NAUTILUS

Why Doctors Make Bad Calls

MICHAEL LEWIS ON BIAS IN MEDICINE p.22

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An Evening with the Sage

THE PSYCHOLOGIST AND NOBEL LAUREATE Daniel Kahneman spoke at an informal event in New York City last month. The by-invitation evening was attended by media professionals, entrepreneurs, scientists, and, randomly, the chief of police, all attracted by the promise of a Q&A with the eminent scientist.

The session began with routine questions: what are some of the biggest problems in psychology right now, how should one run a collaboration, that sort of thing. But when the moderator turned to the audience for questions, a plaintive tone made itself felt. The crowd, it turned out, was anxious.

How do we understand each other better? What can explain the presidential election results? How can you heal from trauma? What is the nature of happiness?

Kahneman was frank about making it clear when he couldn't answer a question, either because it was outside of his area of expertise, or because the question had no answer. At one point he put down the mike and asked the audience for their ideas.

Of the answers he did give, most were "No." There was a question about childhood education: Can we educate our children to produce a future national unity based on fact? Probably not, he answered. Studies have shown that education can be less important than pre-existing beliefs and group identity in interpreting new facts.

Chris Anderson, of TED fame, asked whether we can design the news to appeal to our "system 2" brains, referring to our capacity for slower, more logical thinking. "PBS is already there," Kahneman answered, and how many viewers does it get?

The hopeful questions kept coming. Then it hit me: The crowd wasn't getting it, for exactly the reasons that Kahneman was trying to explain. They—we—were invested in a particular belief system: a redemption through logic, a reduction to a design problem. We thought Kahneman was a sage with hidden wisdom that would prove this is so. Even *Kahneman* couldn't convince us otherwise.

"But I am a pessimist," Kahneman noted at one point. Ah.

Pessimist or no, the science of cognitive distortion, pioneered by Kahneman and Amos Tversky, has in fact paid many dividends (even if it did not on the evening in question). This issue's cover story, by the inimitable Michael Lewis, explores the benefits of uncovering bias in medicine. And many of the stories in the rest of the issue tackle questions of perspective and bias.

It pays to know what we have trouble knowing. Just don't ask about the meaning of happiness.

Welcome to the January/February 2017 *Nautilus* print edition.

—*Michael Segal*
Editor in Chief

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Each print edition identifies different themes in science and explores them from multiple perspectives.

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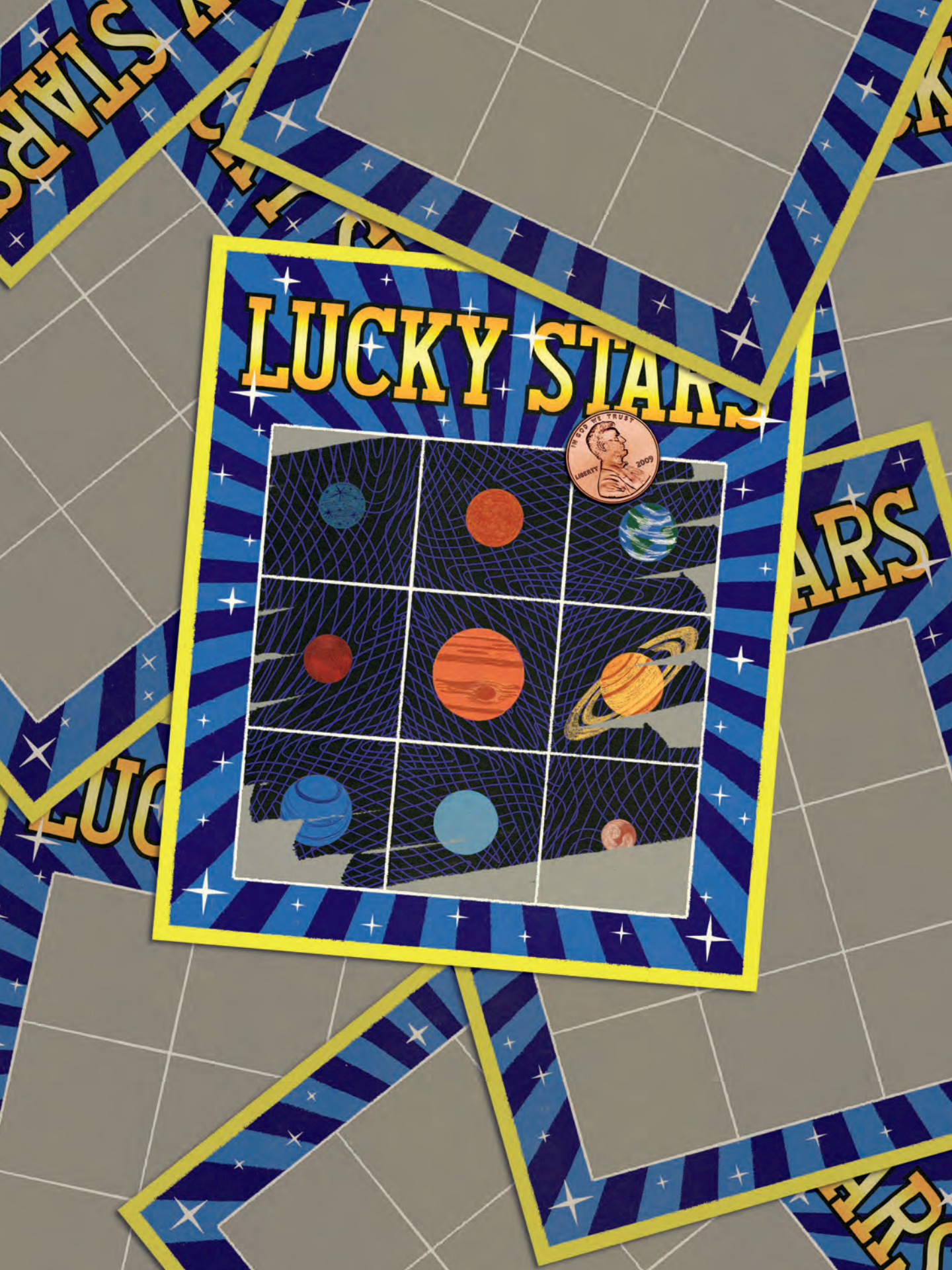
Luck

"Luck is different from chance: It's chance viewed through the mind's eye."

—David J. Hand, p. 42

THEME ART Hannah K. Lee


LUCKY STARS
IN GOD WE TRUST
LIBERTY
2009

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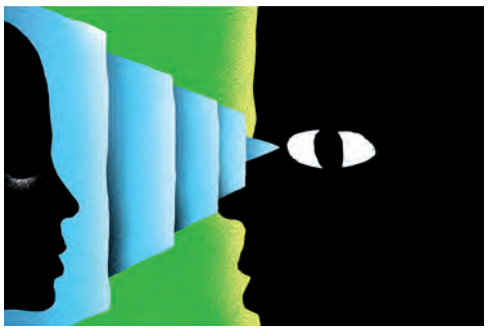

Power

"Water is lifeblood, and worth fighting for."

—John Wendle p. 80

THEME ART Daniel Zender

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Published by:

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NAUTILUS *think*

Letters

Reader responses to the Nov/Dec 2016 print edition.

"WHEN EINSTEIN TILTED AT WINDMILLS"

Bravo! The author wove a mighty fine tapestry, effortlessly weaving Einstein's relativity theories and quantum mechanics with the thread of Mach's prescience of the deep conceptual problems of physics. Usually the reading of popular science articles is frustrating; the subtleties of the physics are handwaved, and so the very fine beauty of the ideas is sacrificed. This article, however, is something different: The author presents each idea so conceptually clearly, and so precisely, that the understanding of the physical ideas presented is enhanced, not subtracted.

The author seems to suggest novel insights as to the continued relevance of Mach's philosophy by emphasizing Besso's influence on Einstein, and Mach's influence on Besso. Einstein's stalwart patronage of local realism is framed as a breaking away from Besso. This author has great skill in gathering together the conceptual and historical underpinnings of a physical theory and assembling it all together in one grand unified theory.

—Jeff Nechleba

"THE ASTROPHYSICISTS WHO FAKED IT"

The agonies of scientists trying to get it right are rarely appreciated by others.

—Acleron

A fascinating article! The point about using the possibility of a fake result to alleviate the biases was very novel to me, and it seems like a continuation of the blind experiments principle.

I imagine it requires a real love for the scientific method to be able to work under such conditions. I wish it was more prevalent.

—Andrew S.

"TO UNDERSTAND FACEBOOK, STUDY CAPGRAS SYNDROME"

Fascinating and insightful. Makes me think about celebrity culture, and also how the telephone and driving (especially on the freeway) have affected our familiarity and recognition. And, not to open a can of worms, but also fiction and religion. How many people "love" Harry Potter (or Jesus)? Atticus Finch? Shakespeare? Musicians? The Beatles? And then there's the way we demonize the "enemy."

We also seem to have lowered our standards for information. We seem more gullible to Facebook memes, rumors, spin, and confirmation bias.

—Bruce Black

"IF NOT DARWIN, WHO"

History marches along, the script largely written by Nature and Evolution, with individual free will and initiative only playing a minor role. Most "great" men and women don't understand the role of chance in their lives. The script largely written, a different actor can only influence so much—and we have lots of actors from whom serendipity can pick.

—James Benson Bacque

Nautilus *welcomes reader responses. Please email* letters@nautil.us. *All letters are subject to editing.*

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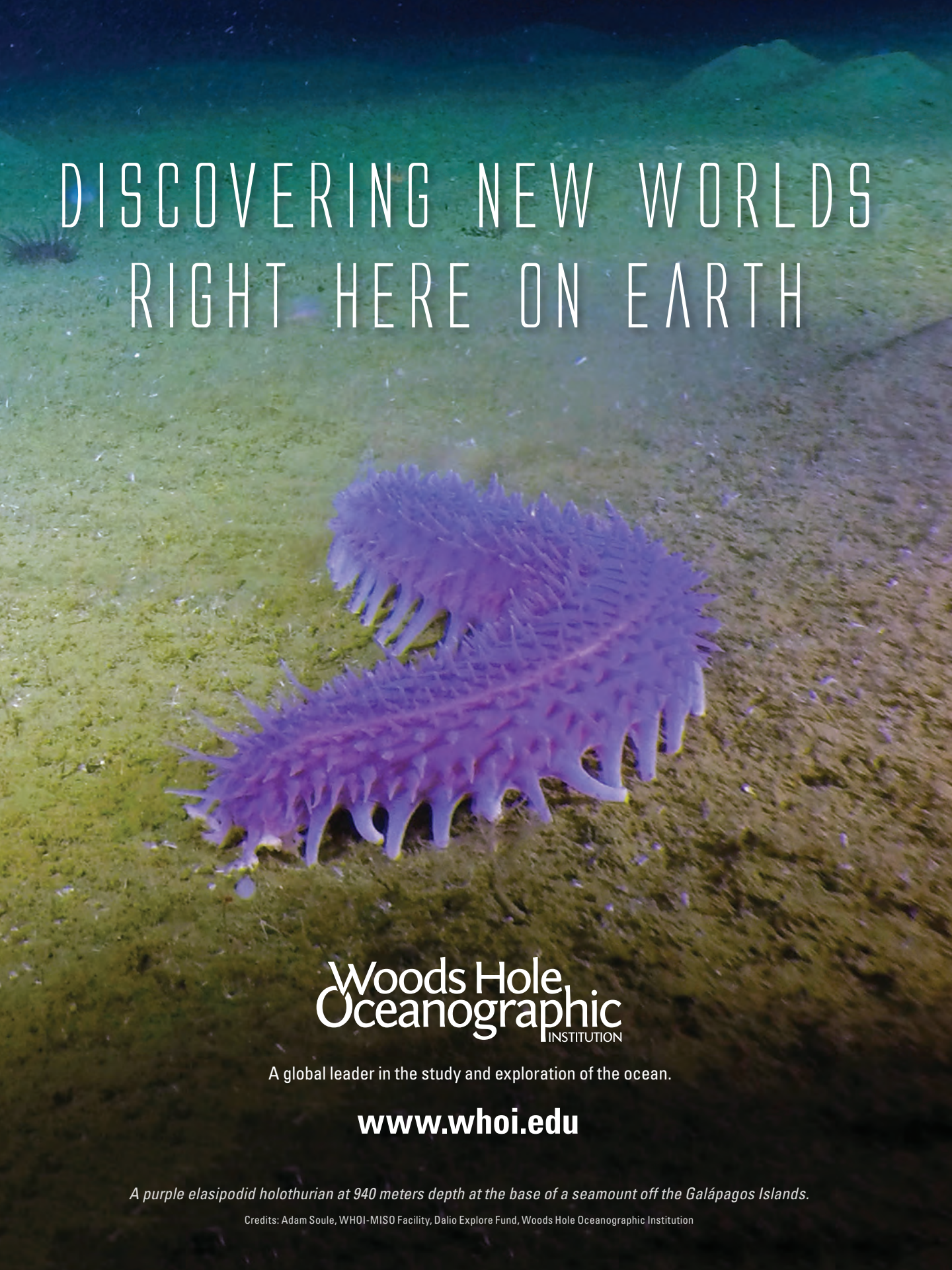
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Preludes

Rituals directing action away from the body are linked to undoing bad luck.

SOCIOLOGY

The Rituals We Use to Ward Off Bad Luck

FOR THE LAST TWO YEARS of his baseball career, George Gmelch didn't eat pancakes. Playing in the Detroit Tigers minor league system in the 1960s, two disappointing post-pancake games were enough to make him swear them off altogether.

Gmelch, now an anthropologist at the University of San Francisco, knows that taboos from his baseball days were not necessarily rooted in reason. Looking back on that time, Gmelch says his rationale was: "My following this ritual gives me confidence that I'm going to play better."

Otherwise reasonable people enact all kinds of rituals to promote good luck or cast off the bad, especially in situations of uncertainty. A small but growing number of social science studies have looked at the underlying psychological mechanisms behind luck-related rituals. They have the usual caveats of using small numbers of participants and drawing associations rather than causal relationships. But they raise excellent questions: To what extent can rituals change our outlook on luck? Are they helpful? If so, how and why?

ILLUSTRATIONS BY JACKIE FERRENTINO

Jane Risen, a behavioral scientist, noticed that, in cross-cultural comparisons, rituals involving an action directed away from the body seem to be associated with *undoing* bad luck: knocking on wood, spitting, throwing salt over a shoulder.

In Risen's studies, an experimenter had a scripted conversation with each participant. It began with small talk, and then took this turn: "A friend of mine recently got into a car accident … it got me thinking about how dangerous it can be on the road, especially when the snow starts to fall. Do you think that there is a possibility that you or someone close to you will get into a horrible car accident this winter?" The control group could respond neutrally, but participants in the "tempting fate" group *had* to read a "jinx" sentence, saying that there was no way this could happen to anyone they knew.

People who made the "jinxed" statement, on average, later said it was more likely that they or someone they know would get into a terrible car accident, compared to the control group. But in another experimental condition, those who "jinxed" themselves were told to knock on the table, which was made of wood. "Jinxed" participants who knocked tended to rate a car accident as less likely than those who didn't. "They're no longer extra worried about getting into a car accident. If they knock down on the table, that bad feeling goes away," said Risen.

"If they knock on the table, that bad feeling goes away."

Could these luck-related rituals directly affect how well we do on tasks? The evidence is not solid. In 2010, studies led by Lysann Damisch found an association between people's performance in a variety of tasks—such as a golf-putting test or memory games—and a luck-related saying or action.

But more recently, a research group at Dominican University failed to replicate these findings with similar golf-based tasks, "much to our disappointment," Tracy Caldwell, one of the co-authors, told me with a laugh. The small sample sizes of the German study may have been to blame, or the groups of participants, she said. Regardless, luck rituals may reduce people's anxiety, which can in turn have an effect on performance. But there are probably better ways to promote one's chances of doing well in an activity, Caldwell said—like, actual preparation: "Luck and superstition are after-the-fact attributions we make to explain what the heck just happened."

—Elizabeth Landau

PYSCHOLOGY

How to Be Lucky

IN A SWELTERING SCENE in *A Streetcar Named Desire*, Stanley has just won a poker hand by drawing to an inside straight. His friend Pablo curses his "rutting luck." "You know what luck is?" responds Stanley. "Luck is believing you're lucky."

Psychologists have proven Tennessee Williams' famously volatile character right. Personality studies have found that belief in good luck goes hand in hand with feelings of control, optimism, and low anxiety. If you believe you're lucky and show up for a date feeling confident, relaxed, and positive, you'll be more attractive to your date.

Feeling lucky can also lead you to work harder and plan better. It can make you more attentive to the unexpected, allowing you to capitalize on opportunities that arise around you. In a study comparing people who consider themselves lucky or unlucky, psychologist Richard Wiseman of the

SCULPTED SAND Fulgurites, like this one, form as a result of lightning strikes.

University of Hertfordshire, author of the 2003 book *The Luck Factor*, asked subjects to count the pictures in a newspaper. But there was a twist: He put the solution on one of the first pages of the newspaper. "The unlucky people tended to miss it and the lucky people tended to spot it," he wrote.

In the early 2000s, Wiseman capped a study of lucky people with the creation of a "luck school," in which he gave unlucky people exercises that taught them to spot chance opportunities, listen to their guts, take an optimistic view, and not dwell on mistakes—in other words, to do the things that lucky people do. He reported that, a month later, 80 percent of the unlucky people in his school said they were happier and luckier.

The key to deciding whether an event is lucky or unlucky is the comparison you make between the actual event versus the "counterfactual" alternative that you're imagining. Assault victims who ask "Why me?" are making what psychologists call an "upward comparison" to people who weren't assaulted. People who feel lucky to have survived the assault are comparing themselves downwardly to people who had a worse fate. Both are valid interpretations, but the downward comparison helps you to hold on to optimism and weave a narrative in which you are the lucky protagonist of your life story.

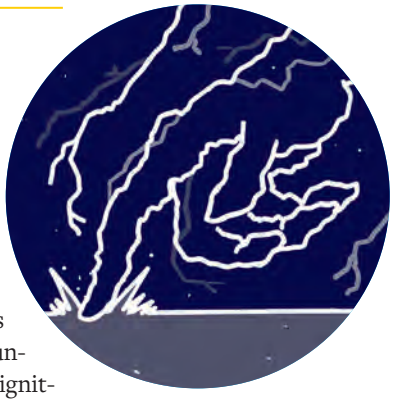
Consider George Bailey in *It's a Wonderful Life*, who embraces life again after an angel takes him on a tour of what the world would have been like had he never been born. In a 2008 study, researchers found that subjects who took themselves on a similar mental journey—thinking about a counterfactual life path in which a positive event like meeting a future spouse never happened—ended up "a little bit happier" than those who simply thought about the positive event itself. The jolt of happiness, which they called the "George Bailey effect," comes from being surprised that a good thing can and did happen to you.

When times are tough, it might seem frivolous to cultivate a belief in luck. But that belief can cast a spell that heals our wounds and gives us another shot at success.

—Chelsea Wald

EARTH SCIENCE

How Much Energy Is in a Bolt of Lighting?



IT WAS A RAINY, summer day in the Hamptons, a few years before World War I, when Robert W. Wood, a physicist at Johns Hopkins University, had a close encounter with a lightning bolt. The ground ignited, producing a smoky column about 7 feet high. Rather than being repelled, he later described the event in a letter to *Nature* as a "fortunate accident"—he had

"hit upon a way of extending our knowledge of these curious autographs of thunderbolts."

The autographs in question were fulgurites (*fulgur* is an old Latin word for lightning). These roughly cylindrical pieces of glass form when lightning travels from a cloud to Earth's surface and penetrates the ground. Prior to dissipating, the subterranean electrical current rapidly heats the sand, clay, and rocks through which it flows, causing them to melt and even boil. The resulting fulgurites are usually hollow, due to the vaporization of a core of soil along the current's underground path. Their exterior often has a gnarled, rough appearance caused by the incomplete fusion of soil particles; the interior, however, where higher temperatures induce more melting, is usually smooth.

Wood found two small holes where the lightning struck his lawn. He filled one with melted solder, excavating a nearly 4-foot-long fulgurite cast covered in patches of fused sand grains. Wood believed this would allow him to study both the fulgurites and the lightning bolts that created them. But it turns out there is an even more straightforward method available, according to a 2016 study in *Scientific Reports*.

The study's authors, Matthew A. Pasek, a geoscientist at the University of South Florida, and Marc Hurst, a geologist at Independent Geological Services, gathered fulgurites previously formed in exposed areas of quartz sand being mined along the Lake Wales Ridge, in Florida. These sands have long been exposed to lightning storms, ensuring a high density of fulgurites.

He excavated a nearly 4-foot-long fulgurite cast covered in patches of fused sand.

The researchers wanted to learn about the amount of energy a lightning strike transfers to the ground. Pasek measured fulgurites' internal diameter to calculate approximately how much energy per unit of length had passed through them (lightning passing through a meter of quartz sand has roughly the same amount of energy as that found in a shot-glass of gasoline, one megajoule).

Their approach adds a new tool to the kit for scientists looking to study lightning. Fulgurite analysis is notable for its directness: By taking advantage of a stable product of lightning, it can establish the amount of energy transferred through a solid material by a strike, and thus the damage it can cause.

—Chris Drudge

ONE QUESTION

"Why is it harder to locate an object with sound than with light?"

Charles Randy Gallistel

Rutgers University professor of psychology and president of the Association for Psychological Science

The basic laws of physics prescribe how the size of a receiver interacts with the frequency of a signal. Wavelengths of light are measured in nanometers. The eye is measured in centimeters or millimeters. That means even a spider eye can focus light coming from different directions to different loci on a receptive sheet. Getting direction from light is relatively simple just because of the physics. But even an elephant ear can't focus energy when it comes in wavelengths that are sometimes meters longer than the size of the structure. This is why tsunamis go right over breakwaters. A breakwater will block ordinary waves because the wavelengths are much shorter than the breakwater, but when a tsunami comes along where it's a mile between peaks, as far as that input's concerned, that breakwater isn't even there. You can't use the trick you use with light, so what *can* you do? Well, sound travels many orders of magnitude slower than light. If you've got two or more microphones, two ears, you can use difference in arrival times to calculate direction. Differences in arrival time translate into phase, and phase is ambiguous depending on the frequency. So you have to look at the phases across all the frequencies, and it gets pretty mathematical.

OPPOSITE PAGE: JI-ELLE / CREATIVE COMMONS
PORTRAIT: RANDY GALLISTEL

PSYCHOLOGY

Why We Swim in Quarries

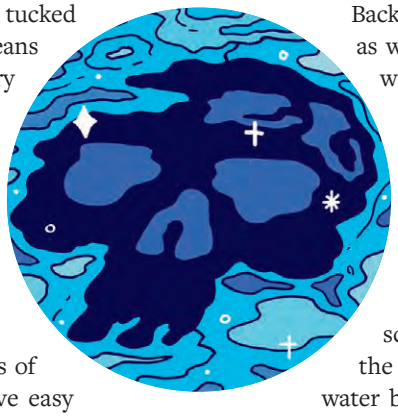
THERE WAS A PLACE in Iowa in 1995, tucked away in the dark-green fields of soybeans and corn, where a flooded rock quarry shimmered aquamarine. I stood on its edge one hot summer day with two friends. To reach the quarry, we had to trespass on private farmland and ignore the "swimming forbidden by law" signs. But we wanted to experience something that we had only seen on postcards. It was "like the lagoons in Hawaii," remembers one friend.

Open-pit quarries exist in many rural parts of the world, enticing swimmers who don't have easy access to the sea. Yet quarries are sometimes toxic and even deadly. One rock quarry in England was called the Blue Lagoon, but it had a pH similar to bleach. Local government officials posted warning signs, yet people stopped swimming only after officials dyed the water black.

So why does blue water have such a draw on our psyche?

Maybe it's the promise of fish. Researchers know that seafood is rich in nutrients critical to brain growth. A 2014 study posits that early hominids lived near the shore with access to these nutrients, explaining the rapid increase in brain development that followed. "We must have been eating more fish, not just for the omega-3 fatty acids, but for the iodine and zinc and iron as well—a cluster of brain selective nutrients that helped the brain grow," says Stephen Cunnane, a professor of medicine at the University of Sherbrooke and an author of the study.

Other research suggests that part of the allure of blue quarries is the color itself. Psychologists Karen Schloss of Brown University and Stephen E. Palmer of the University of California, Berkeley found that an individual's partiality for a certain color is the result of an accumulation of positive associations. Most things we associate with blue are positive, Schloss says, including clear skies and clean water. She found this to be the case in the United States, Japan, and China. In studies, Schloss and her colleagues found a strong, positive association between blue and clean water.



Most things we associate with blue are positive.

Back at the rock quarry in Iowa, as we fully entered the water, we kept our heads just above the surface, inhaling sharply from the exhilaration. The water felt slightly thicker than usual, perhaps heavy from sediment, and it passed over our bodies like silk scarves. As we pushed from the shore to the center, the water became colder. We looked back and saw a trail of decomposing leaves and large, gray clouds of sediment billowing out behind us. Just then the fun started to fade, as we thought of what horror might await us there in the water. Getting snagged on a rusted tractor? Exposure to toxic chemicals? Or being pulled under by a violent current? We quickly swam back to shore, laughing nervously as we lifted ourselves out, happy to be free of whatever dark fate we'd escaped. The quarry looked better from the edge, and our anxiety lifted as we watched the pale-gray clouds slowly settle and give way once again to a pleasing aquamarine.

—Regan Penaluna

FEEL DIFFERENT

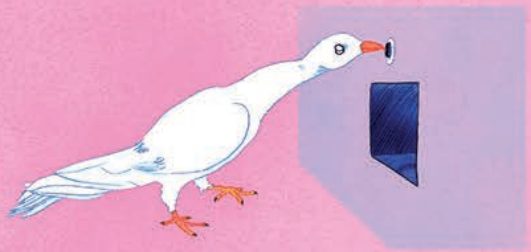
CREATED BY
DAVID PEREZCASSAR

WE HATE THE AMOUNT OF TIME WE'RE ON OUR PHONES, BUT WE CAN'T SEEM TO CONTROL IT. IT'S THE FIRST THING WE DO IN THE MORNING, & THE LAST THING WE DO BEFORE BED. RESEARCH SHOWS WE DO IT ABOUT **85** TIMES A DAY. BUT UNLIKE CIGARETTES, THIS ADDICTION CALLS US TOWARD IT & IS SPECIFICALLY INVENTED & MARKET-TESTED TO BE ADDICTIVELY IRRESISTIBLE.

THE RESEARCH THAT LED TO CREATING IRRESISTIBLE TECHNOLOGY BEGAN OVER **50** YEARS AGO WITH A PSYCHOLOGIST YOU MAY REMEMBER FROM PSYCH **101**.

B.F. SKINNER FELL OUT OF FASHION IN THE HALLS OF ACADEMIA WHEN HE TRIED TO APPLY HIS RESEARCH TO THOSE DIFFICULT CREATURES KNOWN AS HUMAN BEINGS. HE BELIEVED THAT FREE WILL WAS AN ILLUSION & THAT ALL OUR BEHAVIORS WERE LEARNED & BECAUSE OF THIS, WE COULD CREATE A UTOPIAN SOCIETY IF WE ALL AGREED TO ACCEPT NEW FORMS OF CONDITIONING IN ORDER TO BUILD A SOCIETY FREE OF WAR, HATE, HUNGER, ETC... HE ESPOUSED HIS VIEWS IN A BOOK RELEASED IN **1971** TITLED **BEYOND FREEDOM & DIGNITY.**

WE REMEMBR SKINNER BECAUSE HE FOUND THE FIRST DEFINITIVE UNDERSTANDING OF HOW ADDICTION WORKS. HE LEARNED THAT WHEN PIGEONS PERFORMED TASKS BUT HAD NO IDEA IF OR WHEN THEY'D GET A REWARD, OPPOSED TO A TIT-FOR-TAT TRIGGER/REWARD SYSTEM, THEY WERE FAR MORE INVESTED IN PERFORMING THE TASKS, TO A COMPULSIVE DEGREE.



HE ALSO WENT SO FAR AS TO INVENT DEVICES HE CALLED TEACHING MACHINES, WHICH HE EFFECTIVELY USED TO TEACH CHILDREN TO READ BY MATCHING LETTERS FOR REWARDS THE SAME WAY HIS PIGEONS WOULD MATCH SYMBOLS.

SKINNER'S IDEAS BECAME ASSOCIATED WITH BRAINWASHING & ABHORRENT METHODS OF BEHAVIOR MODIFICATION LIKE ELECTRIC SHOCK THERAPY (WHICH SKINNER CONDEMNED) TO "CURE" HOMOSEXUALITY. HE WAS LABELED A FASCIST & HIS IDEAS FELL OUT OF FAVOR.

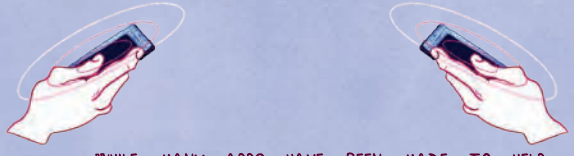
THEN IN THE EARLY AUGHTS SKINNER'S THEORIES ON ADDICTION MADE A COMEBACK THROUGH THE WORK OF

BJ FOGG, A TEACHER AT STANFORD, STARTED MAKING WAVES WHEN HE INTRODUCED THE CONCEPT OF CAPTOLOGY TO THE WORLD. THE FIRST PART OF THE WORD IS AN ACRONYM FOR COMPUTERS AS PERSUASIVE TECHNOLOGY. IN SHORT, FOGG DESCRIBES THE FIELD AS THE "DESIGN, RESEARCH, & ANALYSIS OF INTERACTIVE COMPUTING PRODUCTS CREATED FOR THE PURPOSE OF CHANGING PEOPLE'S ATTITUDES OR BEHAVIORS."

IT WAS A FIELD OF STUDY HIS PEERS FOUND IMMORAL.

HE FOUNDED STANFORD'S PERSUASIVE TECHNOLOGY LAB WHERE HIS RESEARCH MIGHT SHAPE OR RUN PARALLEL TO THE WAY THE PROGRAMS IN OUR POCKETS WORK TODAY & WILL WORK TOMORROW. HIS WORK HAS BEEN PUBLISHED IN VOLUMES OF "LIGHT READING" LIKE **PERSUASIVE TECHNOLOGY:** USING COMPUTERS TO CHANGE WHAT WE THINK & DO, & **MASS INTERPERSONAL PERSUASION.**

IN PERSUASIVE TECHNOLOGY FOGG DESCRIBES THE WAY DEVELOPERS CAN USE TECHNOLOGY TO CHANGE PEOPLE'S BEHAVIOR. HE MIGHT REVIVE OUR FRIEND SKINNER'S ADDICTIVE RESEARCH SAYING THAT PERSUASIVE TECHNOLOGY'S "REINFORCERS ARE MOST EFFECTIVE WHEN THEY ARE UNPREDICTABLE. PLAYING SLOT MACHINES IS A GOOD EXAMPLE."



WHILE MANY APPS HAVE BEEN MADE TO HELP US GET SHIT DONE, TRACK OUR HEALTH, & LEARN NEW SKILLS. THE MORE POPULAR (/ADDICTIVE) ONES CONTINUE TO BE THOSE THAT SATE BOREDOM, TRACK THEIR USERS, & SELL THEIR USER'S BEHAVIOR TO MARKET RESEARCH. WHEN ASKED HOW HE FELT ABOUT HOW HIS RESEARCH IS FARING IN THE WORLD FOGG SAID,

"I'M PART DISCOURAGED & PART EXHAUSTED WITH HOW MANY GREEDY PEOPLE ARE TRYING TO CREATE SOMETHING, NOT TO HELP PEOPLE, BUT JUST SO IT MIGHT MAKE THEM SOME MONEY."

ONE OF FOGG'S MENTEES, NIR EYAL, DISTILLED THE HEADY NERDY IDEAS BEHIND FOGG'S RESEARCH INTO A BEST-SELLING BUSINESS BOOK CALLED **HOOKED:** HOW TO BUILD HABIT FORMING PRODUCTS.

IT'S AN INTERESTING ADDITION TO THE LITERATURE ON CREATING ADDICTIVE TECHNOLOGY BECAUSE IT DISTILLS THE DYNAMIC BETWEEN THE DEVELOPER & THE CONSUMER INTO A SHARP IMAGE WE ALL KNOW & UNDERSTAND. IN AN ECONOMY BASED ON USER ACQUISITION, WE COULD PERCIEVE THAT APP DEVELOPERS ARE THE FISHERMEN, WE'RE THE FISH, & OUR VERY HUMAN NEED TO CONNECT WITH OUR LOVED ONES, ENGAGE WITH OUR COMMUNITY & CREATIVELY EXPRESS OURSELVES IS THE BAIT THAT LURES US TOWARD THESE ADDICTIVE PRODUCTS. NIR EYAL'S HOOK LOOKS LIKE THIS:

1. (INTERNAL) TRIGGER

CAN I DIE OF BOREDOM IN AN AGE OF ENDLESS ENTERTAINMENT?

HEY BB

2. ACTION

3. VARIABLE REWARD

4. INVESTMENT

OR HOW YOU ENSURE THE CYCLE BEGINS ANEW

TOTES!

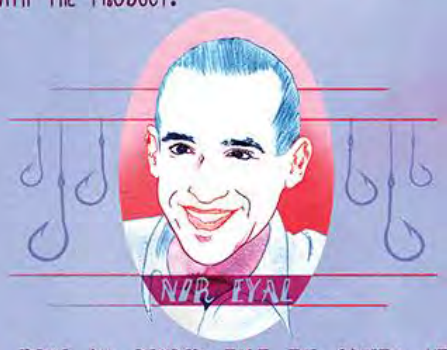
WHICH IS BASICALLY THIS:

LIKE FOGG, NIR'S IDEA OF HOW HE HOPES TO SEE THESE ~~ADDICTIVE~~ HABIT-FORMING TOOLS IMPLEMENTED IS TO HELP US LEAD HAPPIER, HEALTHIER, MORE PRODUCTIVE LIVES.

DESPITE ALL THE GOOD USES FOR THIS TECHNOLOGY, THE INITIAL SPARK (OR INTERNAL TRIGGER) THAT DRIVES US TOWARD THESE PRODUCTS & STARTS NIR'S HOOK MODEL IS OFTEN THE NEED TO QUELL A NEGATIVE EMOTION.

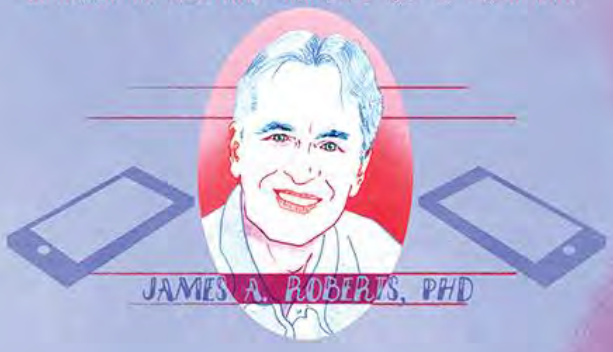
"BOREDOM, LONELINESS, INSECURITY, & UNCERTAINTY HAVE PLAGUED THE HUMAN SPECIES FOR **200,000** YEARS. THE GOAL OF THE HABIT-FORMING PRODUCT IS TO CATER TO THESE PROBLEMS. WE IMPROVE PEOPLE'S LIVES BY SOLVING THESE STRESSES. WE'RE REPLACING TELEVISION. THE AVERAGE AMERICAN WATCHES 5 HOURS OF TELEVISION A NIGHT & I'D MUCH RATHER HAVE THEM INTERACTING WITH OTHER HUMAN BEINGS THROUGH A DIGITAL MEDIUM THAN JUST SITTING IN FRONT OF A BOOB TUBE."

AS FOR THE POTENTIAL FEAR OF THESE PRODUCTS BEING HARMFULLY ADDICTIVE, NIR BELIEVES ADDICTIVE MISUSE "HAS JUST AS MUCH TO DO WITH THE PERSON AS WITH THE PRODUCT."



WE'VE ALL DECIDED THAT THE SAFETY, UTILITY, & PLEASURE OF HAVING THE INTERNET IN OUR POCKETS OUTWEIGHS ANY CONCERNS OVER PRIVACY OR THE ENNUI THAT INFINITE SCROLL ELICITS. IF THESE PRODUCTS ARE ENGINEERED TO BE ADDICTIVE, WHO CARES? HOW BAD COULD AN ADDICTION TO A PIECE OF PLASTIC REALLY BE?

IN ORDER TO FIND THAT ANSWER I GOT IN TOUCH WITH



DR. JIM ROBERTS IS A PROFESSOR OF MARKETING AT BAYLOR UNIVERSITY. HE'S CONDUCTED SOME OF THE VERY FIRST STUDIES LOOKING INTO SMARTPHONE ADDICTION WITH ATTENTION TO GENDER DIVIDES, SPECIFIC APP USAGE, & THE EFFECT OVERUSE HAS ON OUR CAREERS & RELATIONSHIPS. HE LITERALLY WROTE THE BOOK ON THE SUBJECT. IT'S CALLED **TOO MUCH OF A GOOD THING.**

IN ADDITION TO PROVING THAT WE'RE MORE ADDICTED TO SOCIAL MEDIA APPS THAN WE ARE TO UTILITARIAN APPS, HE FOUND THAT THE VICIOUS CYCLE THAT EXISTS WITH ALL OTHER ADDICTIONS EXISTS WITH SMART PHONES AS WELL. WE GET A HIT, IT FEELS GOOD, WE COME DOWN & NEED ANOTHER HIT. ONLY THIS TIME, OUR TOLERANCE HAS INCREASED & WE END UP USING OUR PHONES MORE WITH LESS RETURN ON INVESTMENT. THE NEGATIVE IMPACT GROWS BECAUSE MANY OF US ENGAGE WITH OUR PHONES AS A WAY TO AVOID THE PROBLEMS IN FRONT OF US. SOME FORM OF ANXIETY DRIVES US TOWARD A DEVICE THAT OFFERS A TEMPORARY SALVE, YET EACH TIME WE DO THIS WE'RE LESS FULFILLED. OUR PROBLEM REMAINS UNRESOLVED & WE'RE SPIT OUT CRAVING MORE. IT'S A VICIOUS CYCLE THAT IS CONFIRMED AS A FULL BLOWN ADDICTION WHEN USERS EXPERIENCE SYMPTOMS OF WITHDRAWAL & PANIC ONCE THEY'VE MISPLACED OR LOST THEIR PHONES.

DR. ROBERTS EXPANDED ON A NEW WORD TO DESCRIBE HIS MOST RECENT RESEARCH. HE'S STUDYING THE EFFECTS OF **PHUBBING**. A PORTMANTEAU OF PHONE & SNUBBING THAT DESCRIBES THAT SOCIAL SITUATION WE'VE ALL BEEN THROUGH WHERE SOMEONE HOPS ON THEIR PHONE WHILE YOU'RE SPENDING TIME WITH THEM.

DR. ROBERTS (& HIS ASSOCIATE DR. MEREDITH DAVID)'S STUDY ON PHUBBING FOUND THAT IT CONSISTENTLY LED TO RELATIONSHIP CONFLICT, WHICH RESULTED IN LOWER RELATIONSHIP & LIFE SATISFACTION, WHICH LEAD TO DEPRESSION, WHICH RESEARCH SHOWS, INCREASES OUR SOCIAL MEDIA USE, WHICH IN TURN LEADS US BACK TO THE ADDICTIVE TECHNOLOGY.

MOST ADDICTIVE INDUSTRIES GENERATE A LOT OF MONEY FOR POWERFUL PEOPLE & TAKE A LONG TIME TO REGULATE. IT TOOK OVER **400** YEARS TO START REGULATING TOBACCO & AS A KID I REMEMBER SMOKING IN PLANES & RESTAURANTS TO BE COMMONPLACE DESPITE DECADES OF STUDIES SHOWCASING THE NEGATIVE EFFECTS & CORRELATION TO LUNG CANCER.

IT ISN'T CRAZY TO STRIVE TOWARD TREATING SMART PHONE USE (OR WHATEVER THE NEXT ITERATION OF MOBILE TECHNOLOGY WILL BE) THE SAME WAY. NEED A QUICK FIX? WAIT FOR THE INTERMISSION & STEP OUTSIDE.

Bias in the ER

Medical professionals suffer from the same cognitive distortions as the rest of us

BY MICHAEL LEWIS

THE DAZED YOUNG WOMAN who arrived at Sunnybrook Hospital, Canada's first and largest regional trauma center, from a head-on car crash presented the surgeons treating her with a disturbing problem. In addition to her many broken bones, the rhythm of her heartbeat had become wildly irregular. It was either skipping beats or adding extra beats; in any case, she had more than one thing seriously wrong with her.

She remained alert enough to tell them that she had a past history of an overactive thyroid. An overactive thyroid can cause an irregular heartbeat. And so, when the hospital's resident medical detective, Don Redelmeier, arrived, the staff believed that they no longer needed him to investigate the source of the irregular heartbeat but only to treat it. No one in the operating room would have batted an eye if Redelmeier had simply administered the drugs for hyperthyroidism. Instead, Redelmeier asked everyone to slow down. To wait. Just a moment. Just to check their thinking—and to make sure they were not trying to force the facts into an easy, coherent, but ultimately false story.

ILLUSTRATIONS BY JULIA BRECKENREID

Something bothered him. As he said later, "Hyperthyroidism is a classic cause of an irregular heart rhythm, but hyperthyroidism is an infrequent cause of an irregular heart rhythm." Hearing that the young woman had a history of excess thyroid hormone production, the emergency room medical staff had leaped, with seeming reason, to the assumption that her overactive thyroid had caused the dangerous beating of her heart. They hadn't bothered to consider statistically far more likely causes of an irregular heartbeat. In Redelmeier's experience, doctors did not think statistically. "Eighty percent of doctors don't think probabilities apply to their patients," he said. "Just like 95 percent of married couples don't believe the 50-percent divorce rate applies to them, and 95 percent of drunk drivers don't think the statistics that show that you are more likely to be killed if you are driving drunk than if you are driving sober applies to them."

The world's not just a stage. It's a casino.

Redelmeier's job in the trauma center was, in part, to check the understanding of the specialists for mental errors. "It isn't explicit but it's acknowledged that he will serve as a check on other people's thinking," said Rob Fowler, an epidemiologist at Sunnybrook. "About how people do their thinking. He keeps people honest. The first time people interact with him they'll be taken aback: Who the hell is this guy, and why is he giving me feedback? But he's lovable, at least the second time you meet him." That Sunnybrook's doctors had come to appreciate the need for a person to serve as a check on their thinking, Redelmeier thought, was a sign of how much the profession had changed since he entered it in the mid-1980s. When he'd started out, doctors set themselves up as infallible experts; now there was a place in Canada's leading regional trauma center for a connoisseur of medical error. A hospital was now viewed not just as a place to treat the unwell but also as a machine for coping with uncertainty. "Wherever there is uncertainty there has got to be judgment," said Redelmeier, "and wherever there is judgment there is an opportunity for human fallibility."

Across the United States, more people died every year as a result of

preventable accidents in hospitals than died in car crashes—which was saying something. Bad things happened to patients, Redelmeier often pointed out, when they were moved without extreme care from one place in a hospital to another. Bad things happened when patients were treated by doctors and nurses who had forgotten to wash their hands. Bad things even happened to people when they pressed hospital elevator buttons. Redelmeier had actually co-written an article about that: "Elevator Buttons as Unrecognized Sources of Bacterial Colonization in Hospitals." For one of his studies, he had swabbed 120 elevator buttons and 96 bathroom surfaces at three big Toronto hospitals and produced evidence that the elevator buttons were far more likely to infect you with some disease.

Of all the bad things that happened to people in hospitals, the one that most preoccupied Redelmeier was clinical misjudgment. Doctors and nurses were human, too. They sometimes failed to see that the information patients offered them was unreliable—for instance, patients often said that they were feeling better, and might indeed believe themselves to be improving, when they had experienced no real change in their condition. Doctors tended to pay attention mainly to what they were asked to pay attention to, and to miss some bigger picture. They sometimes failed to notice what they were not directly assigned to notice. "One of the things Don taught me was the value of observing the room when the patient isn't there," says Jon Zipursky, former chief medical resident at Sunnybrook. "Look at their meal tray. Did they eat? Did they pack for a long stay or a short one? Is the room messy or neat? Once we walked into the room and the patient was sleeping. I was about to wake him up and Don stops me and says, There is a lot you can learn about people from just watching."

Doctors tended to see only what they were trained to see: That was another big reason bad things might happen to a patient inside a hospital. A patient received treatment for something that was obviously wrong with him, from a specialist oblivious to the possibility that some less obvious thing might also be wrong with him. The less obvious thing, on occasion, could kill a person.

Redelmeier asked the emergency room staff to search for other, more statistically likely causes of the woman's irregular heartbeat. That's when they found her collapsed lung. Like her fractured ribs, her collapsed lung had failed to turn up on the X-ray. Unlike the fractured ribs, it could kill her. Redelmeier ignored the thyroid and treated the collapsed lung. The young woman's heartbeat returned to normal. The next day, her formal thyroid tests came back: Her thyroid hormone production was perfectly normal. Her thyroid had never been the issue. It was a classic case of what Redelmeier would soon come to know as the "representativeness heuristic." "You need to be so careful when there is

one simple diagnosis that instantly pops into your mind that beautifully explains everything all at once," he said. "That's when you need to stop and check your thinking."

REDELMEIER HAD GROWN UP in Toronto. The youngest of three boys, he often felt a little stupid; his older brothers always seemed to know more than he did and were keen to let him know it. Redelmeier also had a speech impediment—a maddening stutter he would never cease to work hard, and painfully, to compensate for. His stutter slowed him down when he spoke; his weakness as a speller slowed him down when he wrote. His two great strengths were his mind and his temperament. He was always extremely good at math; he loved math. He could explain it, too, and other kids came to him when they couldn't understand what the teacher had said. That is where his temperament entered. He was almost peculiarly considerate of others. From the time he was a small child, grown-ups had noticed that about him: His first instinct upon meeting someone else was to take care of the person. Still, even from math class, where he often wound up helping all the other students, what he took away was a sense of his own fallibility. In math there was a right answer and a wrong answer, and you couldn't fudge it. "And the errors are sometimes predictable," he said. "You see them coming a mile away and you still make them." His experience of life as an error-filled sequence of events, he later thought, might be what had made him so receptive to an obscure article, in the journal *Science*, that his favorite high school teacher, Mr. Fleming, had given him to read in late 1977. He took the article home with him and read it that night at his desk. The article was called "Judgment Under Uncertainty: Heuristics and Biases." It was by two psychologists at the Hebrew University in Jerusalem, Daniel Kahneman and Amos Tversky.

Amos Tversky and Danny Kahneman had been collaborating since 1969, when they wrote a paper together called "Belief in the Law of Small Numbers," which exposed a common flaw in human statistical reasoning. In 1970, Amos left Jerusalem to spend a year at Stanford University; Danny stayed behind. They used the year apart to collect data about how people form statistical judgments. The data consisted entirely of answers to curious questions that they had devised.

Consider the following question:

> All families of six children in a city were surveyed. In 72 families the exact order of births of boys and girls was G B G B B G. What is your estimate of the number of families surveyed in which the exact order of births was B G B B B B?

That is, in this hypothetical city, if there were 72 families with six children born in the following order—girl, boy, girl, boy, boy, girl—how many families with six children do you imagine have the birth order boy, girl, boy, boy, boy, boy? Who knows what Israeli high school students made

of the strange question, but 1,500 of them supplied answers to it. The researchers posed other, equally weird, questions to college students at the University of Michigan and Stanford University. For example:

> On each round of a game, 20 marbles are distributed at random among five children: Alan, Ben, Carl, Dan, and Ed. Consider the following distributions:
>
> | | *I* | | *II* |
> |---|---|---|---|
> | *Alan* | *4* | *Alan* | *4* |
> | *Ben* | *4* | *Ben* | *4* |
> | *Carl* | *5* | *Carl* | *4* |
> | *Dan* | *4* | *Dan* | *4* |
> | *Ed* | *3* | *Ed* | *4* |
>
> In many rounds of the game, will there be more results of type I or type II?

They were trying to determine how people judged—or, rather, misjudged—the odds of any situation when the odds were hard, or impossible, to know. All the questions had right answers and wrong answers. The answers that their subjects supplied could be compared to the right answer, and their errors investigated for patterns. "The general idea was: What do people do?" Danny later said. "What actually is going on when people judge probability? It's a very abstract concept. They must be doing something."

Amos and Danny didn't have much doubt that a lot of people would get the questions they had dreamed up wrong—because Danny and Amos had gotten them, or versions of them, wrong. If they both committed the same mental errors, or were tempted to commit them, they assumed—rightly, as it turned out—that most other people would commit them, too. The questions they had spent the year cooking up were not so much experiments as they were little dramas: Here, look, this is what the uncertain human mind actually does.

Their first paper had shown that people faced with a problem that had a statistically correct answer did not think like statisticians. Even statisticians did not think like statisticians. "Belief in the Law of Small Numbers" had raised an obvious next question: If people did not use statistical reasoning, even when faced with a problem that could be solved with statistical reasoning, what kind of reasoning did they use? Their next paper offered a partial answer to the question. It was called "Subjective Probability: A Judgment of Representativeness."

"Subjective probability" meant the odds you assign to any given situation when you are more or less guessing. Look outside the window at midnight and see your teenage son weaving his way toward your front door, and say to yourself, "There's a 75 percent chance he's

The more easily people can call a scenario to mind, the more probable they find it.

been drinking"—that's subjective probability. "Subjective probabilities play an important role in our lives," they began. "The decisions we make, the conclusions we reach, and the explanations we offer are usually based on our judgments of the likelihood of uncertain events such as success in a new job, the outcome of an election, or the state of the market." In these and many other uncertain situations, the mind did not naturally calculate the correct odds. So what did it do? It replaced the laws of chance with rules of thumb. These rules of thumb Danny and Amos called "heuristics." And the first heuristic they wanted to explore they called "representativeness."

When people make judgments, they argued, they compare whatever they are judging to some model in their minds. How much do those clouds resemble my mental model of an approaching storm? How closely does this ulcer resemble my mental model of a malignant cancer? Does Jeremy Lin match my mental picture of a future NBA player? Does that belligerent German political leader resemble my idea of a man capable of orchestrating genocide? The world's not just a stage. It's a casino, and our lives are games of chance. And when people calculate the odds in any life situation, they are often making judgments about similarity—or representativeness. You have some notion of a parent population: "storm clouds" or "gastric ulcers" or "genocidal dictators" or "NBA players." You compare the specific case to the parent population.

"Our thesis," they wrote, "is that, in many situations, an event A is judged

more probable than an event B whenever A appears more representative than B." The more the basketball player resembles your mental model of an NBA player, the more likely you will think him to be an NBA player. They had a hunch that people, when they formed judgments, weren't just making random mistakes—that they were doing something systematically wrong.

The problem was subtle. The rule of thumb they had called representativeness wasn't always wrong. If the mind's approach to uncertainty was occasionally misleading, it was because it was often so useful. Much of the time, the person who can become a good NBA player matches up pretty well with the mental model of "good NBA player." But sometimes a person does not—and in the systematic errors they led people to make, you could glimpse the nature of these rules of thumb.

For instance, in families with six children, the birth order B G B B B B was about as likely as G B G B B G. But Israeli kids—like pretty much everyone else on the planet, it would emerge—naturally seemed to believe that G B G B B G was a more likely birth sequence. Why? "The sequence with five boys and one girl fails to reflect the proportion of boys and girls in the population," they explained. It was less representative. What is more, if you asked the same Israeli kids to choose the more likely birth order in families with six children—B B B G G G or G B B G B G—they overwhelmingly opted for the latter. But the two birth orders are equally likely. So why did people almost universally believe that one was far more likely than the other? Because, said Danny and Amos, people thought of birth order as a random process, and the second sequence looks more "random" than the first.

The natural next question: When does our rule-of-thumb approach to calculating the odds lead to serious miscalculation? One answer was: whenever people are asked to evaluate anything with a random component to it. For example, Londoners in World War II thought that German bombs were targeted, because some parts of the city were hit repeatedly while others were not hit at all. (Statisticians later showed that the distribution was exactly what you would expect from random bombing.) People find it a remarkable coincidence when two students in the same classroom share a birthday, when in fact there is a better than even chance, in any group of 23 people, that two of its members will have been born on the same day. We have a kind of stereotype of "randomness" that differs from true randomness. Our stereotype of randomness lacks the clusters and patterns that occur in true random sequences. If you pass out 20 marbles randomly to five boys, they are actually more likely to each receive four marbles (column II), than they are to receive the combination in column I, and yet college students insisted that the unequal distribution in column I was more likely than the equal one in column II. Why? Because column II "appears too lawful to be the result of a random process."

Danny and Amos believed that these errors had larger implications. "In their daily lives," they wrote, "people ask themselves and others questions such as: What are the chances that this 12-year-old boy will grow up to be

a scientist? What is the probability that this candidate will be elected to office? What is the likelihood that this company will go out of business?" They confessed that they had confined their questions to situations in which the odds could be objectively calculated. But they felt fairly certain that people made the same mistakes when the odds were harder, or even impossible, to know. When, say, they guessed what a little boy would do for a living when he grew up, they thought in stereotypes. If he matched their mental picture of a scientist, they guessed he'd be a scientist—and neglect the prior odds of any kid becoming a scientist.

In a later paper, Amos and Danny described a second "heuristic." It was called "Availability: A Heuristic for Judging Frequency and Probability." In one example, the authors asked:

> The frequency of appearance of letters in the English language was studied. A typical text was selected, and the relative frequency with which various letters of the alphabet appeared in the first and third positions in words was recorded. Words of less than three letters were excluded from the count.
>
> You will be given several letters of the alphabet, and you will be asked to judge whether these letters appear more often in the first or in the third position, and to estimate the ratio of the frequency with which they appear in these positions. ...
>
> Consider the letter K. Is K more likely to appear in:
>
> the first position?
>
> the third position? (check one)
>
> My estimate for the ratio of these two values is: __ : 1

If you thought that K was, say, twice as likely to appear as the first letter of an English word than as the third letter, you checked the first box and wrote your estimate as 2:1. This was what the typical person did, as it happens. Danny and Amos replicated the demonstration with other letters—R, L, N, and V. Those letters all appeared more frequently as the third letter in an English word than as the first letter—by a ratio of two to one. Once again, people's judgment was, systematically, very wrong. And it was wrong, Danny and Amos now proposed, because it was distorted by memory. It was simply easier to recall words that start with K than to recall words with K as their third letter. The more easily people can call some scenario to mind—the more available it is to them—the more probable they find it to be.

The point, once again, wasn't that people were stupid. This particular rule they used to judge probabilities (the easier it is for me to retrieve from my memory, the more likely it is) often worked well. But if you presented people with situations in which the evidence they needed to judge them accurately was hard for them to retrieve from their memories, and misleading evidence came easily to mind, they made mistakes. "Consequently," Amos and Danny wrote, "the use of the availability heuristic leads to systematic biases." Human judgment was distorted by ... *the memorable*.

FOR DON REDELMEIER, Kahneman and Tversky's work was in equal parts familiar and strange. Redelmeier was 17 years old, and some of the jargon was beyond him. But the article described the ways in which people made judgments when they didn't know the answer for sure. They made the phenomenon they described feel like secret knowledge. Yet what they were saying struck Redelmeier as the simple truth—mainly because he was fooled by the questions they put to the reader. He, too, thought that there were more words in a typical passage of English prose that started with K than had K in the third position, because the words that began with K were easier to recall.

What struck Redelmeier wasn't the idea that people made mistakes. Of course people made mistakes! What was so compelling is that the mistakes were predictable and systematic. They seemed ingrained in human nature. One passage in particular stuck with him—about the role of the imagination in human error. "The risk involved in an adventurous expedition, for example, is evaluated by imagining contingencies with which the expedition is not equipped to cope," the authors wrote. "If many such difficulties are vividly portrayed, the expedition can be made to appear exceedingly dangerous, although the ease with which disasters are imagined need not reflect their actual likelihood. Conversely, the risk involved in an undertaking may be grossly underestimated if some possible dangers are either difficult to conceive of, or simply do not come to mind." This wasn't just about how many words in the English language started with the letter K. This was about life and death.

As a kid, Redelmeier hadn't had much trouble figuring out what he wanted to do with his life. He'd fallen in love with the doctors on television—Leonard McCoy on *Star Trek* and, especially, Hawkeye Pierce on *M*A*S*H*. "I sort of wanted to be heroic," he said. "I would never cut it in sports. I would never cut it in politics. I would never make it in the movies. Medicine was a path. A way to have a truly heroic life." He felt the pull so strongly that he applied to medical school at the age of 19, during his second year of college. Just after his 20th birthday he was training at the University of Toronto to become a doctor.

And that's where the problems started: "Early on in medical school there are a whole bunch of professors who are saying things that are wrong," Redelmeier recalled. "I don't dare say anything about it." They repeated common superstitions as if they were eternal truths. ("Bad things come in threes.") Specialists from different fields of medicine faced with the same disease offered contradictory diagnoses. His professor of urology told students that blood in the urine suggested a high chance of kidney cancer, while his professor of nephrology said that blood in the urine indicated a high chance of glomerulonephritis—kidney inflammation. "Both had exaggerated confidence based on their expert experience," said Redelmeier, and both mainly saw only what they had been trained to see.

The problem was not what they knew, or didn't know. It was their need for certainty or, at least, the appearance of certainty. Standing beside the slide projector, many of them did not so much teach as preach. "There was a generalized mood of arrogance," said Redelmeier. " *'What do you mean you didn't give steroids!!????'* " To Redelmeier the very idea that there was a great deal of uncertainty in medicine went largely unacknowledged by its authorities.

There was a reason for this: To acknowledge uncertainty was to admit the possibility of error. The entire profession had arranged itself as if to confirm the wisdom of its decisions. Whenever a patient recovered, for instance, the doctor typically attributed the recovery to the treatment he had prescribed, without any solid evidence that the treatment was responsible. Just because the patient is better after I treated him doesn't mean he got better because I treated him, Redelmeier thought. "So many diseases are self-limiting," he said. "They will cure themselves. People who are in distress seek care. When they seek care, physicians feel the need to do something. You put leeches on; the condition improves. And that can propel a lifetime of leeches. A lifetime of overprescribing antibiotics. A lifetime of giving tonsillectomies to people with ear infections. You try it and they get better the next day and it is so compelling. You go to see a psychiatrist and your depression improves—you are convinced of the efficacy of psychiatry."

Redelmeier noticed other problems, too. His medical school professors took data at face value that should have been inspected more closely, for example. An old man would come into the hospital suffering from pneumonia. They'd check his heart rate and find it to be a reassuringly normal 75 beats per minute ... and just move on. But the reason pneumonia killed so many old people was its power to spread infection. An immune system responding as it should generated fever, coughs, chills, sputum—and a faster than normal heartbeat. A body fighting an infection required blood to be pumped through it at a faster than normal rate. "The heart rate of an old man with pneumonia is not supposed to be normal!" said Redelmeier. "It's supposed to be ripping along!" An old man with pneumonia whose heart rate appears normal is an old man whose heart may well have a serious problem. But the normal reading on the heart rate monitor created a false sense in doctors' minds that all was well. And it was precisely when all seemed well that medical experts "failed to check themselves."

When subjected to scientific investigation, some of what passed for medical wisdom turned out to be shockingly wrong-headed. When Redelmeier entered medical school in 1980, for instance, the conventional wisdom held that if a heart attack victim suffered from some subsequent arrhythmia, you gave him drugs to suppress it. By the end of Redelmeier's medical training, in 1991, researchers had shown that heart attack patients whose arrhythmia was suppressed died more often than the ones whose condition went untreated. No one explained why doctors, for years, had opted for a treatment that systematically killed patients—though

SAMI SIVA/THE NEW YORK TIMES/REDUX

MASTER INQUISITOR As a resident at Sunnybrook Hospital, Don Redelmeier, pictured here in 2010, became convinced that the mistakes doctors made were consistent and predictable.

proponents of evidence-based medicine were beginning to look to the work of Kahneman and Tversky for possible explanations. But it was clear that the intuitive judgments of doctors could be gravely flawed: The evidence of the medical trials now could not be ignored. "I became very aware of the buried analysis—that a lot of the probabilities were being made up by expert opinion," said Redelmeier. "I saw error in the way people think that was being transmitted to patients. And people had no recognition of the mistakes that they were making. I had a little unhappiness, a little dissatisfaction, a sense that all was not right in the state of Denmark."

Toward the end of their article in *Science*, Daniel Kahneman and Amos Tversky had pointed out that, while statistically sophisticated people might avoid the simple mistakes made by less savvy people, even the most sophisticated minds were prone to error. As they put it, "their intuitive judgments are liable to similar fallacies in more intricate and less transparent problems." That, the young Redelmeier realized, was a "fantastic rationale why brilliant physicians were not immune to these fallibilities."

Error wasn't necessarily shameful; it was merely human. "They provided a language and a logic for articulating some of the pitfalls people encounter when they think. Now these mistakes could be communicated. It was the recognition of human error. Not its denial. Not its demonization. Just the understanding that they are part of human nature."

In 1985, Redelmeier was accepted as a medical resident at the Stanford University hospital. By the age of 27, as he finished his Stanford residency, Redelmeier was creating the beginnings of a worldview that internalized the article by the two Israeli psychologists that he had read as a teenager. Where this worldview would lead he did not know. He still thought it possible that, upon his return to Canada, he might just move back up to northern Labrador, where he had spent one summer during medical school delivering health care to a village of 500 people. "I didn't have great memory skills or great dexterity," he said. "I was afraid I wouldn't be a great doctor. And if I wasn't going to be great, I might as well go to serve someplace that was underserved, where I was needed and wanted." Redelmeier actually still believed that he might wind up practicing medicine in a conventional manner. But then he met Amos Tversky.

IN THE SPRING OF 1988, two days before his first lunch with Amos Tversky, Redelmeier walked through the Stanford Faculty Club dining room where they were scheduled to meet. He didn't eat breakfast usually, but on this day he did, so that he wouldn't overeat during lunch. Hal Sox, Redelmeier's superior at Stanford, who would be joining them, had told Redelmeier, "Don't talk. Don't say anything. Don't interrupt. Just sit and listen." Meeting with Amos Tversky, Hal Sox, said, was "like brainstorming with Albert Einstein. He is one for the ages—there won't ever be anyone else like him."

Hal Sox happened to have co-authored the first article Amos ever wrote about medicine. Their paper had sprung from a question Amos had put to Sox: How did a tendency people exhibited when faced with financial gambles play itself out in the minds of doctors and patients? Specifically, given a choice between a sure gain and a bet with the same expected value (say, $100 for sure or a 50-50 shot at winning $200), Amos had explained to Hal Sox, people tended to take the sure thing. A bird in the hand. But, given the choice between a sure loss of $100 and a 50-50 shot of losing $200, they took the risk. With Amos' help, Sox and two other medical researchers designed experiments to show how differently both doctors and patients made choices when those choices were framed in terms of losses rather than gains.

Lung cancer proved to be a handy example. Lung cancer doctors and patients in the early 1980s faced two unequally unpleasant options: surgery or radiation. Surgery was more likely to extend your life, but, unlike radiation, it came with the small risk of instant death. When you told people that they had a 90 percent

chance of surviving surgery, 75 percent of patients opted for surgery. But when you told them that they had a 10 percent chance of dying from the surgery—which was, of course, just a different way of putting the same odds—only 52 percent chose the surgery. People facing a life-and-death decision responded not to the odds but to the way the odds were described to them. And not just patients; doctors did it, too. Working with Amos, Sox said, had altered his view of his own profession. "The cognitive aspects are not at all understood in medicine," he said. Among other things, he could not help but wonder how many surgeons, consciously or unconsciously,

Think what no one else has ever thought.

had told some patient that he had a 90 percent chance of surviving a surgery, rather than a 10 percent chance of dying from it, simply because it was in his interest to perform the surgery.

At that first lunch, Redelmeier mainly just watched as Sox and Amos talked. Still, he noticed some things. Amos' pale blue eyes darted around, and he had a slight speech impediment. His English was fluent but spoken with a thick Israeli accent. "He was a little bit hypervigilant," said Redelmeier. "He was bouncy. Energetic. He had none of the lassitude of some of the tenured faculty. He did 90 percent of the talking. Every word was worth listening to. I was surprised by how little medicine he knew, because he was already having a big effect on medical decision making." Amos had all sorts of questions for the two doctors; most of them had to do with probing for illogic in medical behavior. After watching Hal Sox answer or try to answer Amos' questions, Redelmeier realized that he was learning more about his superior in a single lunch than he'd gathered from the previous three years. "Amos knew exactly what questions to ask," said Redelmeier.

At the end of the lunch, Amos invited Redelmeier to visit him in his office. It didn't take long before Amos was bouncing ideas about the human mind off Redelmeier, to listen for an echo in medicine. The Samuelson bet, for instance. The Samuelson bet was named for Paul Samuelson, the economist who had cooked it up. As Amos explained it, people offered a single bet in which they have a 50-50 chance to either win $150 or lose

$100 usually decline it. But if you offer those same people the chance to make the same bet 100 times over, most of them accept the bet. Why did they make the expected value calculation—and respond to the odds being in their favor—when they were allowed to make the bet 100 times, but not when they were offered a single bet? The answer was not entirely obvious. Yes, the more times you play a game with the odds in your favor, the less likely you are to lose; but the more times you play, the greater the total sum of money you stand to lose. Anyway, after Amos finished explaining the paradox, "he said, 'Okay, Redelmeier, find me the medical analogy to that!' "

For Redelmeier, medical analogies popped quickly to mind. "Whatever the general example was, I knew a bunch of instantaneous medical examples. It was just astonishing that he would shut up and listen to me." A medical analogy of Samuelson's bet, Redelmeier decided, could be found in the duality in the role of the physician. "The physician is meant to be the perfect agent for the patient as well as the protector of society," he said. "Physicians deal with patients one at a time, whereas health policy makers deal with aggregates."

But there was a conflict between the two roles. The safest treatment for any one patient, for instance, might be a course of antibiotics; but the larger society suffers when antibiotics are overprescribed and the bacteria they were meant to treat evolve into versions of themselves that are more dangerous and difficult to treat. A doctor who did his job properly really could not just consider the interests of the individual patient; he needed to consider the aggregate of patients with that illness. The issue was even bigger than one of public health policy. Doctors saw the same illness again and again. Treating patients, they weren't merely making a single bet; they were being asked to make that same bet over and over again. Did doctors behave differently when they were offered a single gamble and when they were offered the same gamble repeatedly?

The paper subsequently written by Amos with Redelmeier showed that, in treating individual patients, the doctors behaved differently than they did when they designed ideal treatments for groups of patients with the same symptoms. To avoid troubling issues, they were likely to order additional tests, and less likely to ask if patients wished to donate their organs if they died. In treating individual patients, doctors often did things they would disapprove of if they were creating a public policy to treat groups of patients with the exact same illness. "This result is not just another manifestation of the conflict between the personal interests of the individual patient and the general interests of society," Tversky and Redelmeier wrote in a letter to the editor of the *New England Journal of Medicine*. "The discrepancy between the aggregate and the individual perspectives exists in the mind of the physician.

The discrepancy seems to call for a resolution; it is odd to endorse a treatment for every case and reject it in general, or vice versa."

The point was not that the doctor was incorrectly or inadequately treating individual patients. The point was that he could not treat his patient one way, and groups of patients suffering from precisely the same problem in another way, and be doing his best in both cases. And the point was obviously troubling—at least to the doctors who flooded the *New England Journal of Medicine* with letters written in response to the article. "Most physicians try to maintain this facade of being rational and scientific and logical and it's a great lie," said Redelmeier. "A partial lie. What leads us is hopes and dreams and emotion."

Redelmeier's first article with Amos led to other ideas. Soon they were meeting not in Amos' office in the afternoon but at Amos' home late at night. Working with Amos wasn't work. "It was pure joy," said Redelmeier. "Pure fun." Redelmeier knew at some deep level that he was in the presence of a person who would change his life. Many sentences popped out of Amos' mouth that Redelmeier knew he would forever remember:

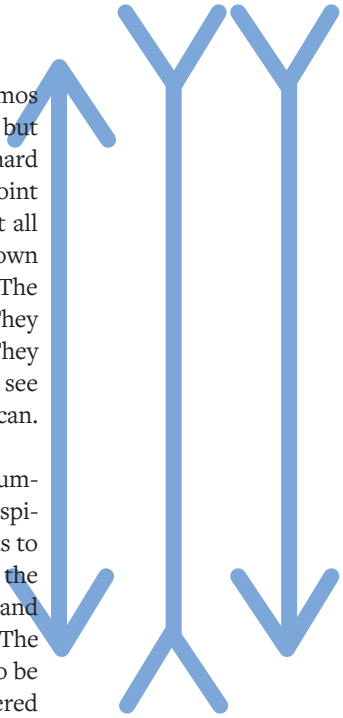
> A part of good science is to see what everyone else can see but think what no one else has ever thought.

> So many problems occur when people fail to be obedient when they are supposed to be obedient, and fail to be creative when they are supposed to be creative.

> It is sometimes easier to make the world a better place than to prove you have made the world a better place.

The man was so vivid that you could not confront any question without wondering how he would approach it. And yet, as Amos always seemed to have all the big ideas, and simply needed medical examples to illustrate them, Redelmeier was left with the feeling that maybe he hadn't done very much. "In many ways I was a glorified secretary, and that troubled me for many years," he said. "Deep down, I thought I was extremely replaceable. When I came back to Toronto, I wondered: Was it just Amos? Or was there something Redelmeier?"

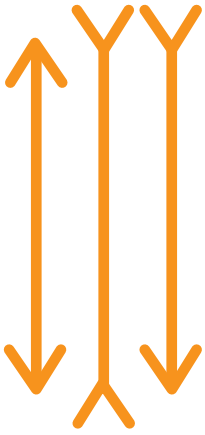
Still, only a few years earlier, he'd imagined that he might wind up a general practitioner in a small village in northern Labrador. Now he had a particular ambition: to explore, as both researcher and doctor, the mental mistakes that doctors and their patients made. He wanted to combine cognitive psychology, as practiced by Danny and Amos, with medical decision making. How exactly he would do this he could not immediately say. All he knew for sure was that by working with Amos Tversky, he had discovered this other side to himself: a seeker of truth.



YEARS LATER, DON REDELMEIER still heard the sound of Amos in his head. He'd been back from Stanford for several years, but Amos' voice was so clear and overpowering that it made it hard for Redelmeier to hear his own. Redelmeier could not pinpoint the precise moment that he sensed that his work with Amos was not all Amos' doing—that it had some Redelmeier in it, too. His sense of his own distinct value began with a simple question—about homeless people. The homeless were a notorious drag on the local health care system. They turned up in emergency rooms more often than they needed to. They were a drain on resources. Every nurse in Toronto knew this: If you see a homeless person wander in, hustle him out the door as fast as you can. Redelmeier wondered about the wisdom of that strategy.

And so, in 1991, he created an experiment. He arranged for large numbers of college students who wanted to become doctors to be given hospital greens and a place to sleep near the emergency room. Their job was to serve as concierges to the homeless. When a homeless person entered the emergency room, they were to tend to his every need. Fetch him juice and a sandwich, sit down and talk to him, help arrange for his medical care. The college students worked for free. They loved it: They got to pretend to be doctors. But they serviced only half of the homeless people who entered the hospital. The other half received the usual curt and dismissive service from the nursing staff. Redelmeier then tracked the subsequent use of the Toronto health care system by all the homeless people who had visited his hospital. Unsurprisingly, the group that received the gold-plated concierge service tended to return slightly more often to the hospital where they had received it than the unlucky group. The surprise was that their use of the greater Toronto health care system declined. When homeless people felt taken care of by a hospital, they didn't look for other hospitals that might take care of them. The homeless said, "That was the best that can be done for me." The entire Toronto health care system had been paying a price for its attitude to the homeless.

A part of good science is to see what everyone else can see but think what no one else has ever thought. Amos had said that to him, and it had stuck in Redelmeier's mind. For instance, one day he had a phone call from an AIDS patient who was suffering side effects of medication. In the middle of the conversation, the patient cut him off and said, "I'm sorry, Dr. Redelmeier, I have to go. I just had an accident." The guy had been talking to him on a cell phone while driving. Redelmeier wondered: Did talking on a cell phone while driving increase the risk of accident?



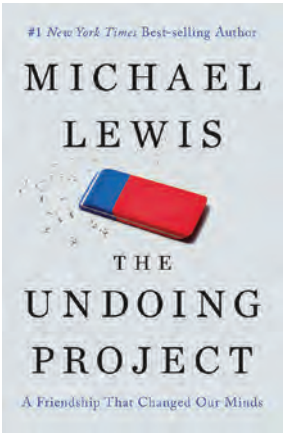
In 1993, he and Stanford statistician Robert Tibshirani created a complicated study to answer the question. The paper they published in 1997 proved that talking on a cell phone while driving was as dangerous as driving with a blood alcohol level at the legal limit. A driver talking on a cell phone was about four times as likely as a driver who wasn't to be involved in a crash, whether or not he held the phone in his hands. That paper—the first to establish, rigorously, the connection between cell phones and car

accidents—spurred calls for regulation around the world. It would take another, even more complicated study to determine just how many thousands of lives it saved.

The study also piqued Redelmeier's interest in what happened inside the mind of a person behind the wheel of a car. The doctors in the Sunnybrook trauma center assumed that their jobs began when the human beings mangled on nearby Highway 401 arrived in the emergency room. Redelmeier thought it was insane for medicine not to attack the problem at its source. One-point-two million people on the planet died every year in car accidents, and multiples of that were maimed for life. "One-point-two million deaths a year worldwide," said Redelmeier. "One Japanese tsunami every day. Pretty impressive for a cause of death that was unheard-of 100 years ago." When exercised behind the wheel of a car, human judgment had irreparable consequences: That idea now fascinated Redelmeier. The brain is limited. There are gaps in our attention. The mind contrives to make those gaps invisible to us. We think we know things we don't. We think we are safe when we are not. "For Amos it was one of the core lessons," said Redelmeier. "It's not that people think they are perfect. No, no: They can make mistakes. It's that they don't appreciate the extent to which they are fallible. 'I've had three or four drinks. I might be 5 percent off my game.' No! You are actually 30 percent off your game. This is the mismatch that leads to 10,000 fatal accidents in the United States every year."

"Amos gave everyone permission to accept human error," said Redelmeier. That was how Amos made the world a better place, though it was impossible to prove.

MICHAEL LEWIS is the best-selling author of *Moneyball*, *Liar's Poker*, *The Blind Side*, and *Flash Boys*.



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FROM ONE PERSPECTIVE, Robert Henry Dicke was a pretty unlucky physicist. He came close to discovering the cosmic microwave background radiation, only to be upstaged by Arno Penzias and Robert Wilson, who stumbled on it while listening for something else. Dicke also came close to developing the laser, filing a key patent two years before Charles Townes and Arthur Schawlow, but then not developing his ideas further.

There is another perspective, though, from which Dicke's career was very lucky indeed. He worked at MIT's rad lab, and at Princeton University. He was involved in some of the century's most important scientific developments, and made important contributions, including developing a ubiquitous instrument called the lock-in amplifier.

In interviews with Dicke, the unlucky narrative is absent. Dicke explains that attending the doctoral program at the University of Rochester was "a bit of blind luck," and even getting into physics itself was a fortunate accident (he was going to study electrical engineering before deciding that the courses looked too boring). He also points out that his work was instrumental to interpreting Penzias and Wilson's data: "While they discovered something, we discovered the nature of this something."

The British statistician and mathematician David Hand has described luck as chance with a human face, the randomness of the real world refracted through our imagined version of how the world should behave. Maybe the right move here is to discount the idea of luck altogether. But can we? After Wilson and Penzias won the Nobel for their work, Dicke made this comment: "One would think that pure serendipity shouldn't be so strongly rewarded, but from the standpoint of the Nobel Prize committee, what else could they do."

Welcome to "Luck."

—MS

"Luck is only luck if it's truly unpredictable."

SIMON PARKIN
"How Designers Engineer Luck Into Video Games" p.64

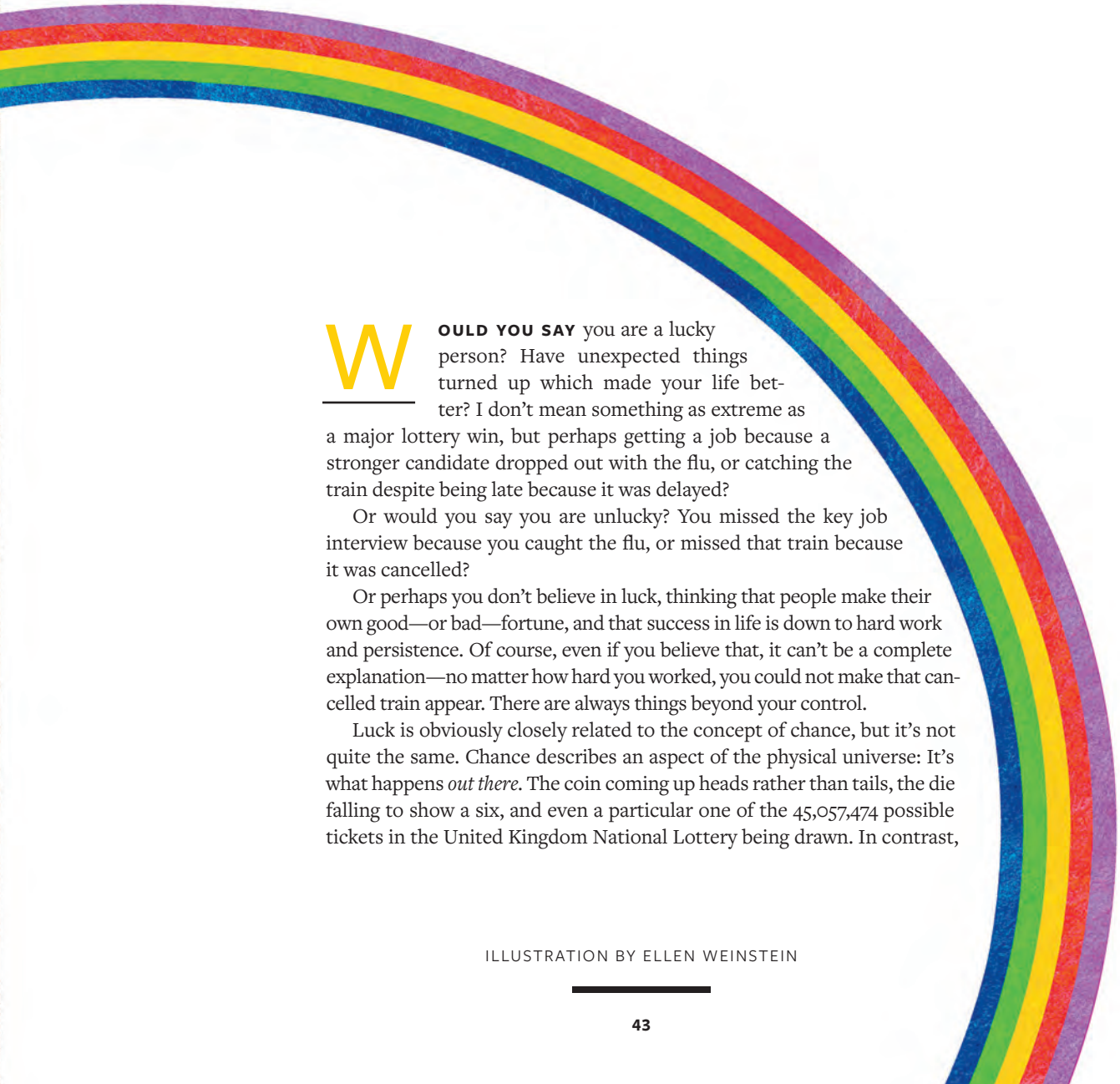
Luck

ALL OR NOTHING

The Deceptions of Luck

Nature makes chance, humans make luck

BY DAVID J. HAND



WOULD YOU SAY you are a lucky person? Have unexpected things turned up which made your life better? I don't mean something as extreme as a major lottery win, but perhaps getting a job because a stronger candidate dropped out with the flu, or catching the train despite being late because it was delayed?

Or would you say you are unlucky? You missed the key job interview because you caught the flu, or missed that train because it was cancelled?

Or perhaps you don't believe in luck, thinking that people make their own good—or bad—fortune, and that success in life is down to hard work and persistence. Of course, even if you believe that, it can't be a complete explanation—no matter how hard you worked, you could not make that cancelled train appear. There are always things beyond your control.

Luck is obviously closely related to the concept of chance, but it's not quite the same. Chance describes an aspect of the physical universe: It's what happens *out there*. The coin coming up heads rather than tails, the die falling to show a six, and even a particular one of the 45,057,474 possible tickets in the United Kingdom National Lottery being drawn. In contrast,

ILLUSTRATION BY ELLEN WEINSTEIN

By increasing the chance of a favorable outcome, you can make your own luck.

luck attaches a value to the outcome of chance. Luck is chance viewed through the spectacles of good or bad fortune. It's really good news, at least for you, if you win the lottery, and it's really bad news if you're one of the passengers on the plane when it crashes.

Chance, then, is the *objective reality* of random outcomes in the real world, while luck is a consequence of the subjective value you place on those random outcomes. Luck, we might say, is chance with a human face. Understanding this gives us a clearer view of reality, and a clearer view of reality means we can choose better courses of action.

GOOD LUCK IS SOMETHING to be desired—having good luck means that the chance events you experienced had positive outcomes. And bad luck is something you hope you don't get. Which naturally leads to the question: Is there anything we can do to make ourselves luckier?

We could try to do this by changing what we regard as a good outcome, but that seems unreasonable. Slipping on ice and breaking your leg seems unlucky however you look at it, whereas it's hard to see winning the lottery as unlucky. So perhaps instead we should look for ways to alter the chance, the probability, that different outcomes will occur.

And the world is full of beliefs that we can change our chances, and hence our luck.

Superstitions are examples: baseball pitcher Turk Wendell drawing three crosses in the dirt before pitching; Manchester United soccer player Phil Jones putting his left sock on first when the team played at home, but his right sock on first when the team played away; you taking your favorite pen into the examination room. Unfortunately, there's precious little evidence that any such things increase the chance of a favorable outcome.

On the other hand, there's an old saying, attributed in various forms to Thomas Jefferson, Stephen Leacock, Sam Goldwyn, and others: "The harder I work, the luckier I get." It's certainly true that if you train hard you are more likely to win a sporting event, but it clearly does not explain everything. Your hard work does not reduce the chance of being kept awake by noisy neighbors the night before, or slipping on a wet patch as you run during the race. And people seem to win lotteries regardless of how dissolute a life they lead.

Louis Pasteur said something similar: "Chance favors the prepared mind"—making sure you are able to recognize and grasp opportunities when they arise.

One kind of preparation is to take advantage of what's called the law of truly large numbers.[1] This is not the same as the statistician's law of large numbers, which describes how averages get closer and closer to a fixed value the more numbers you put into the average.

JAMIE SQUIRE /ALLSPORT

It's something quite different.

Let's begin with the truism that, while you have a tiny chance of winning the lottery if you buy a ticket, you can *guarantee* that you *won't* win if you don't buy one. So that's quite a big difference between two chances, from nothing to something, even if that something is still very small. But we can then take this idea further. Obviously, the more (differently numbered) tickets you buy, the greater your chance of winning. Buy 1,000 tickets instead of just one, and your chance of winning is 1,000 times greater. Buy 1 million—a truly large number—and your chance is even greater. I should comment parenthetically that I am not encouraging you to buy lottery tickets. With the U.K. National Lottery a single ticket has a 1 in 45 million chance of winning the jackpot. If you buy 1,000 tickets you still have only a 1 in 45,000 chance of winning. That's less likely than getting 15 heads in a row tossing a fair coin. Is that something you'd want to bet on?

Still, this example shows that if we increase the number of opportunities for a very improbable event to occur (drawing the winning ticket), we can increase dramatically the chance that it will happen. Put another way, if we give ourselves lots of chances for something good to happen, we can increase our chance of succeeding. This is beginning to look very much as if we can improve our luck.

Actually, we can take this further. If you had a spare £90 million lying around (that's £45 million times two; times two because each ticket costs £2), you could buy all possible combinations of six numbers between 1 and 59 (each ticket in the U.K. National Lottery consists of six numbers chosen from 1 to 59), and so guarantee holding the jackpot winning ticket. This is going beyond the law of truly large numbers and entering the realm of the law of inevitability. This simply says that one of the set of all possible outcomes *must* happen: It's *inevitable* that one of them will occur because, by definition, there isn't anything else.

SUPERSTITION ON THE MOUND
Turk Wendell, a major league pitcher from 1993 to 2004, had more ways to incite luck than a witch doctor. His lucky charms included wearing a necklace of teeth from animals he hunted and drawing three crosses on the mound.

[1] The law of truly large numbers is one of the five laws constituting the improbability principle, described in my book, *The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day.*

NO LUCK AT ALL The odds of winning the U.K. national lottery are 1 in 45 million—if you buy one ticket. But you could take luck out of the equation if you bought tickets for every possible combination. Success is a matter of increasing the chance something will happen.

Returning to the law of truly large numbers, it obviously does not apply solely to winning the lottery, and, in fact, the numbers need not always be truly large.

Di Coke lives in Brighton in the U.K., and has won over £300,000 worth of prizes from competitions. These have included overseas holidays, a trip to the Brazilian Grand Prix, a trip to New Zealand, a car, five iPods, two computers, a ticket to the British Academy of Film and Television Arts awards, and money. Overall, she averages wins equivalent to more than £15,000 per year.

What a lucky woman, you might think. But the fact is Di doesn't rely on blind chance; she uses the law of truly large numbers to increase her chance of getting lucky. She does this by entering over 400 competitions per week. She might have a small chance of winning any one of them, but with so many competitions over the course of a year the chance that she won't win *any* is vanishingly small. She can pretty well guarantee some wins. She's making her own luck.

And have you ever read enviously of an entrepreneur who has just sold his start-up for millions of dollars? If so, ask yourself, was that their first attempt? Did they in fact keep going, through failure after failure, until they happened to hit the jackpot?

And what about job applications? Appointment to a position always involves an element of chance. Who else has applied? What exactly was the appointments panel looking for? Will all the members of the panel see eye to eye? You may be unlucky not to get a particular job, but keep applying and you increase your chance of winning *some* job.

The key to all this is to give chance the opportunity to produce an outcome in your favor: to give yourself a chance of getting lucky. If you don't apply for the job because you believe you will be unlucky, then you are certain not to get it. By increasing the chance of a favorable outcome, you can make your own luck.

But when Pasteur commented on a prepared mind, he didn't just mean keep trying until you succeeded. He also meant something deeper: that he was *ready* to see an opportunity when it arose, and to see the links and relationships that others wouldn't notice. This notion applies in job applications as much as in science. Prepare for that application by carefully studying what they are after and you are more likely to be lucky.

LOOP IMAGES/UIG VIA GETTY IMAGES

Wherever we are in life, we can look back and identify a chain of events that led us there.

At a higher level, people who regard themselves as lucky will tend to be more outgoing. And there's certainly a causal relationship here, although it works in both directions. An outgoing and positive person will be more open to new ideas, new people, and new experiences, and so give themselves more opportunities for positive things to happen. They are more likely to get lucky. But then, positive experiences—learning that good things happen—are likely to make someone more prepared to risk new things. Leading to a self-reinforcing cycle.

We've already seen that luck is different from chance: It's chance viewed through the mind's eye. This is illustrated very clearly by people's attitudes to accidents. For example, people often describe as *good* luck events that an objective observer might describe as horribly *bad* luck. Someone involved in a traffic accident in which their car rolled over three times and was a write-off, but from which they emerged unscathed, might well remark on how lucky they were. Others might think they were very unlucky to have been involved in the accident in the first place. If a rock falls off a cliff face just as you are walking beneath, and narrowly misses you, you might well say how lucky you were that it missed, instead of saying how unlucky you were to be there at the time it fell. But whether you see it as lucky or unlucky, the chance event is the same.

The fact that luck is a human construct is forcefully brought home when we experience a sequence of chance events, one after the other. For example, an accumulator bet involves betting on just such a sequence of events, winning only if all of the events in the sequence happen.

In August 2015, a Manchester United fan from Lichfield in the U.K. placed a 30p bet on a sequence of outcomes of 15 soccer games, leading to winnings of half a million pounds. But although this outcome has almost the same *chance* as getting the first 14 soccer matches right and the last one wrong, we would have described him as extremely *unlucky* had he lost that last bet. And in 2008, when Yorkshireman Fred Craggs placed a 50p stake on an eight horse accumulator, and watched all of his horses romp home, giving him a cool £1 million winnings, we would have described him as unlucky had he got all but the last one right.

It doesn't always go as planned. Indeed, it rarely does so. Joe McGuire placed an accumulator bet on a sequence of six horse races, watching his £10 million jackpot get closer and closer as the first five winners came in according to his predictions, only to lose it all when Escape to Glory and Justonefortheroad, the two horses he had bet on in the final race, came in second and sixth. And guess what? One report described him as "Britain's unluckiest punter."

Whether you see it as lucky or unlucky, the chance event is the same.

Suppose we are pretty good at picking winners in horse races, and can pick the winner of any race with a probability of ½. That means that we can expect to get about half right. Now suppose we bet on a five step accumulator. Then the chance of getting the first right is ½, the chance of getting both of the first two right is ½ x ½ = ¼, the chance of getting the first three all right is ½ x ½ x ½ = ⅛, and so on up to a chance of getting all five right of $\frac{1}{32}$.

This idea has been used in unethical stock price movement predictions. We begin by claiming to be able to predict stock movements; in particular, we will aim to predict whether the market will move up or down next week. We identify 1,024 people, and to 512 of them we send an email saying the price will move up next week, and to the other 512 we send an email saying it will move down. We will be right for one of these two groups, and we discard the other. Next week, for 256 of the 512 we got right, we send an email saying the price will move up and to the other 256 an email saying it will move down. Again, we must get it right for one of these two groups. And we go on in this way, always dropping the group we sent the wrong prediction to, and turning our attention to the other. After 10 weeks like this we have one person left, who has seen us make 10 successive correct predictions about the stock market movements—*and does not know about the other 1,023 people*. To this person we then send an email saying something like "you can see that our algorithm works. If you want our prediction for next week, it will cost you $10,000."

This scam has made use of the law of inevitability: There are only 1,024 possibly up/down patterns in 10 steps, so one of them must come up. And it has also made use of another law, the law of selection, which says you can make probabilities as large as you want if you choose after the event. In this case, step by step, you appear to have chosen the single pattern of 10 correct predictions—*and you can always do this*.

A less extreme version of this arises accidentally in the legitimate investment advisor space. Imagine a large population of such advisors and suppose, for the sake of argument, that none of them are any good—that their predictions are no better than chance. And let's follow their fortunes over 10 weeks of up and down market movements as before. Now, each week, some of them (about half) will get it right, purely by chance—we might say they are lucky that week. Of course, the chance that any particular one of them will get their predictions right for all 10 weeks is just 1/1024, since there are 1,024 patterns. But if there are enough of these people then we would expect some of them to get all 10 right, just by accident. Or by chance, since they don't have any skill. But those lucky ones, the ones who got many predictions right by chance simply

because it was likely that some would, are the ones who see investors flocking to them—only to be disappointed as they move into the future and the predictions turn out to be no better than chance, with about half right and half wrong.

Di Coke, the multiple competition winner, also uses a variant of the law of selection, though in a less extreme way. Perhaps counter-intuitively, she recommends focusing on competitions that take time and effort. Her argument is that fewer people will enter these competitions, so her chance of winning is greater. This clearly makes sense. At an extreme, if only one person gives the right answer, then that person would win. For this same reason, she recommends against entering competitions that involve random draws (like the lottery). Such competitions are easy to enter, so you get huge numbers of people entering, and if there is to be only one winner—for that exotic holiday say—then you are proportionately much less likely to be that person.

Wherever we are in life, we can look back and identify a chain of events that led to us being there. If I hadn't been raised in *that* village at *that* time, I wouldn't have met the teacher who introduced me to playing that musical instrument, so I'd never have played in that band, and I wouldn't have met the woman who had a shared interest in antiques and introduced me to the dealer who offered me the job. "How incredibly lucky," we might think, "that just those things happened which resulted in me being where I am now."

But that's misleading. Wherever we've got to now must have been preceded by some sequence of chance events that had to play out as they did to lead to us being where we are now. So we can *always* find such a chain.

The bottom line is that *stuff happens*. Chance, the essential unpredictability of the natural world, just rolls on, flipping things this way and that way at random. But we look at the outcomes, we relate them to our lives, and we interpret them differently. We say, "Wasn't I lucky?" or "Wasn't I unlucky?" as the case may be. Luck is our attempt to find meaning in a meaningless universe.

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招財進寶

Is the Chinese Language a Superstition Machine?

How ambiguity in language can create unique taboos

BY JULIE SEDIVY

ILLUSTRATION BY LEN SMALL

EVERY YEAR, MORE THAN a billion people around the world celebrate Chinese New Year and engage in a subtle linguistic dance with luck. You can think of it as a set of holiday rituals that resemble a courtship. To lure good fortune into their lives, they may decorate their homes and doors with paper cutouts of lucky words or phrases. Those who need a haircut make sure to get one before the New Year, as the word for "hair" (*fa*) sounds like the word for "prosperity"—and who wants to snip away prosperity, even if it's just a trim? The menu of food served at festive meals often includes fish, because its name (*yu*) sounds the same as the word for "surplus"; a type of algae known as *fat choy* because in Cantonese it sounds like "get rich"; and oranges, because in certain regions their name sounds like the word for "luck."

English speakers can relish a good pun, and messing around with homophones (words that sound the same but have different meanings) is a staple of many a clever ad. But Chinese practices take punning to a whole new level—one that reaches deep into a culture where good fortune is persistently courted through positive words and deeds, and misfortune repelled by banishing the negative. The number four is tainted because of its homophony with the word for "death"—many Chinese people would never consider buying a house whose address contained that number. In visual designs, fish and bats figure prominently because they are sound twins of the words for "surplus" and "fortune." Gift-giving is fraught with homophonic taboos; it is all right to give apples, because their name sounds like "peace," but not pears, whose name overlaps with "separation." Questions about why certain objects or numbers are considered lucky or unlucky are often met with matter-of-fact statements about their sound-alikes.

But why is homophony deeply woven into Chinese traditions and symbols but not Western ones? Ambiguity and homophony are facts of life for all languages, on a scale that rarely enters the consciousness of their native speakers. In 1978, psycholinguist Bruce Britton sifted through a million-word body of English text and estimated—very conservatively—that at least 32 percent of English words have more than one meaning. Among the 100 most frequent words, he found that 93 percent have more than one meaning, some as many as 30. Linguist blogger Geoff Pullum captures this ambiguity with his question: "What do support poles, staff positions, battery terminals, army encampments, blog articles, earring stems, trading stations, and snail mail have in common with billboard advertising, accounts recording, making bail, and assigning diplomats?" It may take a few moments of pondering to realize that the word that makes strange bedfellows of all these notions is *post*.

English speakers are sanguine about homophony—often blithely, so that they make little attempt to clarify meanings even when the context leaves open the

"Languages *love* multiple meanings. They *lust* after them."

CHINA PHOTOS/GETTY IMAGES

FISHING FOR LUCK Fish flags are displayed at the Changdian New Year Temple Fair in Beijing. Fish are symbols of wealth, because the word for fish (*yu*) sounds like the word for "surplus."

possibility of more than one. In one study led by Victor Ferreira, people were asked to describe objects in visual scenes that showed both a baseball bat and a flying bat—but they ambiguously referred to either of these as simply "the bat," under some conditions as often as 63 percent of the time.

But Chinese speakers seem to have a more sensitive radar for ambiguity. Psycholinguists Michael Yip and Eiling Yee have shared with me their impressions that Chinese speakers are more likely to take pains to clarify the intended meaning of an ambiguous word, even when its meaning should be obvious from the context. For example, Yee reported that they might say the equivalent of "I have to renew my mortgage, so I have an appointment with my bank—you know, the financial institution, not a river bank." This type of attunement to ambiguity, if it turns out to be a general characteristic of Chinese speakers, certainly meshes with the elevated role of homophony in Chinese culture.

The connections between language, mind, and culture represent an open vista, a terrain that, for the most part, still awaits exploration by scientists. But, even today, the dance between ambiguity and luck in Chinese cultural practices hints at tantalizing questions: Do different languages heighten different subjective experiences for their speakers? And does the importance of certain concepts—like luck and misfortune—to a culture leave an imprint on its associated language?

PULLUM CONTENDS THAT LANGUAGES make no attempt whatsoever to skirt ambiguity—on the contrary, he writes, "Languages *love* multiple meanings. They *lust* after them. They roll around in them like a dog in fresh grass." Steve Piantadosi, a psycholinguist at the University of Rochester, agrees. He and

his colleagues have argued that far from being a bug, ambiguity is a useful feature for languages.[1] It allows them to create ample vocabularies by recycling some of their most common and easy-to-pronounce clumps of sound. Without ambiguity, we would have to create longer words to distinguish meanings, or become more inventive at coming up with massive collections of speech sounds—and more adept at pronouncing and distinguishing these sounds.

If all languages love ambiguity, then Chinese languages burn with ardor for it. Direct comparisons of rates of ambiguity between languages are tricky, because even within a single language, different dictionaries often disagree about the number of separate meanings they assign to a word. But by any measure, Chinese homophony is truly prolific.

In English, as in many other languages, basic units of meaning (called morphemes) are often composed of processions of multiple syllables—*hippopotamus, president, fastidious*. But in languages like Cantonese and Mandarin, morphemes are almost always monosyllabic. These monosyllables aren't necessarily standalone words, as most words in Chinese are compounds made up of two or more morphemes, each of which is represented by a separate character. Still, each syllable has to be assigned its correct meaning in order for a Chinese listener to grasp the intended meaning of the compound. Add to that the fact that Chinese languages use a much smaller set of vowels and consonants than English, and you have an impressive number of meanings packed into a small sliver of phonetic real estate.

Since distinct meanings in Cantonese or Mandarin are typically expressed by different characters, orthography (the way a language transfers spoken words into

FORTUNATE FRUIT Because the word for "orange" sounds like the word for "luck," Chinese New Year decorations often include illustrations of citrus fruits.

Could cultural associations that shape individuals' linguistic behavior eventually become embedded in the entire language?

written form) is one useful way to track the number of different meanings that have the same pronunciation. Researchers Li Hai Tan and Charles Perfetti reported that within a 1.8-million-character body of Chinese text, 4,500 characters mapped onto only 420 different syllables—so that each character shared its pronunciation with an average of 11 others.[2] In Piantadosi's dataset, even if we look only at monosyllabic English words, which are more ambiguous than multisyllabic words, the average number of homophones that each word has is slightly less than one.

Amazingly, there's no reason to believe that Chinese ambiguity creates a communication problem—experiments show that Chinese speakers are just as efficient as English speakers at squashing down irrelevant meanings based on context, and differences in tone also help to distinguish meanings. But the design of the Chinese writing system, in which different meanings of the same syllable are expressed by different characters, makes it hard for Chinese speakers to ignore the fact that they're swimming in a sea of ambiguity.

Ambiguity has a way of drawing attention to itself when it creates orthographic headaches. While the many meanings of *post* may never have ruffled your thoughts, chances are that at one time or another, you've probably devoted a fair bit of focused effort to the distinctions among *their*, *they're* and *there* as you tried to make sure that your spelling captured your intended meaning. Imagine having to do that for every set of homophones you encounter, and you get a bit of a sense of what it takes to become literate in Chinese. No wonder, then, that among Chinese children who are learning to read, a poor awareness of homophones is one of the strongest predictors of reading problems such as dyslexia.[3]

All of this ambiguity has a direct effect on a Chinese speaker's experience of her language, because ambiguous words can mentally activate more than one meaning. We know this from experiments that use a technique called semantic priming, in which participants are asked to identify whether a target word is a real word in the context of other words. Usually, people recognize a word more quickly if it's preceded by a word that is related in meaning—so that the word *nurse* would be recognized faster if it occurred after *doctor* than after *table*. When people hear an ambiguous word like *bug*, even within a sentence that obviously selects one of its meanings, they're often faster to respond to words related to the other meanings as well. For example, people will be better at recognizing both *ant* and *spy* after hearing *bug* than they will a completely unrelated word like *sew*.

Multiple meanings are held in the mind for only a fleeting moment—very quickly, meanings that are irrelevant in the context of the sentence become suppressed, almost always before they trip the wire of conscious awareness. This allows communication to proceed smoothly, even in languages as riddled with ambiguity as Chinese. But researchers have found that some words pull at attention more than others.[4] Among those that command more than their fair share are words that stir up powerful emotional reactions, especially if they are negative or taboo.

When they happen to overlap in sound with other meanings, these attention-grabbing words should be especially hard to suppress. I'm reminded of how, growing up in a bilingual French-English region, I felt twinges of shyness—and drew snickers from some of my classmates—when I delivered a French-language oral report about seals, the marine mammals whose name, *phoque*, is homophonous with a certain English word that was definitely not supposed to be uttered

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in the classroom. It was a surprisingly uncomfortable word to use, regardless of the clarity of the context. And the aversion to certain homophones may be universal; I've noticed that even though several unrelated meanings are packed into syllables like *bit* or *fit*, there's no non-sweary meaning of *shit*. Even when words do exist that sound just like certain emotionally charged words, they're apt to be swapped out for synonyms—with *rooster* or *donkey* more likely to be used than *cock* or *ass* whenever people refer to the barnyard animals.

Rampant ambiguity in Chinese enables many *phoque* moments; phonetic space is crowded, and the likelihood that a perfectly ordinary word will share its sounds with a more emotionally strident one is just that much greater than it is in English. A cultural obsession with homophony is sparked by the compact nature of Chinese phonetic space.

In turn, culture affects *which* meanings create attentional flares. Chinese tradition dictates that the words you utter can attract luck—either good or bad—into your life, a tradition that is distilled during New Year celebrations, when all talk of death, disease, or divorce becomes taboo and people shower each other with wishes for good health, wealth, and success. It would not be surprising to find that words related to luck—and especially to *mis*fortune—fall into the category of attention-grabbing words that Chinese speakers find hard to ignore. Though no experiments so far have tested this directly, it would provide a neat explanation for why Chinese speakers sidestep certain perfectly ordinary words while being drawn to others, based solely on which emotionally tinged words they sound like. Perhaps, as my Chinese colleague Wei Cai suggested to me, they might have an especially hard time suppressing meanings related to death or unhappiness during New Year celebrations, when the verbal courting of good fortune is on everyone's mind.

AMBIGUITY PROVIDES A UNIQUE BRIDGE between the meaning and use of words. When many meanings map to a single word, they are all more likely to be evoked, changing our experience of both the word and its meanings. If ambiguity allows cultural associations to lead individuals to sidestep certain words merely because they sound like "bad" words—as English speakers do when they use *rooster* instead of *cock*—perhaps they can also leave a broader imprint on the lexicon. Could it be that cultural associations that shape individuals' linguistic behavior eventually become embedded in the entire language?

I asked researchers Ted Gibson and Steve Piantadosi, whose work suggests that languages recruit ambiguity for useful purposes, whether there was any statistical evidence indicating that languages *repel* ambiguity away from words that carry a negative emotional charge (or attract words that carry a positive charge). There isn't—at least not yet. Both agreed that the notion was plausible and worth studying. To test this, psycholinguists would need to establish that emotionally disturbing words (like *shit* or *rape*) have fewer homophones than one would expect based on factors like their number of syllables, or how common their component sounds are. And perhaps words that arouse strong positive emotions (like *rich* or *free*) have more than their fair share of separate meanings.

If such a result is eventually found, it would offer a new way to think about how languages might be shaped by cultural values. In Chinese, we'd expect to find a language-wide reflex of Chinese luck traditions, in which certain homophones are given a wide berth because of their accidental association with misfortune and misery, while others are endorsed because of their coincidental connection to good fortune and prosperity. Chinese language, with its profusion of ambiguity, offers especially fertile ground for testing this hypothesis.

We have an endless fascination with the interplay between language and culture—how a culture might press its values and worldview into its language, and how a language might in turn mold the minds of its speakers. But much of the conversation about the bonds between language and culture turns on a very limited set of questions. For example: What does it say about Japanese culture that the language has a special word (*ijirashii*) to describe seeing someone praiseworthy overcoming an obstacle? Do speakers of languages that have a single word for blue and green have trouble distinguishing between these two colors? These questions focus on how languages use words to capture reality, and how the words we inherit as native speakers might in turn shape our vision of that reality.

But Chinese hints at more intricate links between language and culture: Perhaps languages that jam many meanings into small phonetic spaces heighten their speakers' experience of ambiguity, elevating the cultural importance of punning and wordplay. Perhaps cultural associations cast an emotional tinge onto specific instances of ambiguity, remolding patterns of language use by speakers, and maybe eventually the lexical landscapes of entire languages.

Do luck and homophones provide a small doorway onto this uncharted terrain of the mind? If they did, as a psycholinguist, I'd have to consider that quite a piece of good fortune.

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Investing Is More Luck Than Talent

The surprising message of the statistics of wealth distribution

BY MOSHE LEVY

DEPENDING ON WHICH ECONOMIST you ask, big inequalities in wealth are either an essential engine for growth—the reward that motivates people to work hard, innovate, and prosper—or a ticking time bomb capable of unleashing mass misery, social upheaval, or even violent revolution.

The academic researchers who study inequality are forever arguing about where that tipping point lies, and how much inequality is too much. Many observers wonder if we've begun to tip already, pointing to the surprisingly strong support enjoyed by the avowed socialist Bernie Sanders in the recent United States presidential election.

But what no one can deny is that in many countries around the globe, inequality has reached eye-popping extremes. In the U.S., for example, the top 1 percent of the population holds 42 percent of the national wealth. And the top 100 individuals now have an average wealth roughly 45,000 times the national average.

Where do such massive differences in wealth come from? The positive narrative surrounding inequality might chalk them up to the talent and effort of high earners. Social critics will also cite the many ways that talent and effort can be frustrated by prejudices based on class, race, or gender. Both sets of factors are obviously relevant—but mainly at the lower and middle levels of the wealth spectrum, where people's standings are largely affected by salaries and consumption. They cannot possibly be the whole story at the high end, where people's wealth is primarily determined by capital gains or losses on investments. If the ratio of 50,000 were to hold for other traits, it would imply individuals who are 53 miles tall, have IQs of 5 million points, and live to be 4 million years old. Nobody is that much better than the typical run of humanity.

Could the differences between the very rich and the hugely rich—the differences that amplify moderate inequality into extreme inequality—be the result of pure, dumb luck?

ILLUSTRATION BY KATHERINE STREETER


Streeter

This turns out to be a very difficult question to answer just by looking at individuals. We all know stories of ambitious and talented people like Steve Jobs or Bill Gates, who grew companies and created great wealth. But for each one of these superstars, there may have been many more people who were equally ambitious and talented, yet did not succeed. Maybe the string of investment and managerial decisions that made one person's company successful, and that seem so very wise in retrospect, were actually just the entrepreneurial equivalent of flipping a coin 20 times and getting all heads. The chances of that happening are about 1 in 1 million, so if enough people try it, someone is bound to get lucky and look like a coin-flipping genius—purely by chance.

However, that coin-flip analogy does suggest a better way to differentiate between talent and luck: Instead of looking at specific individuals, look at the way wealth is distributed over the whole population at the high end of the wealth spectrum.

To illustrate the basic idea, suppose that we are flipping coins and trying to figure out whether they are fair or biased. This is tricky with only a single coin. If we flip it 20 times and get 14 heads versus 6 tails, we might be a little suspicious that it's biased. But we could not be completely sure: The chance of a fair coin yielding 14 heads or more is still about 6 percent, and unlikely events do sometimes come to pass. A much better approach would be to perform the same 20-flip experiment with thousands of identical coins: If we still see lots of them coming up with an overabundance of heads, then something is definitely fishy.

I have applied this idea to the world of investments and the distribution of wealth by imagining the following investment game.[1] A large number of investors all start with $100,000. Every year, each investor flips a coin that determines his or her rate of return for that year: Half the time it will come up heads and yield a return of 30 percent, and on the rest of the tosses it will come up tails and yield a loss of 10 percent. The numbers are chosen to give an average annual return of 10 percent, plus or minus 20 percent, which is typical of investments in the real stock market, but the overall conclusions do not depend on these specific numbers.

After playing this game for 20 years, the typical investor will toss about 10 heads and 10 tails, ending up with something like $480,683. But a few lucky investors who happen to toss 20 heads in a row will have wealth of $19 million. Likewise, a few very unlucky investors will toss 20 tails and end up with only $12,158. As the game continues, however, individuals will rise and fall, growing richer or poorer according to the whim of the coin flips. To make the game more realistic, assume that if investors' wealth declines below some level they have to drop out of the game, and are replaced by newly rich players emerging from the middle class. Eventually, the game will reach a kind of equilibrium—one in which the number of players going up is always balanced by the number going down, so that the overall distribution of wealth reaches a steady state and doesn't change anymore.

This distribution turns out to follow a power law, which basically says that it's easier to be sort of rich than really rich: The very, very wealthiest people are very, very rare. More specifically, the power law says that if you count the number of players richer than you, then count the number who are at least twice as rich as you, that second number will always be down by a factor of $(\frac{1}{2})^{\alpha}$.

That symbol α is known as the Pareto exponent in honor of Vilfredo Pareto, the Italian economist who first studied such power law distributions in the 19th century. And it's the kind of modeling result that makes professional economists take notice: A power law distribution of high-end wealth is exactly what they see in the real world, not only in the U.S., but in many other nations. (The typical values of α in Western countries is in the range 1.1 to 1.7.)

In the real world, in other words, the distribution of wealth at the highest end of the scale is quite consistent with pure luck.

Or is it? The obvious objection, of course, is that the coin-flip investment game is a gross oversimplification of reality. For example, it takes no account of consumption—the money that rich people siphon out of the market to spend on travel, penthouses, yachts, or whatever. Nor does it allow for the fact that some people are born with inherited wealth that gives them a huge head start in life. Yet it turns out that neither consumption nor inherited advantages make much of a difference: Even when the model is adjusted to allow for such factors, Pareto still rules. Another

The distribution of wealth at the highest end of the scale is quite consistent with pure luck.

possible objection is that it may take a very long time for the wealth distribution to converge to its steady state. However, it has been shown both numerically and experimentally that the convergence to the Pareto wealth distribution is actually quite fast.[2]

What might make a difference, however, is talent—Steve Jobs-scale abilities that allow some players to beat the odds and do better than others. There is no room for talent in the original version of the investment game, because it assumes that the only source of inequality is pure luck. That's the whole point of the coin flip. And in truth, talent is an intrinsically hard thing to model: If we knew how to come up with strokes of genius like the iPhone, everyone would be doing it.

Still, it is possible to get a crude sense of the effect of talent by modifying the investment game to include two types of players. Normal investors are just like those in the first game: They flip a coin with heads yielding a return of 30 percent, and tails producing a loss of 10 percent. But the talented investors are more skilled at playing the market: They earn slightly more than 30 percent when the coin comes up heads, and lose slightly less than 10 percent when the coin comes up tails. Now we set the players loose and ask an empirical question: How big can this "talent differential" be and still stay statistically consistent with the power law wealth distribution we see in the real world?

It turns out that it can't be more than about 1 percent.[2] A larger talent differential would produce a wealth distribution that is even more extreme than the real one, and that would not follow a power law.

To see what this implies about the relative roles of luck and talent among investors, suppose that Jill is

If we knew how to come up with strokes of genius like the iPhone, everyone would be doing it.

a super-sophisticated investor who is able to obtain an annual return that's 1 percent better than average (which is considered very good in financial markets). Even after 20 years, Jill would have only a 56 percent chance of being richer than Jack, a normal investor. That's only a slight improvement over the 50-50 chance she would have if the two of them were equally talented. Her 1 percent annual talent advantage is swamped by the randomness of raw luck.

This conclusion may seem counter-intuitive at first. But it echoes the conclusion reached by Nobel laureate Paul Samuelson in a fall 1989 article he wrote for the *Journal of Portfolio Management* discussing the relative roles of talent and luck in the success of mutual fund managers:

> Those lucky money managers who happen in any period to beat the comprehensive averages in total return seem primarily to have been merely lucky. Being on the honor roll in 1974 does not make you appreciably more likely to be on the 1975 honor roll.

If this is indeed the case—if the effects of talent are really so much smaller than the effects of luck at the high end of the wealth scale—then corporate boards might want to keep that fact in mind when setting the compensation plans for fund managers or CEOs: "Reward for performance" may actually be mostly a reward for luck.[3, 4] Likewise when it comes to debates over raising taxes on the rich: The argument that this would be punishing talent might not hold. It might

instead be mostly taxing luck—as the French economist Thomas Piketty has famously maintained in his call for a global tax on wealth.[5]

So, at the next cocktail party when someone brags about his latest brilliant investment, you can refer him to King Solomon:

I returned and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favor to men of skill, but time and chance happeneth to them all. (Ecclesiastes 9:11)

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How Designers Engineer Luck Into Video Games

The responsibilities and challenges of programmed luck

BY SIMON PARKIN

ON SEPT. 16, 2007, a Japanese YouTuber who goes by the handle "Computing Aesthetic" uploaded a forty-eight-second-long video with the deafening title, "ULTRA MEGA SUPER LUCKY SHOT." The video shows a high-scoring shot in Peggle, a vastly popular video game, loosely based on Japanese pachinko machines, in which a ball bearing clatters down the screen, accruing points as it bounces through a crowd of candy-colored pegs, which disappear shortly after being touched; more bounces, more points. Although Peggle involves some skill—before firing the ball, the player must carefully aim the launcher that dangles at the top of the screen—you are principally at the mercy of the luck of the bounce. In Computing Aesthetic's footage, the points pile up as the ball bounces fortuitously between pegs. To underscore the seemingly miraculous shot, Beethoven's "Ode to Joy" blares euphorically until, in the video's final moments, the ball bearing sinks into the bucket at the base of the screen and the words "FEVER SCORE" flash onscreen. The description on the video, which has been watched nearly a quarter of a million times, reads, "I couldn't balieve this when it happened!!!!!!!!!"

Computing Aesthetic's video is just one of nearly 20,000 such YouTube clips labelled with the words "Peggle" and "Lucky," uploaded by players so amazed at their good fortune in the game that they were moved to share the achievement with the world. But these players may not be as lucky as they've been led to believe. "In Peggle, the seemingly random bouncing of the balls off of pegs is sometimes manipulated to give the player better results," Jason Kapalka, one of the game's developers, admitted to me. "The Lucky Bounce that ensures that a ball hits a target peg instead of plunking into the dead ball zone is used sparingly. But we do apply a lot of extra 'luck' to players in their first half-dozen levels or so to keep them from getting frustrated while learning the ropes." Tweaking the direction of any given bounce by just a few compass degrees—but not so much that the ball swerves unrealistically in mid-air—is enough to encourage beginners and not make the game too unbelievable, Kapalka said.

Fairness is the unspoken promise of most video games. Controlled by an omniscient and omnipotent designer, a video game has the capacity to be ultimately just, and players expect that it will be so. (Designers also have an incentive to be even-handed: A game that always beats you is a game you'll soon

ILLUSTRATION BY WREN MCDONALD

stop playing.) And yet, when video games truly play by the rules, the player can feel cheated. Sid Meier, the designer of the computer game Civilization, in which players steer a nation through history, politics, and warfare, quickly learned to modify the game's odds in order to redress this psychological wrinkle. Extensive play-testing revealed that a player who was told that he had a 33 percent chance of success in a battle but then failed to defeat his opponent three times in a row would become irate and incredulous. (In Civilization, you can replay the same battle over and over until you win, albeit incurring costs with every loss.) So Meier altered the game to more closely match human cognitive biases; if your odds of winning a battle were 1 in 3, the game guaranteed that you'd win on the third attempt—a misrepresentation of true probability that nevertheless gave the illusion of fairness. Call it the Lucky Paradox: Lucky is fun, but too lucky is unreal. The resulting, on-going negotiation among game players and designers must count as one of our most abstract collective negotiations.

Humans have taken the reins from the gods, and luck has become a design tool capable of changing players' experiences.

IN ANCIENT TIMES, luck was routinely ascribed to divine intervention; games were as much a playground for the gods as a test of human ability. Luck was a central component in the games of the ancient Egyptians, whose deity Theuth was the inventor of dice, according to Plato. In practice, the dice were typically made from astragali, knucklebones of hoofed quadrupeds, which were polished and used in Egyptian board games and in a type of fortune-telling divination called astragalomancy. Loaded dice have been found in tombs alongside ancient game boards; even if the ancient Egyptians believed that a throw of the dice somehow expressed divine will, they weren't averse to lending a helping hand.

Olaf Haraldsson, an 11th-century Norwegian king, once wagered a kingdom in a faith-testing game of dice. Olaf was locked in a territorial dispute with the king of Sweden over the island of Hising; eventually the two agreed to settle the matter with a dice throw. The Swedish king rolled two sixes, the highest possible score, and said there was no point in continuing the game. Olaf insisted on taking his throw; a recent convert to Christianity, he was certain that God would steer the dice in his favor. His faith was vindicated with double sixes. The men continued to take turns throwing their dice, twelve after twelve. The matter was finally settled when, during Olaf's final throw, one of the dice split in two, to show both a six and a one, winning him the kingdom on an unprecedentedly lucky 13.

Luck is equally vital in modern games, whether it emerges from dice rattling in a cup or the treacherous Chance cards in Monopoly. But its role has changed: Humans have taken the reins from the gods, and luck has become a design tool capable of changing players' experiences and expectations. For instance, it enables players of varying abilities to play together by reducing the advantage of actual skill. The New York-based designer Zach Gage recently decided to reinvent chess by introducing a hefty element of luck. "Chess is historically a very balanced game that is entirely up to the skill of the player," he said. "This is great if you want to see who is better at chess but not so good if you're trying to play a fun game with your friends of varying skill levels."

Really Bad Chess, by contrast, gives each player a randomly selected set of pieces at the start of each match. The sides don't mirror each other, so it's

VASSIL / CREATIVE COMMONS

CHEATERS, B.C. Loaded dice, often made from animal hooves (above), have been found in tombs, proving that even if ancients believed that a throw of the dice expressed divine will, they weren't averse to lending a helping hand.

possible for one player to end up with five queens and the other with a battalion of pawns. "This accomplishes two things," Gage said. "It makes weaker players feel like they have a chance against stronger players because they can end up with better pieces. And it makes the relative strength of the board hard to analyze, even for an expert." Here, as in poker, victory is determined as much by the luck of the draw as by the talent of the player. The design also allows Gage to secretly stack the probability of the initial draw—making it more likely, say, that a new player will hold more powerful pieces, while an experienced player will be left at a starting disadvantage.

In mechanical games, luck is the player's saving grace against the mechanism itself. In the early 1950s, the Chicago-based pinball manufacturer Gottlieb noticed that novice pinball players would occasionally lose a ball in the first few moments of a game. So it introduced an inverted V-shaped metal wall that, during a game's opening seconds, would rise between the flippers at the base of the machine in order to keep an errant ball from disappearing down the gulley. In newer pinball machines, the blocking gate, known as a "ball saver" (a phrase invented by Chicago Coin for its 1968 pinball machine, Gun Smoke), is controlled by software; whether the wall rises or not is a matter of luck, of a kind that has been engineered into the algorithm.

In fully digital video games, luck is even more deeply baked into the experience, and must be actively simulated. When the soccer ball sails past the goalkeeper in FIFA, or when, inexplicably, a herd of race cars slows down to allow you to catch up, a game designer's hand has just acted to provide some ghostly rigging. The effect of this manipulation is to flatter you and thereby keep you engaged. But it's a trick that must be deployed subtly. A player who senses that he's secretly being helped by the game will feel patronized; after all,

luck is only luck if it's truly unpredictable.

Which is where the problems begin.

WHEN GODS WERE HELD RESPONSIBLE for luck, we were limited to prayerful petitions for good fortune. Now the architects of our fate in games can be looked up on LinkedIn. With this knowledge, our sensitivity to odds that don't feel quite right has been heightened, and designers need to compensate.

"As soon as the player becomes aware of any sort of pseudo-randomness, it risks undermining the joy of getting lucky," said Paul Sottosanti, a designer at Riot Games, publisher of League of Legends, the world's most-played online game. Games in which you're given seemingly random rewards often employ a device known as a "pity timer," Sottosanti explained, which guarantees that something seemingly fortunate will happen to you after a sustained period of misfortune—anything from 10 minutes to an hour, depending on the game. In World of Warcraft, every time players defeat a foe, they hope to receive a "Legendary"—one of the game's highly powerful weapons. Legendaries have an infinitesimally small chance of being "dropped," but are also on a pity timer. "Fatigue can set in where a player is just waiting for the pity timer to kick in," Sottosanti said. "The primary emotion they feel upon finally finding a Legendary is often not joy but relief, perhaps tinged with sadness."

While some instances of pseudo-randomness are designed to create the feeling of fairness, others are designed for profit. With the rise of so-called freemium games—free games that make real money during the course of play by selling virtual items—comes the temptation to manipulate what looks like a random act of chance in order to encourage further spending. Sottosanti pointed to the popular virtual card game Hearthstone as an example of "pity timers" being used well. "The chance of getting a valuable card increases with each pack that doesn't contain one," he said. "You're virtually guaranteed to open one after around 40 packs." The packs are available for sale to players.

It's a technique straight out of the 1950s playbook of the American psychologist B.F. Skinner. Whether the subject is a pigeon, rat, or person, Skinner found, the strongest way to reinforce a learned behavior was to reward it on a random schedule. The designers of free-to-play games, by using an intermittent variable to dole out small prizes, found that they could keep players engaged—and spending—for longer.

Natasha Schüll is an associate professor of Media, Culture, and Communication at New York University, and the author of *Addiction by Design: Machine Gambling in Las Vegas*. When a player feels favored by luck, she said, "you can pin it to certain neurotransmitters spiking, and you know dopamine is released. Even the compulsive search and hunt for recreating that sense of euphoria is driven by the reward center in the brain." Dopamine's power to turn us into luck-chasers can be seen most vividly in the effects of some drugs used to treat Parkinson's disease, which, in flooding the brain with dopamine, have been shown to turn patients into gambling addicts.

And the temptation to manipulate the appearance of probabilities, in order to appeal to the human brain, is nowhere greater than in the gambling industry, where, whether the game is hosted on the Internet or in a physical machine in a casino, software usually handles the calculations. The results of any modern slot machine are based on arcane random-number generators in a computerized network, not on the fortunate conjunction of three wooden wheels. But losing to that sort of luck can be dispiriting. So gambling machines often employ the fiction of physical luck—by, say, making it look as if you just missed out on a king's ransom as the final matching bar of gold or lemon reels to a stop just shy of a jackpot payout. This entices you to once more bet on odds that remain astronomical.

"Near-misses literally generate mixed feelings," Luke Clark, a psychologist and director of the Center for Gambling Research at the University of British Colombia, said. "On the one hand, people experience near-misses as aversive, but at the same time, the near-miss increases motivation. On a slot machine, a near-miss makes you more likely to continue, because it makes you feel like you're improving at the game."

For games based heavily upon luck, maintaining this illusion of improvement and control is crucial. "The key brain structure here is the striatum, a collection of nuclei in the center of the brain, which generally regulate both movement and reward," Clark said. That brain region seems particularly important to the feeling we had a hand in our own good luck. "The same

DAVID BECKER / GETTY IMAGES

THE MANUFACTURED NEAR-MISS Slot machines often employ the fiction of luck by making it look as if you just missed out on a king's ransom as the final matching bar of gold or lemon reels to a stop just shy of a jackpot payout.

region is implicated in the formation of habits, which is also obviously relevant to addiction."

Persuading a player that he's improving at a luck-based game in turn increases the likelihood that he'll take on unfavorable odds. "For years the gambling industry has had the ability to track individual players, create robust historical profiles on customers, and employ algorithms that can tell when someone is likely to leave," Schüll said. The operators of digital gambling machines have the ability to change payout odds in the middle of a gambling session based on these profiles, by giving a player a small payout in order to tempt him or her to keep playing. Many states have laws that forbid "luck" from being manipulated in this way. To get around that, casino operators dispatch so-called "luck ambassadors," who go onto the casino floor and hand gamblers a cash bonus to keep them invested. Freemium games, which aren't currently subject to the same legal strictures that bind the gambling industry, can freely give these bonus payouts during the game in order to make a player feel lucky—and so keep them playing and spending.

SOME DESIGNERS HAVE SWORN OFF pulling the levers of luck at all. For a long time Larry DeMar, a noted pinball-game designer who worked with Williams, avoided using the ball-saver in the company's designs, believing it undermined the purity of the game. If you lose, you lose—tough luck for you.

Unfortunately, the pure approach doesn't always convince players. "Today, players almost always perceive patterns of manipulation where there are none," Jason Kapalka, the Peggle developer, said. "When I was working on online games, it was nearly impossible to convince certain players that the results weren't rigged in some way. People came up with elaborate theories about how beginners were given better results so as to rope them into subscriptions, or veteran players would be rewarded with better results for their patronage, and so on." At one point Kapalka published huge files, revealing hundreds of thousands of simulated die rolls, to persuade skeptical players that the results were truly random.

Game designers, too, can lose the plot. "Even a veteran designer can lose track of some bits and pieces on a big enough project," Adam Saltsman, a veteran designer, told me. "And even an experienced player can misunderstand a system and attribute skill to luck, or vice versa."

If play is the way in which human beings rehearse life, it follows that we require our games to be filled with uncertainties, moments of caprice to which we must adapt our position and strategy. But we've grown more demanding about the luck that games serve to us—not too much, not too little. What remains constant is our interest in the nature of the luck that we experience. "When we experience luck in a game we feel a deep sense of attunement and alignment, almost like we've found the pattern, and predicted it," Schüll says.

The source of this good fortune—whether it's the gods or a random probability distribution—is a matter of culture. But the message of an encounter with luck in a game is universally comforting: We have found the thing that we were looking for.

SIMON PARKIN is the author of *Death by Video Game: Danger, Pleasure, and Obsession on the Virtual Frontline*, and has written essays and articles for various publications, including the new yorker.com, *The Guardian*, *The New York Times*, *MIT Technology Review*, and the *New Statesman*.

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ONE OF MY FAVORITE DETAILS about the evolution of complex life has to do with the power source. The dominant theory is that mitochondria, which are the chemical powerhouses for virtually all multicellular life, started out as single-cell organisms that entered into a long-term symbiotic relationship with eukaryotes.

It's as if power were a separate category of problem, one not easily solved by the usual processes, and requiring a special solution. Today, as human-engineered systems reach great complexity, we see the same dichotomy. The world's most common means of generating electricity is burning coal, a technology dating back to the 1880s, even as the devices receiving that power race ahead in complexity and efficiency.

In the social world, too, problems of power resist solution. As other aspects of our lives have been entirely transformed for the better—the ability to communicate with each other, for example—just a little over a tenth of the world lives in a full democracy, and democratization has stalled or reversed in many parts of the world.

Power is necessary but dangerous, intimate but foreign, a tangled externality. That makes for a hard problem indeed.

Welcome to "Power."

—MS

"The closer we look, the more willpower appears to unravel. It's time to get rid of it altogether."

CARL ERIK FISHER
"Against Willpower" p.72

Power

ENERGY THROUGH TIME

Against WILLPOWER

Willpower is a dangerous, old idea that needs to be scrapped

BY CARL ERIK FISHER

THOMAS* WAS A HIGHLY SUCCESSFUL and mild-mannered lawyer who was worried about his drinking. When he came to see me at my psychotherapy practice, his wine intake had crept up to six or seven glasses a night, and he was starting to hide it from his family and to feel the effects at work. We discussed treatment strategies and made an appointment to meet again. But when he returned two weeks later, he was despondent: His drinking was totally unchanged.

"I just couldn't cut back. I guess I just don't have the willpower."

Another patient of mine, John, also initially came to me for help with drinking. At our first meeting, we talked about moderation-based approaches and setting a healthier limit. But one month later, he came back to my office declaring that he had changed his mind and made peace with his drinking habits. Sure, his wife wasn't always thrilled with how much he drank, he told me, and occasionally the hangovers were pretty bad, but his relationship was still fairly solid and drinking didn't cause any truly significant problems in his life.

In the abstract, John and Thomas are similar: They both succumbed to short-term temptations, and both didn't keep their long-term goals. But while Thomas attributed that outcome to problems with willpower, John came to reframe his behavior from a perspective that sidestepped the concept of willpower altogether. Both John and Thomas would resolve their issues, but in very different ways.

Most people feel more comfortable with Thomas' narrative. They would agree with his self-diagnosis (that he lacked willpower), and might even call it clear-eyed and courageous. Many people might also suspect that John's reframing of his problem was an act of self-deception, serving to hide a real problem. But Thomas' approach deserves just as much skepticism as John's. It's entirely possible that Thomas was seduced by the near-mystical status that modern culture has assigned to the idea of willpower itself—an idea that, ultimately, was working against him.

Ignoring the idea of willpower will sound absurd to most patients and therapists, but, as a practicing addiction psychiatrist and an assistant professor of clinical psychiatry, I've become increasingly skeptical about the very concept of willpower, and concerned by the self-help obsession that surrounds it. Countless books and blogs offer ways to "boost self-control," or even to "meditate your way to more willpower," but what's not widely recognized is that new research has shown some of the ideas underlying these messages to be inaccurate.

More fundamentally, the common, monolithic definition of willpower distracts us from finer-grained dimensions of self-control and runs the danger of magnifying harmful myths—like the idea that willpower is finite and exhaustible. To borrow a phrase from the philosopher Ned Block, willpower is a mongrel concept, one that connotes a wide and often inconsistent range of cognitive functions. The closer we look, the more it appears to unravel. It's time to get rid of it altogether.

IDEAS ABOUT WILLPOWER and self-control have deep roots in western culture, stretching back at least to early Christianity, when theologians like Augustine of Hippo used the idea of free will to explain how sin could be compatible with an omnipotent deity. Later, when philosophers turned their focus away from religion, Enlightenment-era thinkers, particularly David Hume, labored to reconcile free will with the ascendant idea of scientific determinism.

The specific conception of "willpower," however, didn't emerge until the Victorian Era, as described by contemporary psychology researcher Roy Baumeister in his book *Willpower: Rediscovering the Greatest Human Strength*. During the 19th century, the continued waning of religion, huge population increases, and widespread poverty led to social anxieties about whether the growing underclass would uphold proper moral standards. Self-control became a Victorian obsession, promoted by publications like the immensely popular 1859 book *Self-Help*, which preached the values of "self-denial" and untiring perseverance. The Victorians took an idea directly from the Industrial Revolution and described willpower as a tangible force driving

** Details have been changed to protect patients' privacy.*

CAMERIQUE / CLASSICSTOCK / GETTY IMAGE

Books and blogs offer ways to *"boost self-control,"* but new research shows some of the underlying ideas to be inaccurate.

the engine of our self-control. The willpower-deficient were to be held in contempt. The earliest use of the word, in 1874 according to the Oxford English Dictionary, was in reference to moralistic worries about substance use: "The drunkard … whose will-power and whose moral force have been conquered by degraded appetite."

In the early 20th century, when psychiatry was striving to establish itself as a legitimate, scientifically based field, Freud developed the idea of a "superego." The superego is the closest psychoanalytic cousin to willpower, representing the critical and moralizing part of the mind internalized from parents and society. It has a role in basic self-control functions—it expends psychic energy to oppose the id—but it is also bound up in wider ethical and value-based judgments. Even though Freud is commonly credited with discarding Victorian mores, the superego represented a quasi-scientific continuation of the Victorian ideal. By mid-century, B.F. Skinner was proposing that there is no internally based freedom to control behavior. Academic psychology turned more toward behaviorism, and willpower was largely discarded by the profession.

That might have been it for willpower, were it not for an unexpected set of findings in recent decades which led to a resurgence of interest in the study of self-control. In the 1960s, American psychologist Walter Mischel set out to test the ways that children delayed gratification in the face of a tempting sweet with his now-famous "marshmallow experiment." His young test subjects were asked to choose between one marshmallow now, or two later on. It wasn't until many years later, after he heard anecdotes about how some of his former subjects were doing in school and in work, that he decided to track them down and collect broader measures of achievement. He found that the children who had been better able to resist temptation went on to achieve better grades and test scores.[1] This finding set off a resurgence of scholarly interest in the idea of "self-control," the usual term for willpower in psychological research.

These studies also set the stage for the modern definition of willpower, which is described in both the academic and popular press as the capacity for immediate self-control—the top-down squelching of momentary impulses and urges. Or, as the American Psychological Association defined it in a recent report, "the ability to resist short-term temptations in order to meet long-term goals." This ability is usually portrayed as a discrete, limited resource, one that can be used up like a literal store of energy. The limited-resource concept likely has its roots in Judeo-Christian ideas about resisting sinful impulses, and it seems like a natural analogy to other physical functions like strength, endurance, or breath. In the 1990s, the psychologist Roy Baumeister conducted a key experiment to describe this capacity, which he labeled "ego depletion": A few undergraduate students were told to resist the urge to eat some fresh-baked chocolate cookies and instead eat from a bowl of red and white radishes, while others were allowed to snack freely on the cookies. Students who were made to exercise self-control performed worse on subsequent psychological tests, suggesting that they had exhausted some finite cognitive resource.

Studies supporting the ego depletion effect were supposedly replicated dozens of times, spawning best-selling books (including Baumeister's own, *Willpower*) and countless research programs. But a 2015 meta-analysis examining those findings more closely, along with previously unpublished research, found a good deal of publication bias and very little evidence that ego depletion is a real phenomenon.[2] Psychologists then assembled an international ego depletion experiment composed of more than 2,100 subjects. The recently published results failed to show any evidence that ego depletion is real.[3] It appears to be just another casualty of psychology's replication crisis.

If ego depletion does turn out to be wrong, it's striking how seemingly well-established it became before more rigorous investigations dispelled the assumptions it rests on. The story of its rise and fall also shows how faulty assumptions about willpower are not just misleading, but can be harmful. Related studies have shown that beliefs about willpower strongly influence self-control: Research subjects who believe in ego depletion (that willpower is a limited resource) show diminishing self-control over the course of an experiment, while people who don't believe in ego depletion are steady throughout. What's more, when subjects are manipulated into believing in ego depletion through subtly biased questionnaires at the outset of a study,

BARRY ROSENTHAL / GETTY IMAGE

their performance suffers as well.

The problem with the modern notion of willpower goes far deeper than ego depletion. The usual academic simplifications surrounding willpower are under attack. In a widely-cited 2011 paper, Kentaro Fujita called on the psychology field to stop conceptualizing self-control as no more than effortful impulse inhibition, urging his colleagues to think more broadly and in terms of long-term motivations.[4] For example, some behavioral economists argue that self-control should not be seen as simply suppressing short-term urges but instead understood through the lens of "intrapersonal bargaining": the self as several different decision making systems often in conflict with one another. This model allows for shifting priorities and motivations over time—which is what happened with my patient John, who would say that he simply reevaluated his drinking issues in light of the complex calculus of competing advantages and disadvantages.

Another overlooked dimension of self-control is emotion regulation, a scholarly field that has exploded over the past few decades, with citations increasing approximately fivefold every five years since the early 1990s. This component of self-control is also largely ignored by the unidimensional willpower-as-muscle perspective that dominates today's discussions. Intuitively, though, it should be clear that there's an emotional component to some kinds of willpower: Stopping yourself from yelling at your annoying relative can be much different from resisting the urge to drink. Emotional self-regulation is a complex function, and as we've long known in psychotherapy, trying to willfully manage your emotional states through brute force alone is bound to fail. Instead, regulating emotions also includes skills such as shifting attention (distracting yourself), modulating your physiological response (taking deep breaths), being able to tolerate and wait out the negative feelings, and reframing beliefs.

A paradigmatic example of reframing is the phenomenon of "temporal discounting," in which people tend to discount future rewards in favor of smaller immediate payoffs. When offered $5 today versus $10 in a month, many people illogically choose immediate gratification. However, when the question is reframed to make the tradeoffs explicit—"Would you prefer $5 today and $0 in a month or $0 today and $10 in a month?"—more people choose the larger, delayed reward. Research suggests that reframing the question in this way nudges people toward delayed gratification because the different versions of the question employ entirely different cognitive processes. In a neuroimaging study, when the question is edited to explicitly mention $0, not only are the brain's reward responses reduced, brain activity in the dorsolateral prefrontal cortex (a correlate of effortful self-control) decreases as well.[5] A conscientious reframing of a problem in this manner would certainly be an example of willpower, but it would not fall into the conventional understanding of the term. Rather than relying on an effortful fight against impulses, this kind of willpower has the individual completely reimagine the problem and avoid the need to fight in the first place.

THESE HIDDEN DIMENSIONS of willpower call into question the whole scholarly conception of the term, and put us into a lose-lose situation. Either our definition of willpower is narrowed and simplified to the point of uselessness (in both research and casual contexts), or it is allowed to continue as an imprecise term, standing in for an inconsistent hodgepodge of various mental functions. Willpower may simply be a pre-scientific idea—one that was born from social attitudes and philosophical speculation rather than research, and enshrined before rigorous experimental evaluation of it became possible. The term has persisted into modern psychology because it has a strong intuitive hold on our imagination: Seeing willpower as a muscle-like force does seem to match up with some limited examples, such as resisting cravings, and the analogy is reinforced by social expectations stretching back to Victorian moralizing. But these ideas also have a pernicious effect, distracting us from more accurate ways of understanding human psychology and even detracting from our efforts toward meaningful self-control. The best way forward may be to let go of "willpower" altogether.

Doing so would rid us of some considerable moral baggage. Notions of willpower are easily stigmatizing: It becomes OK to dismantle social safety nets if poverty is a problem of financial discipline, or if health is one of personal discipline. An extreme example is the punitive approach of our endless drug war, which dismisses

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The earliest use of the word *"willpower"* was in reference to moralistic worries about substance abuse.

THE BIRTH OF WILLPOWER The modern conception of willpower has its roots in the Victorian era, when there was great concern over the moral standards of a growing underclass. This 1828 satirical sketch warned of the dangers of alcohol.

Willpower is *usually* portrayed as a discrete, limited resource.

substance use problems as primarily the result of individual choices. Unhealthy moralizing creeps into the most quotidian corners of society, too. When the United States started to get concerned about litter in the 1950s, the American Can Company and other corporations financed a "Keep America Beautiful" campaign to divert attention from the fact that they were manufacturing enormous quantities of cheap, disposable, and profitable packaging, putting the blame instead on individuals for being litterbugs. Willpower-based moral accusations are among the easiest to sling.

In the end, believing in willpower is often simply not necessary. Now, when I hear the word "willpower," it's a mental red flag that prompts me to clarify further. Did my patient, Thomas, really have a willpower problem? While he struggled with alcohol cravings, he had no problem motivating himself in the positive sense, continuing to be extremely successful in his professional career and excelling as an amateur athlete, winning several competitions around the New York City area. His difficulty resisting the impulse to drink didn't seem to be related to this ability to stick with a plan. Some researchers call this quality "self-discipline" and differentiate it from impulse control or resisting temptations. Which of those cognitive functions is the "real" willpower? To ask that question is to miss the point.

He ended up doing well. Once we got further into the issues driving his drinking, it became clear that he hadn't fully realized how much stress was affecting his life. Not only was he beating himself up, thinking that he should just be able to force himself to quit, he had totally unrealistic ideas of how much he should be able to accomplish at work, home, or otherwise. By focusing on the bigger picture—managing his stress and anxiety and interrogating his expectations of himself—he was finally able to cut back, without such a sense of struggle.

And he did this all without worrying much about willpower.

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KEITH BEATY / CONTRIBUTOR / GETTY IMAGE

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When Climate Change Starts Wars

Rising temperatures are bringing ethnic tensions to a boil in Central Asia

STORY AND PHOTOGRAPHS BY JOHN WENDLE

THE KYRGYZ SOLDIER STEPPED quietly out of the dark green bushes and swung his Kalashnikov rifle in the direction of our car. Another emerged and did the same. Their checkpoint was a skinny log dragged across a broken asphalt road heading toward an ethnic Uzbek village and the disputed waters of the Kasan-sai, a reservoir that irrigates the agricultural heartland of the ancient Fergana Valley. With a sleepy shake of his head, the special forces sergeant waved his rifle and made us turn our beat-up Mitsubishi around. "There won't be any fighting here," the sergeant said.

At least not today. The quiet of the hot September afternoon was unbroken as we turned around and slowly ground off through the heat. Driving back the way we came through the parched foothills on the edge of the western Tian Shan range, a spur of the Himalayas, we did not pass any other cars.

But it has not always been this quiet. Throughout the spring and summer in 2016, tensions flared after ethnic Uzbek villagers and police blocked access to the reservoir and its water, which lies inside Kyrgyzstan. Uzbekistan drove armored personnel carriers into Kyrgyzstan, and both sides have captured and detained each other's citizens. Fistfights and potshots have been common. For farmers scratching out a bare existence from increasingly dry land, water is lifeblood, and worth fighting for.

I have come to this remote and haphazard army post, standing between Uzbek and Kyrgyz farmers whose lands both need water, to see for myself the front line of climate change. A 2014 study in the *Journal of Climate*, published by the American Meteorological Society, reported that the warming rate in Central Asia has been twice the average global warming rate over the same period, and larger than any previous decade, over the first 12 years of the 21st century. As the region heats up, it faces increasing political instability and violence.

This is particularly so in the vast Fergana Valley. Its tangled knot of borders, ethnicities, water rights, decreasing resources, and increasing temperatures makes it a crucible of global warming and human conflict—a place where geography, climate, and politics collide. Indeed, historically violent ethnic divides and regular disputes over natural resources make armed conflict as a result of climate change more likely in this region, one that has already seen hundreds killed in two pogroms over the past 27 years, in part fueled by fights over territory and water.

"These small villages fight almost every day for water and land," said Altynbek Kadyrov, an agricultural project manager for the U.S. State Department's Agency for International Development (USAID) in Kyrgyzstan. "As soon as something disrupts their agriculture, they have to fight or do something to ensure that they don't go hungry in the winter."

DOWN THE ROAD from the checkpoint, ethnic Uzbek farmers stacked dried sunflower stalks onto the bed of a dilapidated truck. They were too nervous about the armed standoff over the nearby reservoir to talk. They turned up the music in their truck and laughed nervously as they sweated in the dust and sun.

This has been the situation in this borderland since March, when Uzbek troops cut off the road to the town of Ala-Buka, near the reservoir. This move was sparked after Kyrgyz authorities denied an

COMING STORM (PREVIOUS) A Kyrgyzstan shepherd stands in front of a yurt as a storm approaches in the upper reaches of the Chon-Kemin Valley.

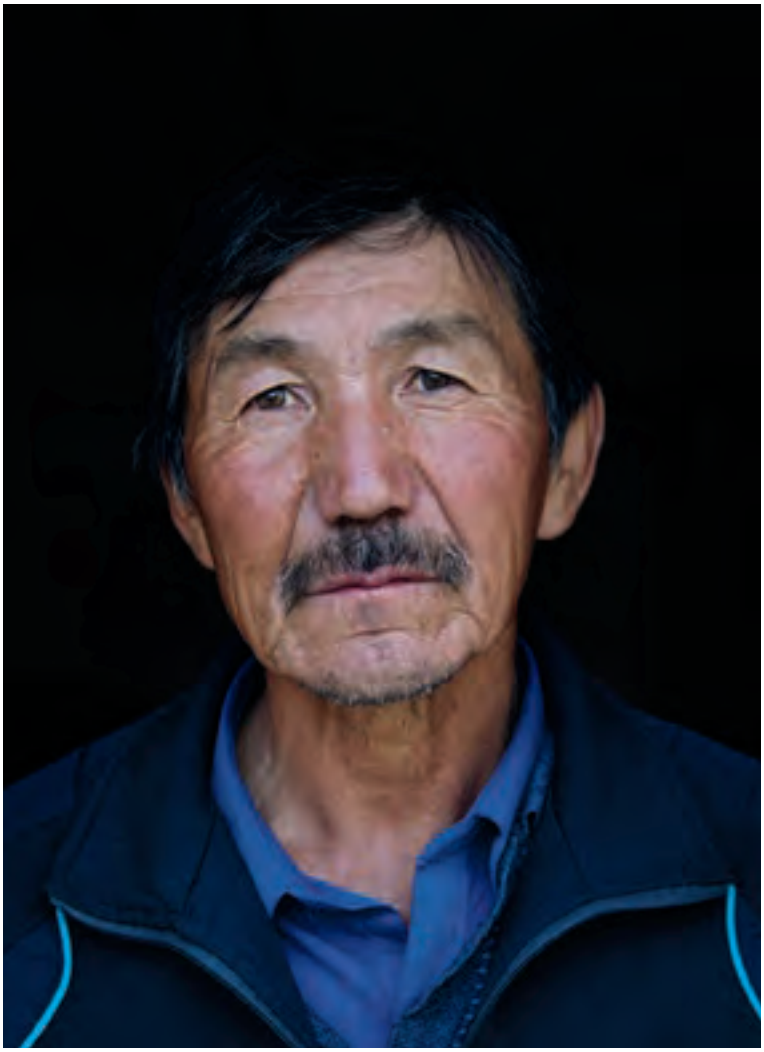
ALONG THE WATCHTOWER (TOP) A Kyrgyz border guard tower stands watch over the Uzbek border. Both sides frequently make incursions into each other's territory, particularly over water.

LOCAL MARKET (RIGHT) A woman at the Osh Bazaar in Kyrgyzstan sells carrots in multiple colors. Foods at the bazaar hail from the Fergana Valley, agricultural heartland of Central Asia.

Uzbek request to repair the reservoir in Kyrgyz territory using Uzbek engineers. The security situation escalated from there and culminated in August with the seizure of a Kyrgyz communications relay tower on a disputed mountaintop by helicopter-borne Uzbek police, who detained a number of Kyrgyz technicians.

And there is reason to fight. The Fergana is the great cornucopia of fruit, vegetable, and cotton farms that once made up the agricultural heart of Central Asia. The wide basin was an oasis of food that built emirates, fed a blossoming of Sufi poetry, and was a stop in its own right on the ancient Silk Road. Today, the flatlands are covered in irrigated fields still famous for their melons, peppers, tomatoes, and strawberries. The Uzbek villages stand in the shade of innumerable poplars, fed on the water streaming out of Kyrgyzstan's mountains. Sitting above this lush bowl, the rugged lands of Kyrgyzstan and Tajikistan are too mountainous for cultivation, supporting mostly livestock. They remain dry.

But this is all in flux. Climate change will continue to increase the area's "environmental insecurity," with the densely populated Fergana Valley being the most vulnerable, reads a 2014 report by the World Bank, which is funding economic research into how climate change will alter how people live around the world. Some 22 million people in the valley depend on irrigation for their livelihoods, and shortfalls in water—due to increased evaporation caused by higher temperatures and because glaciers are disappearing—are predicted to become a bigger problem.



FACING THE FUTURE Nurdin Ismailov, a 61-year-old retired biology and geography teacher, says, "More than 40 years ago there were a lot of glaciers in the mountains. Today there is not even snow in the summer."

Rasul Kasymov's rice farm is representative of the region's problems. To get to his smallholding farm in the village of Kyzyl-Sengir from the historic city of Osh, I drove 45 minutes through parched Kyrgyz countryside, past young boys herding bony cattle, and dusty communities of one-story homes. The Soviet-educated farmer greeted me and guided me down a road to his rice terraces on the floodplain of a river that flows into Uzbekistan.

The first thought many farmers have about their counterparts across the border is, "We should kill them."

Open irrigation ditches rushed with silted, blue water on either side of the dusty track and shady willows grew on their banks. Cows and horses drank from the muddy slopes as the water flowed into the surrounding fields. This bucolic scene is typical of the rural Fergana Valley, but the pleasant surroundings obscure the environmental problems.

"We keep telling these guys about climate change," Kadyrov, the USAID agricultural specialist, said. "There are some good farmers who understand they need to worry about it, but they do nothing." Because their plots are small, most farmers in the Fergana do not have the money to invest in new equipment or infrastructure, and they are not trained in water conservation.

It's a hand-to-mouth existence. Much of the water in the canals along this path evaporates, and when it does reach a field, it leaches minerals and salt out of the soil. At the same time, livestock is allowed to overgraze, making the poor earth more susceptible to desertification and erosion caused by flash floods.

We dropped down a short dirt slope to Kasymov's rice paddies above the river. The irrigation water in the ditch formed a small waterfall. The cool sound of the water splashing into a grassy pool was in contrast to the heat of the day. Below this, the water overflowed and flooded the path in wasteful abundance before running back into the village's rice fields. The old farmer walked out onto an earthen berm and pulled up a handful of the reddish colored rice for which this area is famous.

"Before there was a lot of water, but now it seems to me that water is becoming less everywhere," Kasymov said. "The glaciers are melting." He waved a sheaf of rice at the mountains upstream. "We are dependent on the water here. Without this water no one would live here." When I asked if there were ever fights over water between farmers he answered, "No. There are no conflicts here. We don't have any Uzbeks."

IN THE FERGANA VALLEY, ethnicity is a volatile issue. Kyrgyzstan and Tajikistan both have significant ethnic Uzbek minorities of around 14 percent. Layered on top of this is a population exploding across a landscape with limited farmland. Since 2000, the population of the five former Soviet republics in Central

TENSE FARMERS Ethnic Uzbek farmers load sunflower stalks near the disputed Kasan-sai reservoir in Kyrgyzstan. Because of a recent armed standoff among farmers, they were too nervous to talk to a reporter.

Asia has grown by almost 10 million, and this is expected to grow to 95 million by 2050. Of the 65 million people currently living in the region, around 5 million lack reliable access to food.

Climate change represents an enormous challenge to these growing populations. If temperatures continue to climb at their current rate, the World Bank predicts a 10 to 15 percent drop in the water levels of the Amu Darya, one of Central Asia's great rivers, by the 2040s, and a 10.7 percent drop in the GDP of the region.

Besides ethnicity, evaporation, misuse, population, and poverty, the issue of water is further complicated by the borders in the region. Before the Soviet Union's breakup, water ran through a united country. Now the water courses through independent countries, crossing disputed borders. Kyrgyzstan and Tajikistan control most of the sources, while Uzbekistan, Kazakhstan, and Turkmenistan have to either accept what their upstream neighbors give them, pay, negotiate, or try to take it.

What's more, bubbles of independent ethnic territory exist within Kyrgyzstan and Uzbekistan, where ethnic villages have been cut off from their home countries. Water sometimes crosses three or four borders in just as many miles. The confusing map has caused fights to break out between neighboring farmers.

These altercations, which often

lead to the police or military having to be called, inflame preexisting ethnic tensions. Kyrgyz farmers "hate" Tajik farmers, while Tajiks say the Kyrgyz block water, keeping it from flowing downstream. When the water stops flowing, said Kadyrov, the first thought many farmers have about their counterparts across the border is, "We should kill them." Politicians have used the disagreements over natural resources to stoke ethnic tensions. These exploded once in Kyrgyzstan in 1990 and again in 2010—incidents in which hundreds, if not thousands, of ethnic Uzbeks were killed and tens of thousands were displaced.

One afternoon in Ala-Buka, Akim Orozov, a thick-set, retired policeman, commanded Ala-Buka's livestock market with an unbelievably loud voice, brokering rough-and-tumble trades with a crushing handshake under the shade of the lot's lone tree. "The reservoir is ours," he told me. "It is an important strategic object. We will not give it up." Like everyone in the area, he understands water intimately. "If [the Uzbeks] don't have water, they'll have a drought," he said. "If there is a war, we will stand with dignity. Let them come."

CONFLICTS OVER NATURAL RESOURCES ARE NOT NEW, but as climate change shrinks access to water, their occurance is bound to rise worldwide. From 1980 to 2010, almost a quarter of all armed conflicts in ethnically divided countries coincided with climate-related natural disasters, reported the Potsdam Institute for Climate Impact Research, in a study published in the *Proceedings of the National Academy of Sciences*. The risk of violence was "exacerbated by anthropogenic climate change and in particular climate-related natural disasters," the report said, adding that Central Asia is "exceptionally vulnerable to anthropogenic climate change and characterized by deep ethnic divides."

The analysis noted similar linkages between climate-related natural disasters, ethnic divides, and armed conflict outbreak in Syria, Somalia, and Afghanistan over the past 30 years, citing the "societal consequences" of drought. "We're not saying there's a climate disaster and this will cause a conflict, but in the context where it will basically add to societal stress, then this could enhance the risk for the outbreak of conflict," said lead researcher Carl-Friedrich Schleussner.

Around 10 percent of Central Asia's population has already been hit by natural disasters since the 1990s. These include mudflows, landslides, heat waves, drought, desertification, earthquakes, torrential rains, and spreading malaria.

In 2015, half a village was destroyed in the mountains of neighboring Tajikistan when a multistory wall of water blasted out of a slot canyon, caused by either torrential rains or a glacial lake bursting its dam upstream. To put this in context, scientists report that more than 2,000 glacial lakes cover Kyrgyzstan. Of these, almost 20 percent pose a hazard of "outburst" and 12 are considered "actually dangerous." This sounds like a small number, but around 300,000 cubic meters of water sits in dangerously unstable glacial lakes above the Kyrgyz capital of Bishkek, with a population of around 1 million people. Since 1952, more than 70 "disastrous" cases of lake outbursts have occurred across Kyrgyzstan. These numbers put Bishkek in the crosshairs and illustrate the risks posed by a litany of environmental disasters.

THE COWBOY WHISTLED piercingly and Barsik, his 140-pound sheepdog, shot over the rolling green humps of the high mountain valley, and chased an errant bull back into the herd. High on the mountainside, Nurdin Orozaliev's flock of around 500 sheep streamed through the well trimmed grasses of late summer.

The 15,000-foot peak of Chok-Tal was just catching the first rays of the early morning sun, washing the blue monochrome of dawn out of the valley. Nurdin, 52, sprang into his saddle and trotted into the snorting confusion of cattle, guiding them to their pasture for the day.

This is the Kyrgyz high country. In summer, shepherds from across the nation flock to the Chon-Kemin, a 2-mile high, 75-mile long valley in the north. Every summer they bring their livestock here to fatten up on the lush grasses. Nurdin's morning chores done, he rode ahead toward the loose rock moraines and glacier on the flanks of Chok-Tal.

The Dzhindi-suu, or Crazy Water River, rushed past on the floor of the ravine. This will be their last year at this camp. "The wind coming off the glacier is too


I have come to this
remote land to
be on the front line
of climate change.

RECEDING WATERS (PREVIOUS) The Kasan-sai reservoir, which irrigates the Fergana Valley, stands half drained near the Uzbek border. The reservoir sits in Kyrgyz land but supplies water to Uzbekistan's Fergana Valley.

BREAK TIME (TOP) Laborers rest on the edge of a corn field after helping in the harvest in a village near Uzgen. The fields are irrigated by a river flowing from Kyrgyzstan into Uzbekistan, but there is little agreement about how much of that water either side can use.

GLACIER MELT (LEFT) Almost all glaciers in Central Asia are losing mass, scientists say. They will lose up to two-thirds of their 1955 mass by the end of the 21st century.

cold. My sheep and cattle haven't fattened up as much as they would have in another side valley," Nurdin said. But with glaciers disappearing, his grandsons might be able to return here in a couple decades.

"Before, the glacier was visible [from our valley] and now it is not," said Nurdin, approaching the end of the grass and the start of the rock. The feeder streams of the Crazy Water poured out of the face of the glacier 1,000 feet above us and cascaded down through the boulder field. Jumping from rock to rock, he headed up the mountain. "The glacier is melting. I don't know how it will be for us in 20 or 25 years," he said. "It's a tragedy. It will have a bad effect."

After more than an hour of climbing through the steep rubble of pink and gray granite boulders, the rocky tongue of the glacier came into view. Sheer planes of dirty ice stepped almost vertically into the sky. Nurdin climbed under an overhang and drank water melting off the curved lip. He grabbed a rock and hacked off a chunk of ice. He held it up to the sun and the piece of glacier lit up, light refracting off the ancient air bubbles locked in the shard.

"The signs are very clear. Almost all glaciers in Central Asia are losing mass," said Annina Sorg, a Swiss scientist who has made multiple trips to the Chon-Kemin valley to research its glaciers. A study by Sorg and others of the Tian Shan range found annual glacier area losses of 0.36 to 0.76 percent, "causing concern about future water security." Even in cooler, wetter conditions, glaciers will lose up to two-thirds of their 1955 extent by the end of the 21st century, while in warmer scenarios, they are expected to "disappear completely" by around 2080.

Right now, though, the melt is having a somewhat positive effect, since melting glaciers provide a steady supply of water. But Sorg's research has shown that "peak water" could be reached by the 2020s. And, regardless of any way the climate could change, "the days of plenty will not last much longer, as summer runoff is projected to decrease."

Sorg worries how the coming water shortages will be handled across unstable borders between countries and ethnic groups that already distrust one another. "I'm more scared that climate change will lead to war and to political conflicts," she said. "I would be more afraid of people than of nature."

Some see an opportunity for action. André Fabian, a project manager in Central Asia with GIZ, a German development agency, believes climate change might ironically offer a solution. The battle over water has made neighboring countries into enemies. "There are the upstream countries, there are downstream countries, and they blame each other for whatever reason," he said. But the countries have a common enemy in climate change. "They come, and we can talk sometimes, even about the same topics, but under the umbrella of climate change."

But it is unclear what that means for actual farmers, cowboys, and everyone else in the region—both in parched upstream countries like Kyrgyzstan, and in wet, downstream countries like Uzbekistan. Driving slowly out of Ala-Buka, our Mitsubishi weaved through the overflowing Saturday market between old, mustachioed men carrying giant yellow melons and women in headscarves pulling along young children.

After a 20-minute drive through the dry hills, we reached the grassy edge of the reservoir. Satinbay Mamashev herded his cattle and shouted when some wandered into a burdock thicket. "If I had water, I'd live like a king here," said the 73-year-old through his long whiskers. "Where they have water, that's Uzbek agriculture. Where there is no water, that's my land." He pointed his shepherd's stick toward the green of the Fergana Valley. "Without water, it is impossible to live."

Above us, on a rocky escarpment overlooking the disputed reservoir, stood a Kyrgyz armored vehicle with its guns pointing toward the Uzbek village.

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Does Depression Have an Evolutionary Purpose?

Some psychologists believe suicide and depression can be strategic

BY MATTHEW HUTSON

I HAD A TOUGH TIME in high school. Like many other young adolescents, I saw myself as fundamentally flawed, and felt a searing isolation. Nothing I looked forward to brought any hope. I stopped getting out of bed. I cut myself. I drafted a suicide note.

It was a terrible time that I wouldn't wish on anyone. But in a strange way, my self-destructive behavior may have had a benefit. I eventually dropped clues about my situation, leading to an intervention that put me on a better track. I was hospitalized. It scared me straight, highlighting a pathway of suffering I no longer wanted to indulge. I went back on medication and did what it took to stay at my school.

One in six Americans will suffer a major depressive disorder at some point in life.[1] That word—disorder—characterizes how most of us see depression. It's a breakdown, a flaw in the system, something to be remedied and moved past.

Some psychologists, however, have argued that depression is not a dysfunction at all, but an evolved mechanism designed to achieve a particular set of benefits. I've certainly considered whether it's done that for me, both in high school and later in life. If they're right, it means that our thinking about depression needs an intervention too.

THEORIES ABOUT the evolutionary function of depression are numerous.[2] One of the most popular current ideas is the analytical rumination hypothesis. This idea was described most thoroughly in a long 2009 article by Paul Andrews, an evolutionary psychologist now at McMaster University, and J. Anderson Thomson, a psychiatrist at the University of Virginia Student Health Services.[3] Andrews had noted that the physical and mental symptoms of depression appeared to form an organized system. There is anhedonia, the lack of pleasure or interest in most activities. There's an increase in rumination, the obsessing over the source of one's pain. There's an increase in certain types of analytical ability.

ILLUSTRATION BY DANIEL ZENDER

And there's an uptick in REM sleep, a time when the brain consolidates memories.

Andrews sees these symptoms as a nonrandom assortment betraying evolutionary design. After all, why would a breakdown produce so synchronized a set of responses? And that design's function, he argues, is to pull us away from the normal pursuits of life and focus us on understanding or solving the one underlying problem that triggered the depressive episode—say, a failed relationship. If something is broken in your life, you need to bear down and mend it. In this view, the disordered and extreme thinking that accompanies depression, which can leave you feeling worthless and make you catastrophize your circumstances, is needed to punch through everyday positive illusions and focus you on your problems. In a study of 61 depressed subjects, 4 out of 5 reported at least one upside to their rumination, including self-insight, problem solving, and the prevention of future mistakes.[4]

A small minority of researchers believe that we may have evolved to, under the right conditions, try to kill ourselves.

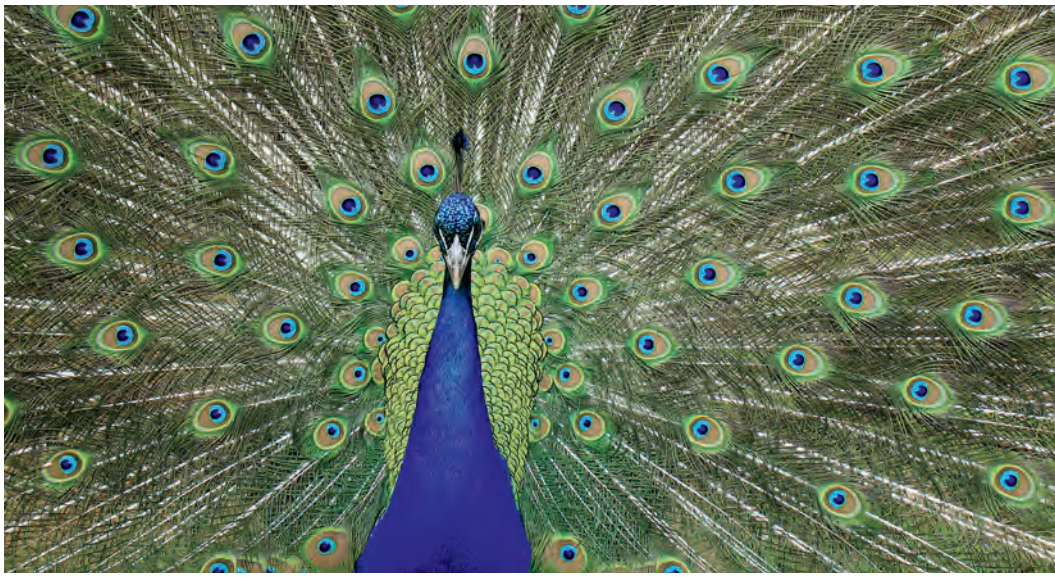
"Most episodes of depression end on their own—something known as spontaneous remission—and Paul may have an explanation for just how that happens," says Steven Hollon, a professor of psychology at Vanderbilt University. Further, "cognitive behavioral and problem-solving therapies may work precisely because they tap into and accelerate—in a matter of weeks—the very processes that have evolved to occur over the space of months."

Even suicidal behavior might serve a design function. A small minority of researchers believe that we may have evolved to, under the right conditions, try to kill ourselves. Edward Hagen, an anthropologist at Washington State University, is one of the most vocal supporters of this idea, and he presented fresh support for it in the May 2016 issue of *Evolution and Human Behavior*.[5] He and two WSU collaborators, Kristen Syme and Zachary Garfield, set out to find evidence for two models of suicidal behavior, each of which cast suicide as a strategic behavior.

The first model is called inclusive fitness, and it relies on the notion of the "selfish gene": The most basic unit of reproduction in natural selection is not the individual organism but the gene. Your genes don't care if you survive to reproduce, as long as they do, and they exist in more people than just you. So they might lead you, their host organism, to sacrifice yourself if it sufficiently benefits your family members, who share many of your genes. Hence, people seek to maximize not only their own fitness but, inclusively, that of their kin too. Most parents would decide in an instant to jump in front of a bus to save their children. And in studies of suicidal thinking, people frequently speak about not wanting to be a burden.

The second strategic model of suicidality is the bargaining model, which relies on the notion of "costly signaling."[6] A colorful example of costly signaling is the peacock. Managing a big, eye-catching tail is costly, in that it wastes energy and draws predators. But the fitter a peacock, the less costly a big tail, and so big tails have evolved to signal genetic fitness to peahens. They are attractive not despite their costliness but because of it. In addition to communicating fitness, costly signals can also communicate need. Consider baby birds. They don't need to chirp for food if their mother is right there, and chirping attracts predators, making it costly. But the more hungry or sickly a chick is, the less it has to lose by being eaten, and the more it has to gain by being fed. So chirping louder is an honest signal of greater need for food, and the mother responds. (Anthropologists and psychiatrists have long framed suicide attempts as cries for help, but considered them pathological forms of pleading rather than the results of context-sensitive and evolved cost-benefit analyses.) Whereas the goal of suicidality in the inclusive fitness model is death, the goal in the bargaining model is help. Crucially, the vast majority of suicide attempts are not fatal.

With these models in hand, Hagen and his colleagues analyzed 474 ethnographic records describing suicidal behavior in 53 diverse cultures around the world, looking for clues consistent (or inconsistent)



COSTLY SIGNAL According to the bargaining model of suicidality, an attempt to take one's own life is a costly, and therefore honest, signal to one's network—characteristics shared by a peacock's tail.

NGELA NICHOLSON/PHOTOPLUS MAGAZINE VIA GETTY IMAGES

with each model. Supporting the inclusive fitness story, 1 in 3 cultures had a record describing a suicide victim as a burden to others. In a few records, the victim was described as having low reproductive potential (due to advanced age or poor health), and in a few the victim's survivors were described as being better off after a death. Against the model, however, many more records described family members as being worse off, and many victims were healthy.

In support of the bargaining model was the fact that those who had attempted suicide were often healthy, their attempts were often public and unsuccessful, and they often benefited. Three observations were most telling: First, victims had often suffered a threatening event, such as loss of a mate or resources, whose long-term repercussions depended on how others responded. Second, victims were often personally powerless. Third, they were often in conflict with those around them, thus looking for a bargaining tool. Overall, victims needed help solving a critical problem and weren't receiving it. The authors provide a paradigmatic example of the bargaining model from a 1958 study of a people in Papua New Guinea:

> Attempted suicide is punishable by a beating administered by the woman's owner. Facts: The girl was being forced to marry a man she did not like. She attempted suicide several times in order to prevent the marriage. She was always saved from the river or captured on its bank. Outcome: Every time she attempted a suicide, she was beaten severely afterward. Since she did not stop, her brother and father consented to her marriage with Jok, whom she loved.

Hagen and his co-authors concluded that both inclusive fitness and bargaining are viable models of suicidality, each applying in difference circumstances. "Hagen has proposed some really interesting and compelling theoretical models that fit with available data and may help to explain suicidal behavior from an evolutionary perspective—a long-standing puzzle in the field," says Matthew K. Nock, an expert on suicide and self-injury at Harvard University. The evidence in the paper is not a clincher for either model—evolutionary theories, while often powerful, can also be slippery—but a few other studies lend additional tentative support to the bargaining model.

For example, the model predicts that depression—a

leading risk factor for suicide—will be used as a bargaining tool most often when others will respond accommodatingly. In a 1987 study, people's ratings of how upset they were with their social networks predicted their own level of depression, but only among those who found their networks generally helpful.[7] And in a 1997 study, fighting with their mothers or friends led women who'd just had an abortion to report greater depression and anxiety, but only if they described their mothers or friends as highly supportive.[8] Reacting to a social conflict with depression won't work if the people around you won't care. Depression can become a bargaining chip by risking the survival of one's genes and one's dependents, which should concern anyone invested in the sufferer's health.

The bargaining model might also help explain why women are twice as likely as men to suffer depression. In a 2016 paper, Hagen and Tom Rosenström, a psychologist at the University of Helsinki, analyzed data on 4,192 American adults from an ongoing study by the CDC.[9] They hypothesized that because men are physically stronger than women, they're more likely than women are to use anger as a bargaining tactic in social conflicts, whereas women are more likely to rely on depression. The data showed that people with greater upper body strength were less likely to suffer depression. What's more, once the researchers took the effect of physical strength out of the equation, men and women were equally likely to be depressed. Hagen has written about post-partum depression in terms of costly signaling: A mother's loss of interest in the health of herself or her newborn can act as leverage, recruiting the assistance of an insufficiently helpful mate or community.[10] Depression appears to be a tool (conscious or unconscious) for those who can't muscle the support they need.

SO WHAT SHOULD WE DO, based on these evolutionary models of depression? "I'm a bit hesitant to give advice based on my theories," Hagen says, "because that would assume that my theories are true and therefore we're ready to take this knowledge out of the lab and apply it clinically. I don't think we're at that point yet." And if his theories *are* true, the picture

is somewhat bleak, he says, in that there's no easy fix. Treating depression will likely require resolving severe conflicts between you and your family, situations with no good guy and bad guy. In terms of therapy, clinicians might bring in patients' family members to work through issues together, but many already do that—"So in practice a lot of what I'm saying isn't radical," he says.

These theories do cast some of our traditional responses to depression in a new light, however. If depression is a strategic response that we are programmed to carry out, consciously or unconsciously, does it make sense to try to suppress its symptoms through, say, the use of antidepressants? Hagen describes antidepressants as painkillers, arguing that it would be unethical for a doctor to treat a broken ankle with Percocet and no cast. You need to fix the underlying problem. He regrets the fact that the DSM, psychiatry's diagnostic manual, has removed from major depressive disorder's diagnostic criteria any exception for life circumstance, even bereavement. This is part of an effort to make diagnosis more objective and scientific, and encourage the profession to focus on observable symptoms rather than causes.[11]

But in the case of depression, which often has clear preceding events, indifference to causality allows many appropriate patient responses to be categorized as disordered—and that flows directly from seeing depression as a breakdown rather than a strategic, evolved response. Prescribing antidepressants may improve a patient's mood, but in the process prevent the patient from solving the underlying conflict and improving his or her mood even more in the long run. Depression usually doesn't appear out of nowhere. It's typically a response to adversity, with up to 80 percent of cases following major life events. The death of a woman's close relative, for instance, was measured to increase their chances of suffering depression within the next month by 20 times.

The battleground over depression's functionality may lie in those 20 percent of episodes without an obvious trigger. Perhaps you could say there's some nonobvious cause, a conflict lurking in one's psyche or latent in one's family life. Thomas Joiner, an expert on suicide at Florida State University, says that "as episodes accrue, it can be harder and harder to find the

"It may be best to let depression work its miserable magic, under supervision."

PHOTO12/UIG/GETTY IMAGES

trigger, but it's usually there—triggers can be things like memories." But since you can always point to something in your past with potential psychic consequences—that one time you got teased on the playground—the hypothesis that depression is an appropriate response to a stressful situation becomes nearly impossible to test objectively.

There's another big caveat. Even if depression evolved as a useful tool over the eons, that doesn't make it useful today. We've evolved to crave sugar and fat, but that adaptation is mismatched with our modern environment of caloric abundance, leading to an epidemic of obesity. Depression could be a mismatched condition. Hagen concedes that for most of evolution, we lived with relatives and spent all day with people ready to intervene in our lives, so that episodes of depression might have led to quick solutions. Today, we're isolated, and we move from city to city, engaging with people less invested in our reproductive fitness. So depressive signals may go unheeded and then compound, leading to consistent, severe dysfunction. A Finnish study found that as urbanization and modernization have increased over the last two centuries, so have suicide rates.[12] That doesn't mean depression is no longer functional (if indeed it ever was), just that in the modern world it may misfire more than we'd like. And of course some cases of depression would remain unexplained by evolutionary design. Peter Kramer, a psychiatrist at Brown University and the author of *Listening to Prozac* and *Against Depression*, notes that at least some episodes of depression are likely to be caused by genetic glitches or by negative thought patterns learned during previous unresolved episodes. Most sources, including Hagen, agree that depression is not one disease with one cause.

Inversely, even if depression and suicidality serve some purpose today, that doesn't mean they evolved to do so. Randolph Nesse, a psychiatrist and the director of the Center for Evolution and Medicine at Arizona State University, raises this possibility with regard to the bargaining model. "Some people do use threats of suicide to manipulate others, just as they use threats of murder or exposing secrets," he says, "but I don't see these as specific adaptations shaped by selection. They are just some of the myriad ways people try to influence others."

Nesse is even more dismissive of the inclusive fitness model of suicide: "There are many examples of animals sacrificing themselves for their kin, but I don't see that suicide is one of them. Why not just go away?" Still, he says, the "broader perspective that there is something useful about low mood is, I think, the key to making progress and I wish more psychiatrists would recognize it."

It's clear that evolutionary models for depression have not won over the psychiatry community at large. According to Thomson, "My profession of psychiatry still views depression purely as an illness." Insurance limitations have pushed many psychiatrists away from talk therapy and toward the more efficient prescription pad. So "there's a lot of institutional and scientific investment in the exclusively disease model of depression," Thomson says. "I'm basically telling colleagues they're medicating people when they shouldn't be. That's not going to be welcome news."

If Thomson, Hagen, and others are right that evolution has engineered us to be strategically depressed, our treatment strategies would need to change. Hagen sees depression as a social problem and not a medical problem. Andrews and a colleague, Paul Watson, describing the social navigation hypothesis, a theory that includes a version of the bargaining model, wrote in a 2002 paper that instead of prescribing drugs, "it may be best to let depression work its miserable yet potentially adaptive magic on the social network under protective supervision."[13] And a greater attention to circumstance and cause would be warranted.

It's hard for anyone to think about a condition as destabilizing as depression in impersonal evolutionary terms, particularly those who have felt its burdensome grip. I sometimes lament how much more industrious I would be without my own (now manageable) depression. But I also allow that, even today, my melancholia may have benefits. It focuses me on deeper questions of where I'm going in my life, even though—or, alas, because—it makes me question the value of anything and everything: including depression itself.

MATTHEW HUTSON is a science writer who's written for *Wired*, *The Atlantic*, and *The New York Times*. He is the author of *The 7 Laws of Magical Thinking*.

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Time Is Contagious

How to control the subjective experience of time

BY ALAN BURDICK

ON A RECENT SATURDAY morning, my wife, Susan, and I slipped into the city to visit the Metropolitan Museum of Art, a place we hadn't gone together since before our sons were born. The crowds hadn't yet descended and for an hour or so we wandered around and absorbed the cavernous hush of art. We separated for a bit, together but apart; while Susan roamed among the Manets and Van Goghs I slipped into a small side gallery, not much larger than a subway car, that held a series of glass cases with small bronze sculptures by Degas. There were a few busts and several horses in stride and the figure of a woman stretching, a small bronze rising to her feet and curling her left arm upward as if waking from a long nap.

At the end of the gallery, in one long case, were two dozen ballerinas in various states of motion or repose. One dancer was examining the sole of her right foot; another was putting on her stocking; a third stood with her right leg forward and her hands behind her head. Arabesque decant—tilted forward on one foot, arms outstretched, like a child imitating an airplane. Arabesque devant—upright on left leg, right leg pointed forward, left arm overhead. Their motion was frozen yet still fluid; I felt as though I had wandered into a rehearsal and the dancers had paused just long enough for me to appreciate the mechanics of their grace. At one point a group of young men wandered through whom I also took to be dancers. Their instructor said, "Quick, which one are you right now?" and they each picked out a bronze to emulate—the man nearest me with his right leg forward and his hands on his hips, elbows winged backward. "I like that you picked that one, John," the instructor said.

Time flies when you're having fun. It can slow in moments of duress, during a car crash or fall from a roof, or distort under the influence of intoxicants, moving faster or slower depending on the agent. There are myriad lesser-known ways to bend time too, and scientists are discovering more all the time.

ILLUSTRATION BY LEIGH WELLS

For instance, consider the two sculptures by Degas on this page and its opposite.

They belong to the series I was viewing, which demonstrates the dance positions across the range of exertion; the ballerina on the left is at rest and the ballerina on the right is executing the third movement of the great arabesque. The sculptures (and the images of them) aren't moving, but the ballerinas depicted seem to be—and that, it turns out, is enough to alter your perception of time.

In a study published in 2011, Sylvie Droit-Volet, a neuropsychologist at Université Blaise Pascal, in Clermont-Ferrand, France, and three co-authors showed images of the two ballerinas to a group of volunteers. The experiment was what's known as a bisection task. First, on a computer screen, each subject was shown a neutral image lasting either 0.4 seconds or 1.6 seconds; through repeated showings, the subjects were trained to recognize those two intervals of time, to get a feel for what each is like. Then one or the other ballerina image appeared onscreen for some duration in between those two intervals; after each viewing, the subject pressed a key to indicate whether the duration of the ballerina felt more like the short interval or the long one. The results were consistent: the ballerina en arabesque, the more dynamic of the two figures, seemed to last longer on screen than it actually did.

That makes a certain sense. Related studies have revealed a link between time perception and motion. A circle or triangle that moves quickly across your computer monitor will seem to last longer on screen than a stationary object does; the faster the shapes move, the bigger the distortion. But the Degas sculptures aren't moving—they merely suggest movement. Typically, duration distortions arise because of the way you perceive certain physical properties of the stimulus. If you observe a light that blinks every tenth of a second and simultaneously hear a series of beeps at a slightly slower rate—every fifteenth of a second, say—the light will seem to you to blink more slowly than it does, in time with the beep. That's a function of the way our neurons are wired; many temporal illusions are actually audiovisual illusions. But with Degas there's no time-altering property—no motion—to be perceived. That property is entirely

manufactured by, and in, the viewer—reactivated in your memory, perhaps even reenacted. That simply viewing a Degas can bend time in this way suggests a great deal about how and why our internal clocks work as they do.

One of the richest veins in temporal-perception research is on the effect of emotion on cognition, and Droit-Volet has conducted a number of compelling studies that explore the relationship. In a recent series of experiments, her subjects viewed a series of images of faces, each of which was neutral or expressed a basic emotion, such as happiness or anger. Each image lasted onscreen for anywhere from 0.4 seconds to 1.6 seconds, and the viewer was asked to say whether the image lasted for a "short" or a "long" time—that is, closer to one of the two standard durations they'd been trained beforehand to recognize. Consistently, viewers reported that happy faces seemed to last longer than neutral ones, and both angry and fearful faces seemed to last longer still. (The angry faces lasted even longer to 3-year-old children, Droit-Volet found.)

The key ingredient seems to be a physiological response called arousal, which isn't what you might think. In experimental psychology, "arousal" refers to the degree to which the body is preparing itself to act in some manner. It's measured through heart rate and the skin's electrical conductivity; sometimes subjects are asked to rate their own arousal in comparison to images of faces or puppet figures. Arousal can be thought of as the physiological expression of one's emotions or, perhaps, as a precursor of physical action; in practice there may be little difference. By standard measures, anger is the most arousing emotion, for viewer and angry person alike, followed by fear, then happiness, then sadness. Arousal is thought to accelerate our internal metronome, causing more ticks than usual to accumulate in a given interval, thereby making emotionally laden images seem to last longer than others of equal duration. In

A WRINKLE IN TIME Our perception of time is not constant, but rather changes with our experiences and environment.

JONATHAN KNOWLES

Droit-Volet's study, sad faces were deemed to last longer than neutral faces but not to the same degree as happy ones did.

Physiologists and psychologists think of arousal as a primed physical state—not moving but poised to move. When we see movement, even implied movement in a static image, the thinking goes, we enact that movement internally. In a sense, arousal is a measure of your ability to put yourself in another person's shoes. Studies find that if you watch an action—someone's hand picking up a ball, say—the muscles in your hand become primed for action. The muscles don't move, but their electrical conductivity rises as if they were prepared to do so, and your heart rate increases slightly too. Physiologically speaking, you're aroused. The same will occur if you merely observe a hand resting next to an object—presumably primed to pick it up—or even just a photograph of a hand holding the object.

A wealth of research suggests that this sort of thing goes on all the time in our daily lives. We mimic each other's faces and gestures, often unknowingly; various studies have found that subjects will imitate a facial expression even when, through laboratory trickery, they aren't aware that they're seeing a face. Moreover, this sort of mimicry induces physiological arousal and seems to open a path that helps us perceive emotions in others. Studies find that if you make a face as though you're expecting a shock, the actual shock, when it comes, will feel more painful. Exaggerating your facial expression while viewing pleasant or unpleasant film clips amplifies your heart rate and skin conductivity, the typical measures of physiological arousal. Studies using fMRI have found that the same areas of the brain are activated whether the subject experiences a particular emotion, such as anger, or observes a facial expression of it. Arousal signals a bridge to the interior lives of others. If you

see a friend feeling angry, you don't merely infer how she feels: You literally feel what she feels. Her state of mind, and state of motion, become yours too.

And so does her sense of time. In the last few years, Droit-Volet and others have demonstrated that when we embody another person's action or emotion, we embody the temporal distortions that come with it. In one experiment, Droit-Volet had her subjects view a series of faces—some elderly, some young—briefly on a computer screen, in no particular order or pattern. She found that the viewers consistently underestimated the duration of the elderly faces but not the young ones. In other words, when the viewers saw an elderly face, their internal clocks slowed down as if to "embody the slow movements of elderly people," Droit-Volet writes. A slower clock ticks less often in a given interval of time; fewer ticks accumulate, so the interval is judged to be briefer than it actually is. Perceiving or remembering an elderly person induces the viewer to reenact, or simulate, their bodily states, namely their slow movement. "By means of this embodiment," Droit-Volet writes, "our internal clock adapts to the speed of movement of elderly people and makes the elapsed stimulus duration feel shorter."

Or recall Droit-Volet's earlier experiment, in which participants reported that angry and happy faces seemed to last longer onscreen than neutral ones. She had attributed the effect to arousal but she began to suspect that embodiment might play a role too. Perhaps the subjects were mimicking the faces as they viewed them and the act of imitation was giving rise to the time distortion. So she ran the experiment again, with a critical difference: One group of participants was asked to view the faces while holding a pen between their lips, to suppress their facial expressions. Viewers without the pen significantly overestimated the duration of angry faces and moderately overestimated happy ones—but the other viewers, their lips and faces constrained, saw virtually no temporal difference between the emotional and the neutral faces. Time had been righted by, of all things, a pen.

This all leads to a strange and provocative conclusion: Time is contagious. As we converse with and consider one another, we step in and out of one other's experience, including the other's perceptions (or

We must put aside the idea of a single time.

The time I perceive isn't soley mine.

what we imagine to be another's perception, based on our own experience) of time. Not only does duration bend, we are continuously sharing these small flexions among us like a currency or social glue. "The effectiveness of social interaction is determined by our capacity to synchronize our activity with that of the individual with whom we are dealing," Droit-Volet writes. "In other words, individuals adopt other people's rhythms and incorporate other people's time."

Our shared temporal distortions can be thought of as manifestations of empathy; after all, to embody another's time is to place oneself in his or her skin. We imitate each other's gestures and emotions—but we're more likely to do so, studies find, with people with whom we identify or whose company we would like to share. Droit-Volet found this to be true in her study of faces: Viewers perceived elderly faces as lasting less long onscreen than young ones, but only when the viewer and the viewed belonged to the same gender. If a man viewed an elderly female face, or a woman viewed an elderly male face, there was no temporal illusion. Studies of ethnic faces have reported a similar effect: Subjects overestimate the duration of the angry faces compared to neutral ones, but the effect is more likely and pronounced when both the viewer and the face are of the same ethnicity. Droit-Volet found that the viewers most likely to overestimate the duration of angry faces were those who measured highest on a standard test for empathy.

We step out of ourselves and into one another all the time, but we enter these exchanges with inanimate objects too—faces and hands, pictures of faces and hands, and other figurative objects, such as the balletic sculptures of Degas. Droit-Volet and her co-authors of the Degas paper argue that the reason the more dynamic sculpture appears to last longer on screen—the reason it's physiologically arousing in the first place—is that "it involved the embodied

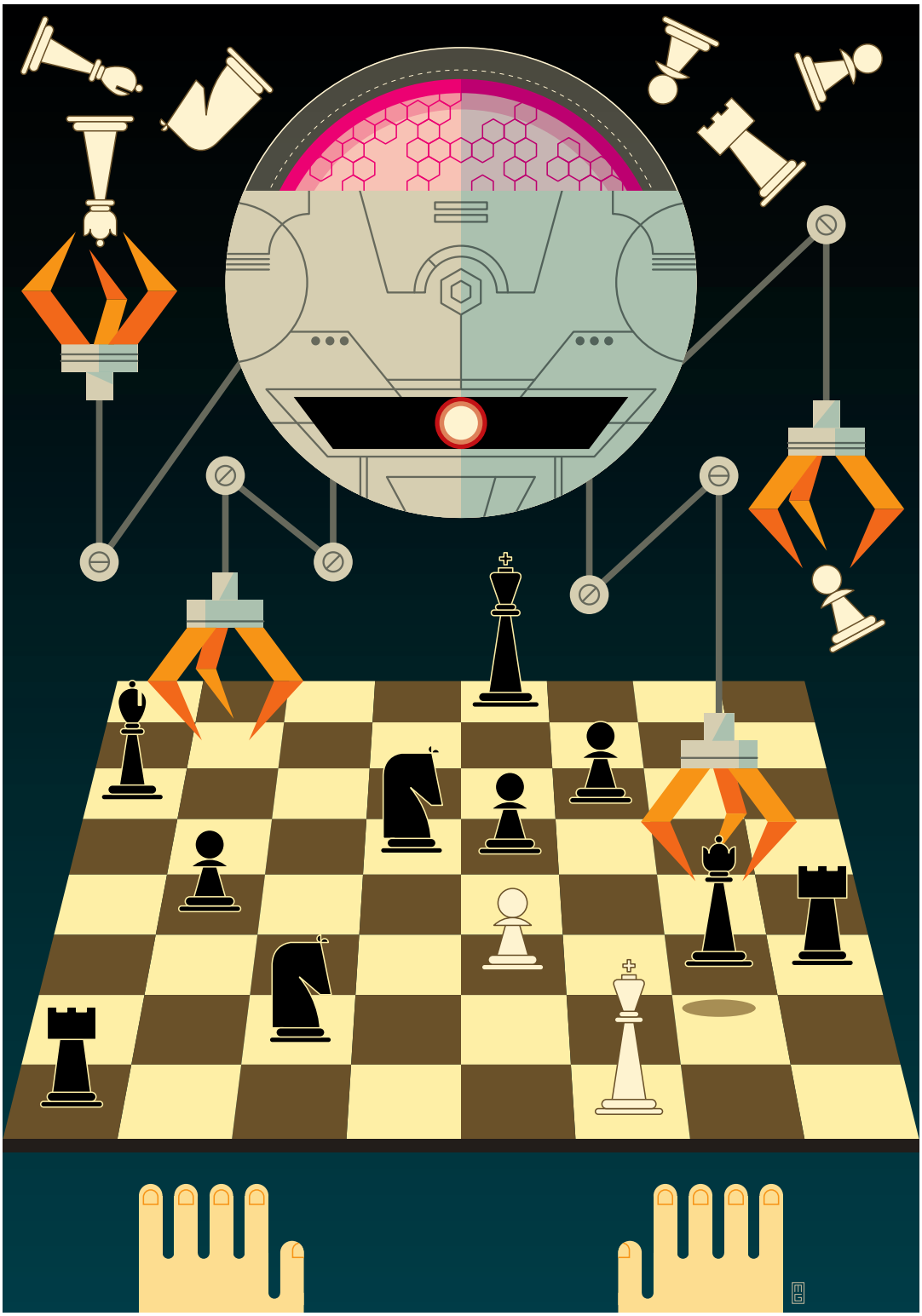
simulation of a more effortful and arousing movement." Presumably this is what Degas had in mind all along: an invitation to participate, an inducement to even the most lead-footed observer to step inside. I see a sculpture of a ballerina bending forward on one foot and, in a small, outwardly imperceptible yet essential way, I'm right there with her, performing my own internal arabesque. I am bronzed with grace and, in the moment of my gaze, time bends to me.

Emotional faces, moving bodies, athletic sculptures—all can induce temporal distortions, and in a manner that can be explained with the common psychological model of how the mind processes duration. Yet Droit-Volet still finds the effect puzzling. Clearly, life dictates that we possess some sort of internal mechanism to keep time and monitor brief intervals—yet the one we have can be thrown off course by the least emotional breeze. What's the point of owning such a fallible clock?

Maybe there's a better way to think about it, Droit-Volet suggests. It's not that our clock doesn't run well; on the contrary, it's superb at adapting to the ever-changing social and emotional environment that we navigate every day. The time that I perceive in social settings isn't solely mine, nor is there just one cast to it, which is part of what gives our social interactions their shading. "There is thus no unique, homogeneous time but instead multiple experiences of time," Droit-Volet writes in one paper. "Our temporal distortions directly reflect the way our brain and body adapt to these multiple times." She quotes the philosopher Henri Bergson: "*On doit mettre de côté le temps unique, seuls comptent les temps multiples, ceux de l'expérience.*" We must put aside the idea of a single time, all that counts are the multiple times that make up experience.

Our slightest social exchanges—our glances, our smiles and frowns—gain potency from our ability to synchronize them among ourselves, Droit-Volet notes. We bend time to make time with one another, and the many temporal distortions we experience are indicators of empathy; the better that I'm able to see myself in your body and your state of mind, and you in mine, the better we can each recognize a threat, an ally, a friend, or someone in need. But empathy is a fairly sophisticated trait, a mark of emotional adulthood; it takes learning and time. As children grow and develop empathy, they gain a better sense of how to navigate the social world. Put differently, it may be that a critical aspect of growing up is learning how to bend our time in step with others. We may be born alone, but childhood ends with a symphony—a synchrony—of clocks, as we lend ourselves fully to the contagion of time.

ALAN BURDICK is a staff writer and former senior editor at *The New Yorker*. His writing has also appeared in *The New York Times Magazine*, *Harper's*, *GQ*, *Discover*, and *Best American Science and Nature Writing*, among others. His first book, *Out of Eden: An Odyssey of Ecological Invasion*, was a National Book Award finalist and won the Overseas Press Club Award for environmental reporting.



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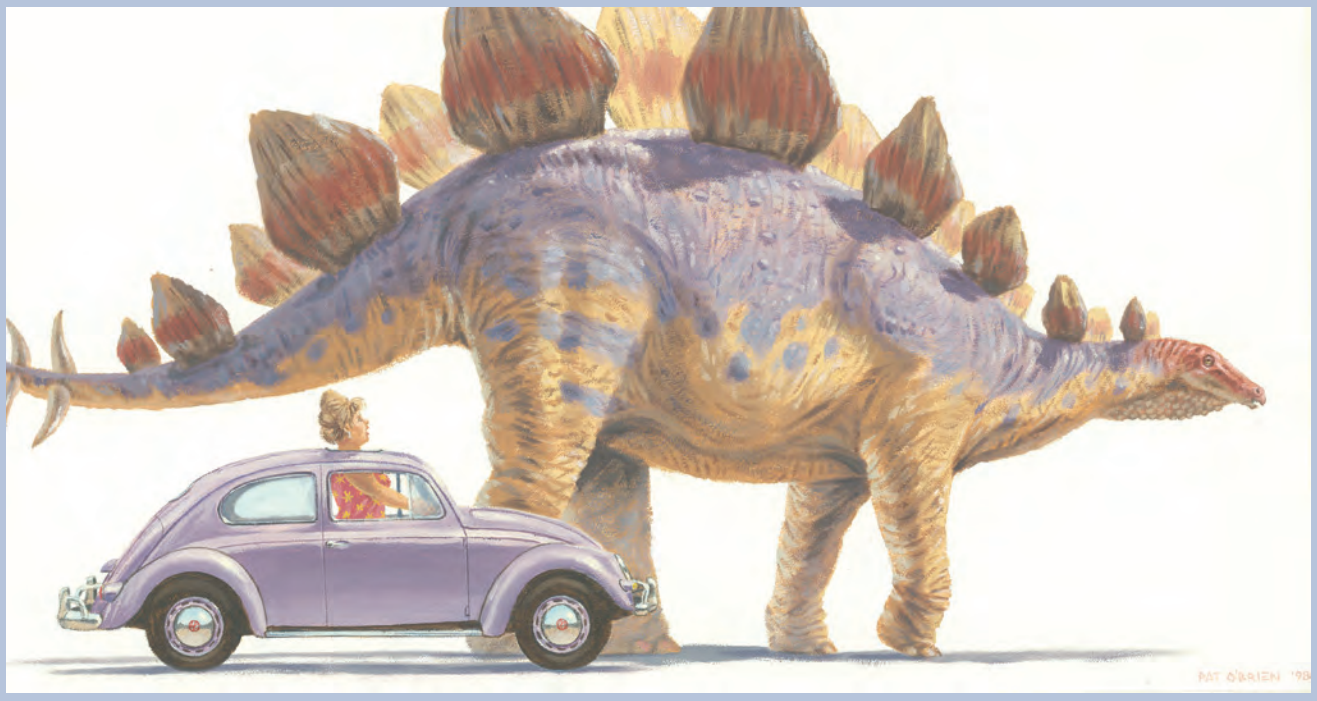

Pat O'Brien, *"Dinosaur and Volkswagen" Gigantic*, 1998 Oil on canvas. From the collection of The Mazza Museum of International Art from Picture Books, University of Findlay, Ohio.

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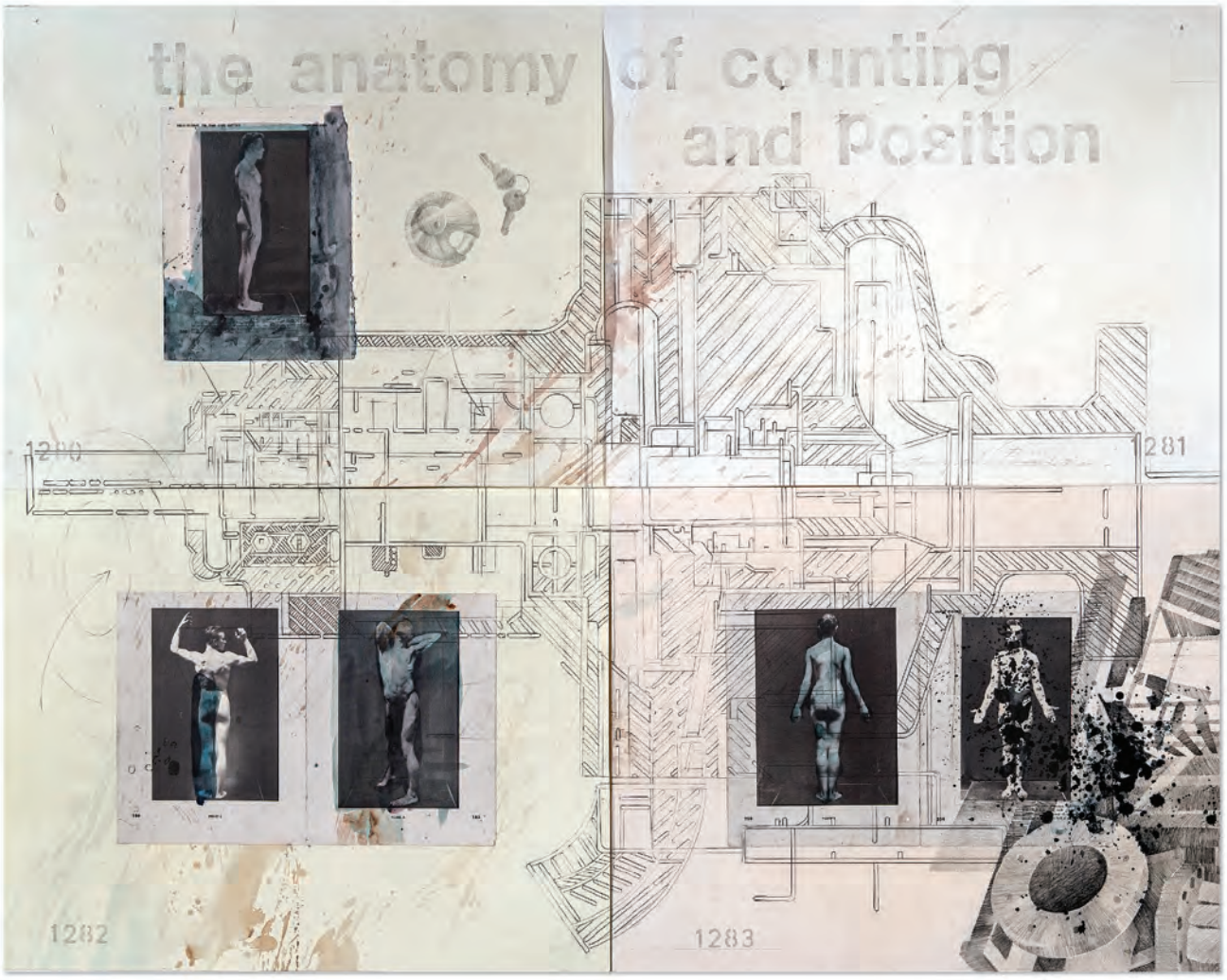

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Above: James Drake, *The Anatomy of Counting and Position*, drawings #1280-1283, 2014 graphite, ink, charcoal, and book pages on paper, 38" x 48"


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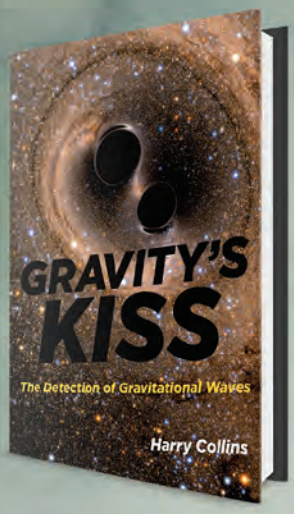

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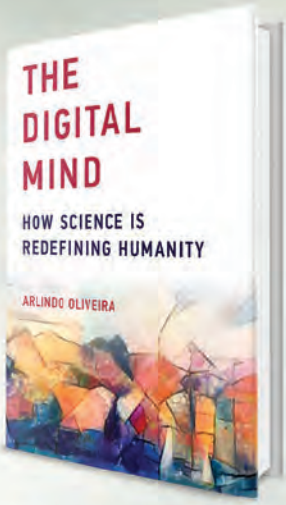

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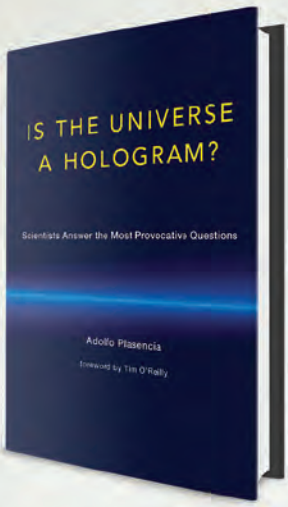

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Adolfo Plasencia

foreword by Tim O'Reilly

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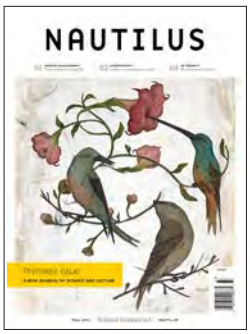

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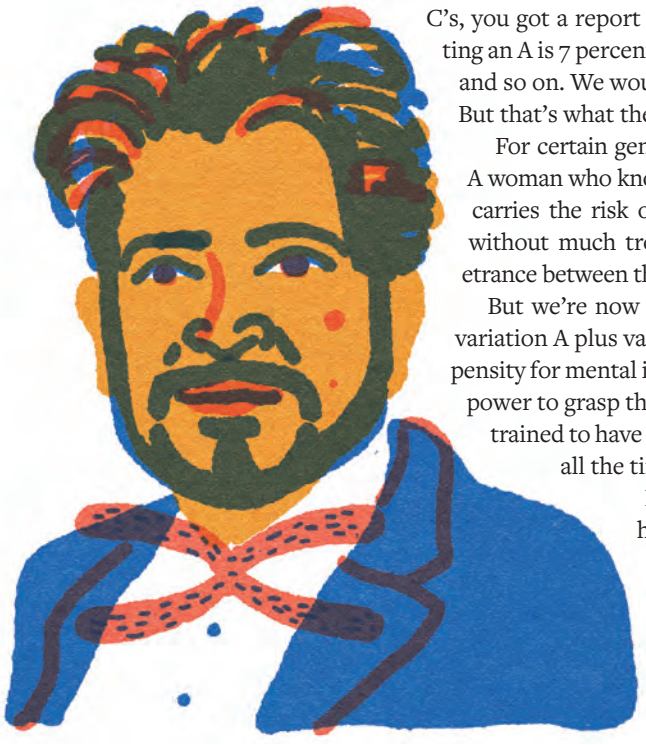
Siddhartha Mukherjee

The oncologist and author of The Gene: An Intimate History *reflects on the themes in* Nautilus

INTERVIEW BY MICHAEL SEGAL

ON LUCK Genes can be understood as lenses through which chance is refracted. They allow plenty of space for us to interact with environments and with random acts of fate and chance, and thereby, in a kaleidoscopic way, create different outcomes, different cells, different beings, different individuals. If you change the lens, change the genetic makeup, you will get a different refraction, but it only exists as an intersection between destiny, chance, environment, and genes themselves.

This creates a compartmentalization of destiny. Rather than speaking about destiny as if it was a gray cloud, we can begin to speak about it in terms of very incisive information about particular genomes correlating or coexisting with particular environments. We could then ask the question "what happens when you put schoolchildren with these kinds of genes versus schoolchildren with those kinds of genes in the same classroom?" The appropriate dissection of these interactions allows us to manipulate and understand human beings to profound effect, and with profound danger.



ON POWER What if instead of getting a report card with A's, B's and C's, you got a report card which said that your propensity for getting an A is 7 percent, your propensity for getting a B is 24 percent, and so on. We would not know how to judge your performance. But that's what the genomic report card can look like.

For certain genes, the genomic report card can be clarifying. A woman who knows that she has a *BRCA1* mutation knows she carries the risk of breast and other cancers. We process that without much trouble because there is a high degree of penetrance between the genetic variation and the final outcome.

But we're now asking more complicated questions. What if variation A plus variation C plus variation D increased your propensity for mental illness by 18 percent? Do we have the narrative power to grasp that? I'm not sure we do. Even doctors who are trained to have this kind of Bayesian narrative power struggle all the time.

Remember, though, that narrative powers in human beings change. We didn't have the narrative power to deal with vast amounts of simultaneous information streaming into us. And yet in 10 years that's become part of our lives.

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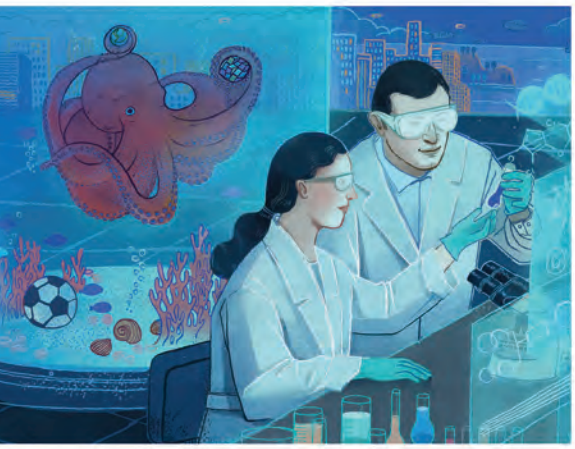

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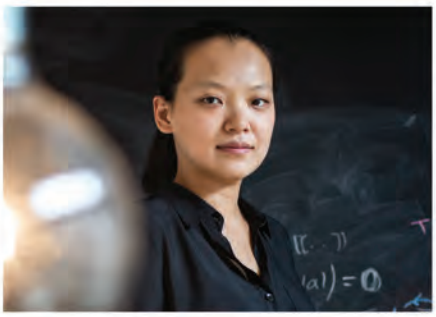

MATHEMATICS

Miranda Cheng is chasing a mysterious link between string theory, algebra and number theory.

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