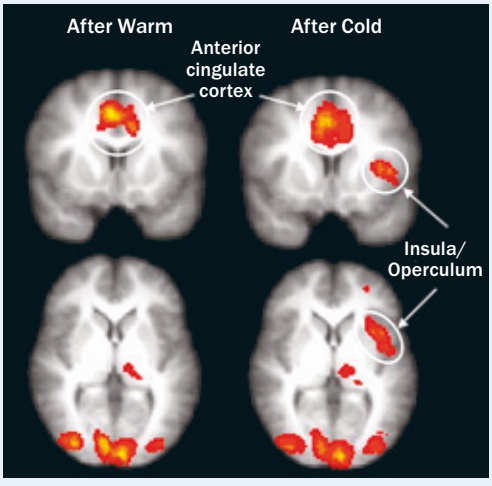
According to a growing body of research, there may be real merit to this popular remedy. During the past decade scientists have discovered that our physical temperature can affect how "warm" or "cold" we feel toward other people. For instance, studies have found that when we are hurt, isolated or betrayed, a short dose of heat—in the form of a hot beverage, warm bath or even the sun—may help restore feelings of trust and bonhomie. Likewise, other investigations have shown that a chill in the air can raise our suspicions.

In general, this line of inquiry belongs to a larger research field called embodied cognition, which holds that our body—and not just our brain—plays a role in our thinking, emotions and memories. The field has its critics, but when it comes to temperature, there is little doubt that the link between physical and psychological warmth and coolness is built on more than just metaphor. Researchers have uncovered overlapping mechanisms that govern both the system that regulates body temperature and the one that governs our emotional state. Imaging studies have tracked both systems to the insula in the cerebral cortex. And as neuroscientists and psychologists begin to understand this circuitry better, they are looking for ways to manipulate it to treat depression and other disorders that can put a freeze on our social connections.

Warm Hands, Warm Heart

Yale University psychologist John A. Bargh first began exploring the links between physical and psychological temperatures in 2008. At the time, he says, his laboratory was "scouting into a new territory about the warm-cold effect." As part of that initial foray, he paired up with psychologist Lawrence E. Williams, now at the University of Colorado Boulder. They invited 41 undergraduate students to visit their fourth-floor psychology lab. During the elevator ride up, the students all encountered a woman carrying an armful of books, a clipboard and a coffee cup. She asked each one to hold her cup, which was either steaming hot or icy cold, while she scribbled something down on her clipboard. Once in the lab, the students read a short description about a fictitious "person A" and then had to rate the warmth of his or her personality. When the scientists analyzed the results, a clear pattern emerged: most of the students who held the hot cup had judged "person A" to be significantly more generous and caring than those who held the chilly cup.

Many similar experiments soon followed, extending the association. For instance, in 2013 psychologists Simon Storey of Bath Spa University in England and Lance Workman of the University of South Wales found that merely holding a gel-based hand warmer made some students more trusting. They asked 30 pairs of volunteers to hold either a hand warmer or a freezer pack and then to play repeated rounds of the Prisoner's Dilemma game, a classic test of cooperation between two people. When they analyzed the results, they found that those primed with warmth chose to cooperate with a partner more



Students showed greater activity in part of the insula when they held a cold pack (*right*), compared with when they held a warm pack (*left*). They were also less likely to "invest" money in a game of trust.

FROM "PHYSICAL TEMPERATURE EFFECTS ON TRUST BEHAVIOR: THE ROLE OF INSULA," BY YOONA KANG ET AL., IN *SOCIAL COGNITIVE & AFFECTIVE NEUROSCIENCE*, VOL. 6, NO. 4; AUGUST 27, 2010

FAST FACTS

RUNNING HOT AND COLD

1. Our physical temperature affects how warmly we feel toward other people, and vice versa. Heat can make us more trusting; feeling excluded can make a room seem colder.
2. Scientists have found that our perceptions of physical and psychological temperatures share at least some of the same underlying mechanisms, based within the insula.
3. Two explanations may account for the overlap: from birth, we learn to associate warmth with loved ones—plus borrowing warmth from others, which requires trust, offers a survival advantage.

often than those primed with cold.

A study the following year found that people waiting in a heated room would also turn a kinder eye toward their fellow human. Scientists from Germany and Switzerland gave study participants eight mugshots and asked them to guess what crimes these individuals had committed. If the temperature of the room was set at around 79 degrees Fahrenheit, participants were more likely to think of lesser or white-collar crimes, such as drug possession or tax evasion. But if the thermostat was turned some 11 degrees colder, they jumped to cold-blooded accusations, including murder and kidnapping.

Subsequent studies demonstrated that this temperature effect also works in reverse. When scientists analyzed data from an online movie rental company and surveyed students about their film choices, they found evidence to suggest that we rent more romantic movies when we are cold (perhaps to feel more connected to others). Similarly, studies suggest that drinking icy water threatens our feelings of belonging. Both eating alone or reminiscing about a time we were left out socially can make us judge the surrounding air temperature as colder. In contrast, thinking of a friendly person can boost our perception of a room's temperature by as much as 3.6 degrees F. "There are tons more of these kinds of effects, and the theory behind these findings seems quite robust," says psychologist Hans IJzerman of Free University Amsterdam, who has studied similar links himself.

Some temperature-related results have met with criticism. For example, in 2012 Bargh and psychologist Idit Shalev of Ben-Gurion University in Israel reported that lonely people took more warm baths or showers. But when psychologists Brent Donnellan, Richard Lucas and Joseph Cesario of Michigan State University tried to reproduce the same results two years later, they failed. Bargh offers one possible explanation for why studies may not always replicate: "Researchers make significant changes to the original procedures."

FRANS LANTING *Getty Images*

Emperor penguins in Antarctica stay close to steal warmth from one another. In fact, all warm-blooded animals can save precious energy and keep warm in a huddle, which probably helps to explain at least in part why physical warmth primes human beings to feel socially included and to be more trusting of other people.

Brain Freeze

For definitive proof that physical and psychological temperatures are linked, scientists have turned to neuroimaging. "Neuroscience has confirmed the reality of these phenomena, using much more powerful measurement tools," Bargh says. These tools have tracked the source of the connection to the insula, a small, pyramid-shaped structure deep within the cerebral cortex. This region plays a role in how much we trust others and how much empathy we feel toward them. A 2015 study, for example, showed that damage to the insula causes people to misplace their trust and be overly naive in some situations but cagey in others.

Critically, studies also reveal that the insula is important in temperature perception. In 2010 neurologist Hans Lüders of University Hospitals Case Medical Center in Ohio and his colleagues investigated the cases of five women with intractable epilepsy. In hopes of better understanding their seizures, they surgically placed electrodes in the women's insulae, among other brain structures. They reported that stimulating regions within the insula made these patients experience sensations of warmth in different body parts.

That same year, working with his colleagues at Yale and Boulder, Bargh conducted an experiment that linked both feelings of interpersonal trust and temperature perception to the insula at the same time. They asked 23 participants to play a game inside a functional MRI scanner. The game required players to hypothetically "invest" small amounts of money with other people. As they lay inside the machine, some of them held an ice pack for a few seconds; others held a pack heated to a toasty 105.8 degrees F. The scientists observed clear differences in activation within the insula, depending not only on the decisions the players made in the game but also on the temperature of the pack they held. In addition, they noted that participants primed with cold were less willing to invest. (Practical tip: if you want to ask your boss for a raise, bring a hot cup of coffee first!)

In 2013 another study lent further

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credence to the idea that physical and psychological temperatures run on the same thermostat, located in the insula. Two psychologists—Naomi Eisenberger of the University of California, Los Angeles, and Tristen K. Inagaki, now at the University of Pittsburgh—placed participants in fMRI scanners while holding either a warm pack or a room-temperature ball. Next they asked the volunteers to read messages from their close friends and family. Some of the messages were emotionally neutral, such as "You have curly hair." Others were heartwarming, such as "I love you more than anything in the world." The researchers found that whether the subjects read tender notes or held heated packs, the activity in their insula looked similar. In addition, the volunteers themselves reported that they actually felt physically warmer after they read the emotional messages.

From birth, we learn to associate warmth with the presence of a loved one. Touch and warmth also both prompt the release of oxytocin, the so-called cuddle hormone, which in turn helps us regulate our own body temperature.

The Opioid Link

Inagaki, Eisenberger and another colleague at U.C.L.A., Michael R. Irwin, have further explored the ties between warmth, social bonding and trust by manipulating the opioid system in the brain, which controls pain, rewards and addictive behaviors. In fact, the insula is packed with opioid receptors of the type that play a role in drug addiction. And previous research has shown that opioids such as morphine and heroin can increase body temperature, which may be why people taking these drugs sometimes describe the experience as being "wrapped in a blanket" or feeling a "warmness inside."

In 2015 Inagaki and his co-workers gave 31 volunteers a four-day course of naltrexone, a medication commonly administered to help recovering alcoholics and drug users quit. Naltrexone blocks opioid receptors in the brain and prevents addictive substances from having their desired effect. The scientists discovered that blocking these same receptors also makes people feel less socially connected—an effect recovering addicts should be warned about. Specifically, they found that while the study volunteers received a placebo drug and held a warm pack, they described feeling closer to loved ones when prompted to think about them. Those feelings became less intense when the same participants took naltrexone and held a warm pack. "We think that there is really no reason for why this should happen," Inagaki says, "unless physical warmth and social warmth are using the same mechanisms."

Animal studies have revealed that other substances—such as oxytocin, the so-called cuddle hormone, and serotonin—are involved in regulating both physical and psychological warmth. "They are all part of this network that we think drives us toward rewarding outcomes and social connections," Inagaki adds. Scientists have long known that serotonin plays a key role in social behavior—with abnormally low levels associated with social anxiety. Newer evidence indicates that physical temperature may affect serotonin production. In 2011 neuroscientist Christopher Lowry and his colleagues at Boulder raised two groups of rats—one incubated at a sizzling 98.6 degrees F for a brief period and another kept at room temperature. Later the scientists removed the animals' brains for examination. They discovered that the hot surroundings had activated more serotonin-producing neurons in the brain stem.

Researchers have also found that mice genetically engineered to lack oxytocin receptors have trouble regulating body temperature—and that warm temperatures prompt oxytocin's release, much in the same way that a touch or a hug can. Skin, IJzerman notes, is another key element in temperature control. In 2012, in collaboration with his colleagues at Purdue University and the University of Milano-Bicocca in Italy, he asked 41 student volunteers to play an interactive computer game, in which online players (preprogrammed by the researchers) actively shunned some of the players in the lab. While they played, the researchers monitored their skin temperature. Among the students who were excluded, skin temperature dropped by an average of about 0.68 degree F. The finding may help explain why people experiencing rejection literally feel a chill in

NICK STEVENS *Getty Images*

the air and tend to perceive a room's temperature as lower. Of interest, the scientists also found that if they asked socially excluded students to hold a hot cup of tea for only 30 seconds, those students described feeling less hurt than others who did not hold the cup.

Evolutionary Hot-wiring

The big question, of course, is why? Why are physical and psychological temperatures linked in the first place? There are two theories, which are not necessarily mutually exclusive. "One notion is that from birth we've learned that warmth signals the presence of loved ones, so one experience brings to mind the other one," Inagaki says. "The second theory is that it's part of our innate system."

For years researchers have explained the connection by way of the first theory, but recent neurobiological evidence gives more weight to the second idea that we have evolved this way. "For all warm-blooded animals, temperature regulation is very metabolically expensive and also required for survival," IJzerman points out. "But it becomes cheaper when there are others to help us regulate our temperature."

Indeed, animal research has revealed that kleptothermy—or stealing warmth from others, much as huddled emperor penguins do in Antarctica—saves metabolic resources. One 2014 study estimated that in a species of Chilean rodents, sharing a cage with just a few other animals lowered an individual's basal metabolic rate by up to 40 percent. Similarly, a 2015 study of vervet monkeys showed that friendly grooming not only helps these animals with tangles and pests, it also renders their pelts better insulated against the cold.

If we can save precious energy and feel warmer among others, it makes sense that we would also feel more socially included and trusting when primed with physical warmth. "Throughout evolutionary time, if you needed somebody else to cuddle with, you needed to know how reliable they were," IJzerman explains, "so temperature expectation became involved as a 'sociometer' to assess how we think of other people. Despite modern conveniences like central heating, thermoregulation has remained important for how we understand our relationships, which is why in English we refer to emotionally responsive people as 'warm' and emotionally unresponsive as 'cold.'"

The evolutionary advantage of sharing body heat factors into how we understand relationships today, so we describe those closest to us as "warm" and those who are emotionally distant as "cold."

Lowry has hopes of exploiting this innate connection to treat depression. Serotonin appears to be involved both in the disorder and, as noted above, in temperature. In addition, depressed people often have a raised body temperature and unusual temperature perception. In 2013 Lowry and his colleagues reported the results of a novel experiment: They administered a single session of whole-body heating with infrared lamps to 16 severely depressed adults, all of whom were hospitalized in a private clinic in Switzerland. "Infrared radiation doesn't penetrate the body very effectively," he says, "so what we are really doing is heating the skin." In fact, the lamps boosted skin temperature by several degrees F. Some participants reported that it was the hottest they had ever felt.

The lamps also produced impressive changes in the participants' moods. Compared with a control group, who lay under a nonheating lamp, those who baked under infrared radiation scored on average more than six points lower on the Hamilton Depression Rating Scale, a classic scale used to gauge depressive symptoms. This change was present six weeks later and significant enough to shift some patients from severe to moderate depression. Though promising, heat-lamp therapy needs to be validated by additional and bigger studies.

IJzerman speculates that some comforts of modern society, such as readily available hot showers, may be interfering with how we relate to others. "In the Middle Ages, people would sleep with about five people to one bed because they needed to warm one another up," he says, "but we don't do that anymore—we have central heating."

Newer technologies may continue this trend of separating warmth from social contact. IJzerman mentions a product under development called Wristify, a bracelet that can cool or heat your body whenever you want. "It could make us even less dependent on others," he notes, "and, perhaps, profoundly alter our interpersonal relationships." To counter such trends, we would do well to practice the time-honored traditions of offering friends a warm embrace and a steaming cup of tea. **M**

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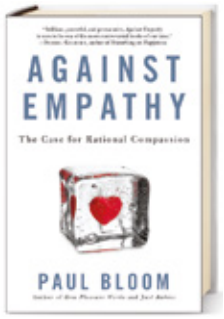
COLD HEARTS

Against Empathy: The Case for Rational Compassion

by Paul Bloom. Ecco, 2016 ($26.99; 304 pages)



Most of us see empathy as a force for good. From an early age, adults tell children to imagine stepping into another's shoes to teach them respect and kindness. But in his new book, Yale University psychologist Bloom argues that empathy is actually a poor moral guide and that we may be better off with less of it.

To start, Bloom notes just how shortsighted, biased and irrational empathy can be. We sympathize more, for instance, with people who are similar to us or with whom we identify. Thus, our feelings do not always scale with the degree of someone's suffering: we typically feel much worse about a death in our own community than 100 deaths in some unfamiliar, distant land.

Thanks to this bias, empathy can even lead to violence, Bloom explains. Research shows that more empathetic people are more likely to endorse harsher punishments toward people they view as threats. "It is because of empathy that we often enact savage laws or enter into terrible wars; our feeling for the suffering of the few leads to disastrous consequence for the many," he writes.

But simply having empathy for a wider range of people is not the solution. Constantly internalizing the suffering of others can lead to emotional burnout. Instead, Bloom asserts, we should rely on compassion. Compared with empathy—which involves actually sharing another's emotions—compassion reflects a more distanced form of caring and concern.

In fact, compassion and empathy look different in the brain. In one neuroimaging study, researchers trained participants either to imagine how someone else might feel (empathy) or to project loving thoughts toward them (compassion). They found that compassion training increased activity in the medial orbitofrontal cortex and ventral striatum, areas associated with love and reward; empathy training increased activity in the insula and anterior cingulate cortex, typically involved in registering another's pain. There were psychological differences as well: compassion led to positive emotions and greater motivation to help, but empathy brought unpleasant feelings, such as stress and sadness.

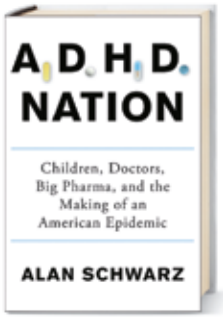
Bloom knows his negative take on empathy is controversial. Many psychologists and scholars criticize his point of view, insisting that empathy drives important social movements, among them advocacy for antislavery and gay rights. Bloom fires back that almost any strong feeling—anger or fear, for instance—can mobilize people for a good cause, but there are better ways to achieve the same outcome, such as deploying compassion. This book forces us to confront the uncomfortable, often ugly realities of human nature, but Bloom uses a conversational style and deeply personal examples to make it more palatable. By the end, it is hard not to agree that less empathy and more compassion are what our world desperately needs.

—Diana Kwon

MISDIAGNOSED

ADHD Nation: Children, Doctors, Big Pharma, and the Making of an American Epidemic

by Alan Schwarz. Scribner, 2016 ($28; 352 pages)



During the 1940s chemist Leandro Panizzon tinkered with the molecular structure of amphetamine, a powerful stimulant in the central nervous system, in hopes of discovering a nonaddictive substance to increase his wife Rita's energy and focus on the tennis court. The drug he developed not only turned Rita into a tennis-playing machine but also kept her slim. She loved it so much he named it after her. In 1956 Ritalin was approved to treat narcolepsy, chronic fatigue, depression and erratic behavior in adults. By the 1960s a small group of clinicians had realized that the drug improved learning and focus in children diagnosed with a broad swath of emotional and behavioral issues. Others soon began investigating the underlying pathology in these children, which ultimately gave birth to attention-deficit/hyperactivity disorder (ADHD).

In *ADHD Nation,* Schwarz, an investigative reporter for the *New York Times,* traces the evolution of ADHD as one of the most widely diagnosed—and misdiagnosed—conditions in American medical history. He details how big drugmakers propelled ADHD into the national spotlight, conspiring with physicians, researchers, policy makers and educators to create, what he calls, the ADHD-industrial complex. In essence, pharmaceutical companies aggressively, and often misleadingly, marketed Ritalin and other stimulants to help fix "troubled" kids.

Researchers played their part by downplaying serious side effects, government officials by expanding health coverage and developing school policies to promote ADHD testing. In the 1990s schools received extra funding for each pupil diagnosed, and many administrators coerced parents into having their children tested and treated. The more attention ADHD received, the more children were diagnosed. "Of course, there was no way to disentangle which children were actually impaired by severe hyperactivity and distractibility … and which were either questionable diagnoses or, at the most cynical end of the spectrum, labeled merely for money or extra services," Schwarz writes.

These factors created an epidemic in the U.S., with 11 percent of all school-age children diagnosed with ADHD. When drug companies realized the potential to expand stimulant sales to adults, they devised a new market, to which Schwarz attributes the rising recreational use of ADHD drugs by students, professors, shift workers, doctors and others with demanding schedules.

Schwarz's book is an engaging, fast-paced exploration of what the father of ADHD research, psychologist Keith Conners, has called "a national disaster of dangerous proportions." The book serves as an indictment of the ADHD epidemic but ultimately ends on a sobering, even hopeful note. Perhaps we can learn from our mistakes, Schwarz suggests, by reining in overtreatment and focusing research and resources on individuals who can actually benefit from ADHD therapies.

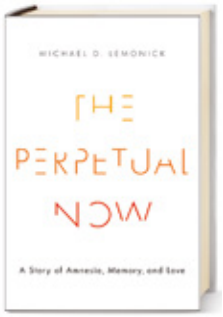
—Moheb Costandi

Alan Schwarz answered questions from Mind *contributing editor Gareth Cook. The interview appears online at* ***http://bit.ly/sciamadhdnationPb***

MAKING MEMORIES

The Perpetual Now: A Story of Amnesia, Memory, and Love

by Michael D. Lemonick. Doubleday, 2017 ($27.95; 304 pages)



In his latest (and seventh) book, *Scientific American* editor Lemonick introduces readers to Lonni Sue Johnson, an important new character in the ongoing quest to understand how our brain forms memories. In 2007, when Johnson was 57 years old, a viral infection ravaged her hippocampus. She survived, but the damage left her trapped—as the book's title attests—in the perpetual now: Johnson cannot remember what has happened more than five minutes ago nor anticipate what might come next.

Her fate is similar to that of Henry Molaison, one of neuroscience's most famous research subjects, who, until his death in 2008, was known in the literature as H.M. In 1953 a surgeon suctioned away most of his hippocampus in hopes of relieving his crippling epileptic fits. It worked—but also left him unable to recall specific events or commit new experiences to long-term memory. Scientists discovered, however, that H.M. could master new skills, even if he had no memory of practicing them.

In hundreds of tests over 40 years, they parsed H.M.'s memories into several broad categories—including declarative memories, or "knowing that," and procedural memories, or "knowing how." But as Lemonick notes, experiments with Johnson are revealing that some of "those distinctions may have been too crude to capture the subtleties of human memory."

Compared with H.M., Johnson may offer an even greater research opportunity, thanks to her unusual range of talents. Before her illness, she was a successful artist, an amateur pilot and a gifted musician. "I think she might be the most interesting amnesic to have been studied in this level of detail," cognitive scientist Michael McCloskey of Johns Hopkins University is quoted as saying. His team is one of several Lemonick interviews about working with Johnson.

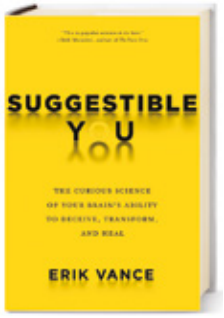
Initially McCloskey and his colleagues, Barbara Landau and Emma Gregory, chose to plumb Johnson's once deep knowledge of art. In 2014 they showed her 70 paintings. Out of 60 famous works, she could name only two: *Mona Lisa* and *The Last Supper.* But she readily identified 10 of her own paintings and spotted others done in a similar style. "Whatever it is that allows her to recognize her own style," Landau says in the book, "I don't think we know how to categorize that sort of memory." Later tests showed that Johnson retains other memories—such as the rules for playing in a string quartet or how it feels to fly in a headwind—that appear to be part declarative and part procedural at the same time.

In his introduction, Lemonick asks, "If we have no memories of the experiences that made us, how can we know who we are?" Johnson seems to be largely unaware of what she has lost. What stands out in this sensitive portrait of her is just how many of her characteristic traits—an intense drive, an impulse to create art, a zany sense of fun—have survived. When Johnson's sister and late mother realized the extent of her injuries, they vowed to make something good of it. Thanks to their efforts, Johnson's remarkable brain is poised to help scientists rethink what we know about the workings of memory. *—Kristin Ozelli*

THE MIND CURE

Suggestible You: The Curious Science of Your Brain's Ability to Deceive, Transform, and Heal

by Erik Vance. National Geographic, 2016 ($26; 288 pages)



Last fall my son woke up ill one morning. He moaned nonstop through our usual Friday pancake breakfast at the diner. But as soon as we were on our way to the doctor, his stomach pain subsided, and he fell asleep. What prompted the turnaround? Perhaps my son knew his doctor would make him feel better, so his brain unleashed a cascade of pain-fighting neurotransmitters in anticipation.

The fact is that our expectations can assuage a range of physical symptoms. In his new book *Suggestible You,* science writer Vance opens our innate mental medicine cabinet to look at the placebo effect—or what happens when a person receives a fake treatment and feels better just the same. In the past two decades scientists have discovered a surprising amount about why placebos influence the mind and body and how we can enhance our responses to them.

So how exactly do placebos work? Essentially, Vance says, our beliefs can increase levels of mood-enhancing and pain-soothing neurotransmitters, including dopamine, serotonin and endorphins. Just telling ourselves that doctors will provide relief can produce real improvement, regardless of what they prescribe. Scientists now know that certain conditions, such as Parkinson's disease, depression and irritable bowel syndrome, respond especially well to placebos, but others, including cancer and the flu, do not. Vance recommends that people use evidence-based medicine first, when possible, but then incorporate placebos to enhance outcomes.

Vance's exploration of the placebo effect is deeply personal. He grew up in the Christian Science religion, which practices self-healing and largely eschews health care. As an adult, though, he wanted to explain the mysterious cures he observed in his youth—such as his father's healed rotator cuff. For Vance, the placebo effect bridges the gap between faith and science.

His skill at weaving together the relevant research, anecdotes and his own experiences makes *Suggestible You* an enjoyable, quick read—one that relays many intriguing, if unexplained, discoveries: yellow pills, for instance, work best on depression, and bigger pills generally produce stronger effects.

In the end, Vance stresses that relief from painkillers and placebos are neurologically identical. "People experiencing a placebo effect aren't crazy or deluded or gullible," he writes. "For decades the world has seen you as too easily influenced and pharmaceutical companies have been aggravated by you. But no longer. From here on out, call yourself what you are: talented." *—Meredith Knight*

Meredith Knight conducted an interview with Erik Vance, which is available online at ***http://bit.ly/sciamplaceboDZ***

Why do we cry?

—**Rowena Kong** via e-mail

Oriana Aragón, an assistant professor of marketing at Clemson University, answers:

People cry to express a range and degree of emotions—from happiness after acing a tough exam to grief after the death of a friend. Some wear their hearts on their sleeves and shed tears at the slightest provocation; others clam up and remain dry-eyed in emotional situations. Crying can even evoke seemingly contradictory behaviors—think "tears of joy." What provokes this complex behavior in the first place?

Two key factors can help explain why we cry. The first is our crying threshold—the point at which a feeling becomes so intense that we tear up. This threshold varies from person to person. Some have a low threshold and may need only a small push, such as missing the bus to work or being slighted by a friend. But for those with a high threshold, it may take a significant event—the birth of one's child or the loss of a loved one—to produce strong enough emotions. These thresholds may vary throughout a person's lifetime or even within a single day. Being physically exhausted, for instance, can make a person more prone to tears.

> "An individual with a high threshold who is thick-skinned may rarely feel the need to cry, whereas a person with a low threshold who is hypersensitive may be brought to tears easily."

The other central factor is the intensity with which an individual reacts to a situation, known as emotional reactivity. Certain people may have their emotional intensity dialed up to 10 most of the time (consider the brooding artist), but such strong feelings will not necessarily bring a person to tears. In other words, whether someone cries depends on how readily he or she responds to a situation, not necessarily the person's baseline emotional state.

It is quite likely that these two elements—threshold and reactivity—interact along a spectrum. At one end, an individual with a high threshold who is thick-skinned may rarely feel the need to cry, whereas on the other end, a person with a low threshold who is hypersensitive may be brought to tears easily.

Interestingly, a tendency to display incongruous behaviors may also influence whether we shed tears. My colleagues and I recently found that someone who expresses feelings dimorphously (in two distinct forms)—such as tears of happiness and of sadness—is more likely to weep in a range of scenarios, regardless of the intensity of the emotion. But we also discovered that incongruous behaviors—such as wanting to pinch a cute baby's cheeks—occur more often when a person feels intensely about something and could help neutralize the extreme feeling.

Overall, crying is not a simple reaction but rather a multifaceted behavior that can offer clues to how we process and regulate our feelings and how we experience the world around us.

Can I learn to think more rationally?

—**Adolfo Castañeda** Mexico

Daniel Willingham, a professor of psychology at the University of Virginia and author of *Raising Kids Who Read: What Parents and Teachers Can Do,* responds:

The short answer is yes: you can learn to think more rationally but only *about specific subjects*. Enhancing rational thinking overall is much more difficult.

Before exploring the question in more depth, we first need to define rational thinking. For this discussion, let's stick with a relatively straightforward interpretation—rational thinking encompasses our ability to draw justifiable conclusions from data, rules and logic.

Schooling can indeed improve rational thought, research suggests. A recent analysis of many studies showed that college courses contribute to critical thinking abilities. But decades of research have also consistently found that students improve only in the type of reasoning skills emphasized in the course, not in other tasks. That is, if students work on logic puzzles, they

JAMIE CARROLL ©iStock.com

Does temporal lobe epilepsy influence personality?

—**Claire Heptinstall** via e-mail

Sallie Baxendale, a consultant neuropsychologist at the Institute of Neurology at University College London, explains:

Temporal lobe epilepsy—a common form of epilepsy characterized by seizures that begin in the memory-regulating temporal lobe—does appear to influence personality, though not in the way many may think and certainly not in the way people have believed throughout history.

The idea of the epileptic personality is an ancient one. Thousands of years ago people with epilepsy were thought to be possessed by either divine beings or demons. In fact, the notion that a seizure represents a kind of communion with another spiritual realm still holds sway in some societies today. In more recent history, Westerners largely perceived epilepsy as a punishment for morally lax behavior. In one 1892 paper, the author claimed that debauchery and excessive lust frequently led to epilepsy and that a person could trigger a seizure by listening to love songs and eating chocolate. More recently, scientists began investigating whether epilepsy, in fact, altered personality.

In 1975 neurologists Stephen Waxman and Norman Geschwind, both then at Harvard University, published an analysis based on observations of their patients with temporal lobe epilepsy in which they reported that many patients had a tendency toward religiosity, intense emotions, detailed thoughts, and a compulsion to write or draw. This cluster of characteristics became known as the epileptic personality. Over the next decade other researchers added hostility, aggression, lack of humor and obsessiveness to the list of personality traits supposedly associated with the condition.

By the 1980s, however, researchers began to question the notion of the epileptic personality altogether. They pointed out that the supposed core characteristics did not appear in all individuals with temporal lobe epilepsy and that many also occurred in other patient populations. By the end of the 20th century researchers came to a consensus that only a minority of temporal lobe epilepsy sufferers exhibited some of these core features.

In the meantime, psychologists working on theories of personality began to realize that although some aspects of character do have a biological basis, our natures are largely shaped by life experiences. Research shows that temporal lobe epilepsy may rewire the brains of some people, but by far the most significant influence will be how it changes people's outlooks or experiences.

Thus, the answer to the question is yes: having temporal lobe epilepsy will probably influence personality to a degree but mostly in the way that being diagnosed and coping with any serious condition might.

get better at logic puzzles but not at other things, such as forming coherent arguments or winning debates.

This pattern makes sense. Rational thinking requires different skill sets in different situations. The logic we use when interpreting a science experiment is not the same logic we need when buying a car or following a new recipe.

In general, our brain did not evolve to think in this logical fashion, and some types of reasoning are simply a bad fit for what our brain can do. We are, for instance, pretty good at understanding the frequency of events (how often commercial airplanes crash) but not so good at gleaning probabilities (the likelihood that our plane will crash).

Rational thinking is also a challenge because we instinctively harbor a range of irrational biases. We tend to fear a loss more than we relish an equivalent or greater gain. For example, most people would turn down a favorable gamble in which they could earn $22 if a coin lands on heads but lose $20 if it settles on tails. Although most recognize that taking such a bet makes sense, people often choose not to because the potential pain of losing often outweighs the pleasure of winning. These types of reasoning problems are widespread and interfere with our ability to cultivate rational skills.

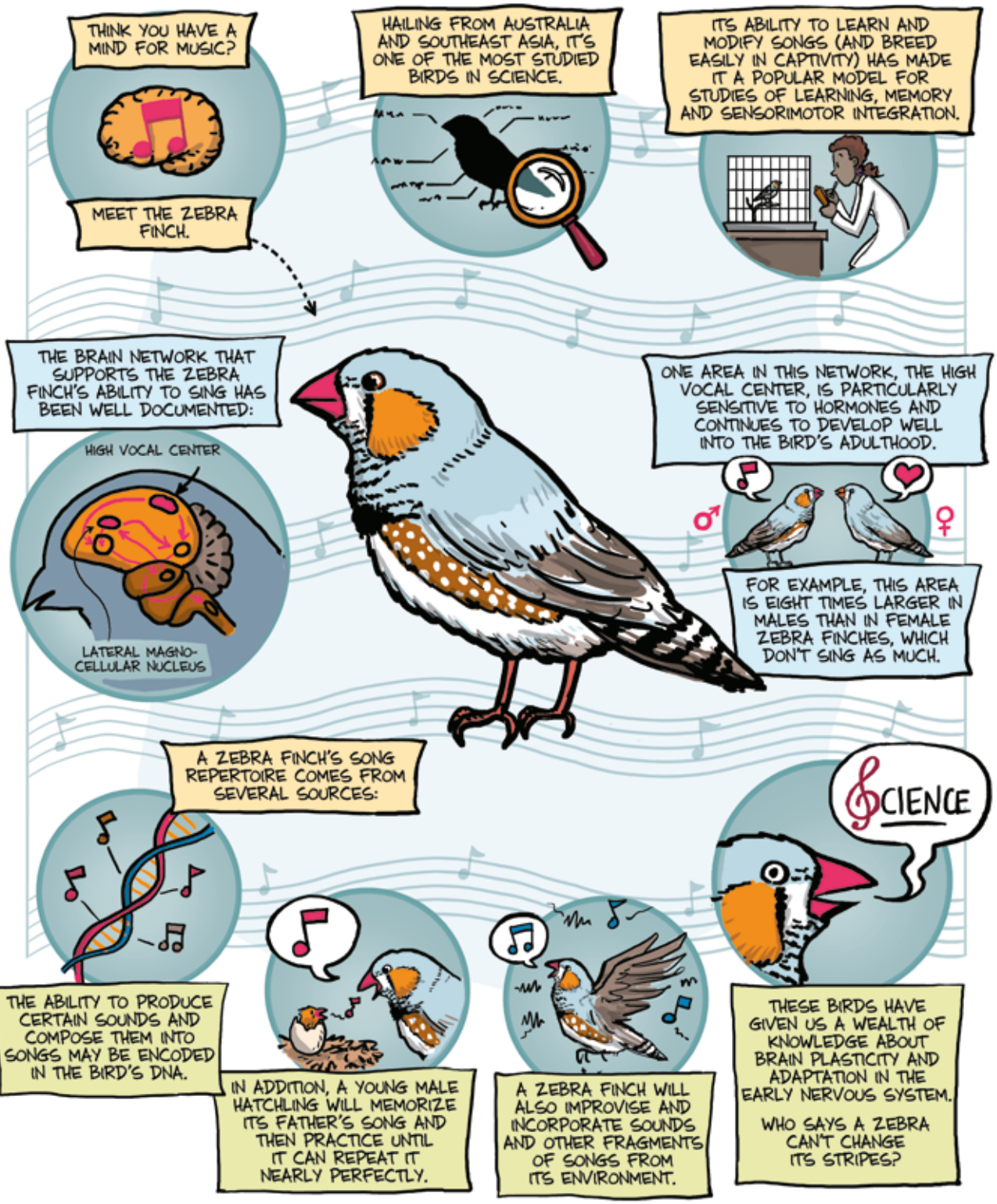
So, although we can learn to think rationally, it is important to understand how that learning works. Becoming a more rational thinker across the board is not really a feasible goal. We will find the best results by focusing on the areas we value most. **M**

Do you have a question about the brain you would like an expert to answer?

Send it to MindEditors@sciam.com

Singin' in the Brain

BY DWAYNE GODWIN & JORGE CHAM



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

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