WHAT SOCIAL MEDIA IS DOING TO JOB HUNTERS page 42

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

July/August 2013
Mind.ScientificAmerican.com

Bored to Death

Yes, it can happen
page 54

True Grit

6 *science-tested* tips for building your resilience

Teen Brains on Alcohol

Growing Out of Autism

Can Caresses Treat Stroke?

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The Resilient Brain

What does it mean to be resilient? As our art director Patti Nemoto put it, "It's kind of like being Gumby." The green clay character bounces back from any setback—becoming stranded on the moon, getting turned into a robot, dissolving into a puddle. In the U.S. Marine Corps, where flexibility in changing circumstances can be lifesaving, a common saying is "Semper Gumby."

Adaptability in the face of challenges predicts success across many pursuits. As psychologists Steven M. Southwick and Dennis S. Charney write in our cover story, "Ready for Anything," taming our emotions, exercising regularly and strengthening our social ties can help us shake off misfortune. Turn to page 32 for more.

Recovery is not always under our conscious control, of course. Among the most common and lethal medical events is stroke, suffered by nearly one million Americans every year. Journalist Stephani Sutherland describes how an observation in the lab has excited researchers hunting for treatments: simply wiggling a rat's whisker in the moments after a stroke saved the rodent's brain from damage. Scientists are now seeking the human equivalent of tickling a whisker, such as caressing the lips or fingertips. See "A Magic Touch for Stroke Prevention?" on page 48.

Sometimes health threats are subtle, chipping away at well-being over decades. Take boredom. We have all experienced tedium, but chronic boredom has serious consequences: increased risk of cardiac events, higher rates of depression and shorter lives. In "Descent of the Doldrums," on page 54, psychologist James Danckert posits that boredom may emerge from an errant sense of what is new versus old and familiar.

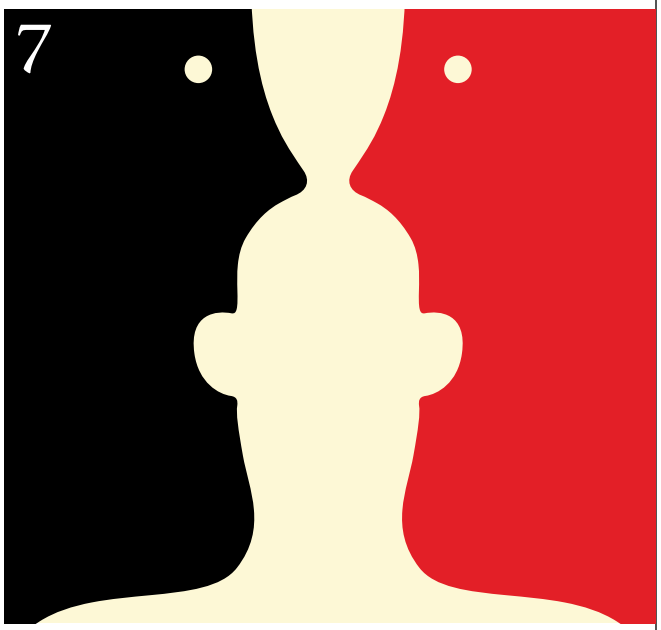
Speaking of novelty, you can now read this magazine on the iPad. Subscribe by visiting ScientificAmerican.com/Mind/tablet or check out our free issue by going to the Apple App Store on your iPad. And in March we launched a new home page and blog network at Mind.ScientificAmerican.com. As they say, Semper Gumby.

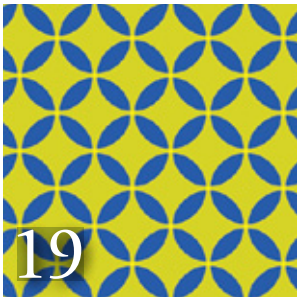
Sandra Upson
Managing Editor
editors@SciAmMind.com

SCIENTIFIC AMERICAN MIND
Volume 24, Number 3, July/August 2013

FEATURES

DEPARTMENTS





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BE MINDFUL OF HYPNOSIS

As the author of the book *Mindfulness and Hypnosis: The Power of Suggestion to Transform Experience* (W. W. Norton, 2011), I suggest there is much to be gained by studying the relation between clinical hypnosis and mindfulness, which Amishi P. Jha wrote about in "Being in the Now." Just as people experience perceptual shifts, sensory shifts, physiological alterations, cognitive changes, and more during mindful experiences, so do they in response to suggestions given in *any* similarly focused and responsive state, such as during hypnosis.

The difficult questions mindfulness practitioners must eventually answer are the same ones hypnosis researchers and practitioners have been studying for a much longer time. These include: How does a suggested experience transform into a genuinely "felt" experience? Is everyone capable of focused attention to the same degree? Are there mindful approaches that may generate undesirable effects?

Mindfulness works, but to better understand how, we need more cross-fertilization of ideas and methods between mindfulness and parallel approaches such as clinical hypnosis.

Michael D. Yapko
Fallbrook, Calif.

HAPPINESS NOW OR LATER

I'm wondering if you have a deliberate editorial policy of having adjacent articles contradict each other. In the current issue we have "Being in the Now," by Amishi P. Jha, closely followed by "Time-Warping Temptations," by David H. Freedman, which advises us not to live in the now. My life has been very instructive in this regard: When I lived in the now, it was always about doing things that messed me up in the long run; whenever I resisted temptation, invested in the future and stalwartly did not yield to impulse, I missed a lot of fun and never got my long-run payoff. After a lifetime of this, it seems to me that a first approximation to wisdom might counsel that impulses for honest, nondamaging fun should not be resisted (things won't be better later!) but that one should invest in the future if it's something you like doing now and will like better later on.

Meanwhile I hope these articles that contradict each other will continue! They make the reader think.

E. N. Anderson
Riverside, Calif.

THE EDITORS REPLY: *You seem to have solved the contradiction. Research says we should live in the moment as a rule, as a way of appreciating life as it passes by. Doing so will help us stay calm and be happy, according to work by Jha and others. But when we are faced with a decision that pits immediate impulses against our long-term goals, we should generally not choose what would make us happy immediately, as Freedman explains.*

Most of the day, though, we are not faced with such choices, and so we can appreciate the sights, sounds and other sensations of the day, as well as the many immediate joys—such as finishing a project or watching the home team win a game—that do not come in conflict with any long-term goals.

NOT NECESSARILY DEMENTIA

As an enthusiastic reader of *Scientific American Mind,* I was disappointed

to see the magazine peddling inaccurate myths about mild cognitive impairment (MCI) in "Is Cocoa the Brain Drug of the Future?" by Daisy Yuhas [Head Lines]. The article misleadingly states that MCI is a "precursor to Alzheimer's disease." The fact is that MCI is still a controversial clinical construct. Most unbiased studies show that individuals with the "condition" either stay stable or recover within any given assessment period (no studies appear to have assessed cognition for longer than a 10-year period). Thus, because only a minority of people with MCI progress to dementia, it hardly qualifies as a blanket precursor to Alzheimer's. Currently the best measures of preventing dementia (including Alzheimer's) relate to maintaining a healthy lifestyle, reducing obesity and preventing the onset of type 2 diabetes.

John Anderson
Cardiff, Wales

YUHAS RESPONDS: You are quite right that MCI remains a relatively recent and controversial concept. Mayo Clinic researchers created the diagnosis "mild cognitive impairment" to identify elderly individuals in the earliest stages of dementia. Although a minority of those with MCI transition to Alzheimer's disease each year (just 10 to 15 percent), studies have suggested that within a six-year period roughly 60 to 80 percent will develop dementia. It is also true that between 15 and 20 percent of individuals diagnosed with MCI appear to revert back to a healthier state; however, this finding may reflect flaws in methodology. For instance, some diagnoses are based on only one test, which can result in a high rate of false positives.

Nevertheless, it is important to highlight—as you have done—the reality that not everyone diagnosed with MCI will develop Alzheimer's or a similar severe dementia. I regret that the description in my article overstated the relation.

DRIVE LIKE A PILOT

I had to chuckle about #2, "Put your cell phone in the trunk," on your list of tips in "How to Be a Better Driver," by Sunny Sea Gold [Head Lines]. Anyone who has learned to fly has heard that you must "aviate, navigate, then communicate" for the very reasons you mention, among others. It seems to me that most people seriously underestimate how much their attention is diverted by taking or making a phone call while driving. I know for certain that mine is, so I ignore my phone when it rings while I'm driving. I'm not even entirely sold on talking GPS in cars for the same reason—they can distract a driver at the wrong time.

As far as #5 goes, I came to the conclusion decades ago that it was safest to assume all other drivers are "out there to kill me," as psychologist Paul Atchley says. Indeed, I taught our kids to drive with that in mind.

"Gregg"
via e-mail

DIVORCED DADS

I found "Is Divorce Bad for Children?" by Hal Arkowitz and Scott O. Lilienfeld [Facts and Fictions in Mental Health], important to me as a divorced father. There was a reference to people whose parents split up when they were young as having greater relationship difficulties.

When divorced parents have shared custody, how are kids affected?

When our twin boys were age four, their mother and I divorced, sparing the children, now age 11, from hearing our arguments. We have 50 percent shared custody, which is facilitated by us living in the same town. Every Monday, Tuesday and Wednesday are my custody days, every Thursday, Friday and Saturday are their mother's, and we alternate Sundays. My ex and I get along better now than when we were married, and the children have a balance of time with each parent.

Arkowitz and Lilienfeld made reference to the "noncustodial father" but not to the shared joint custody one. We are alive and well! Don't overlook us!

Joseph Gironda
Bayonne, N.J.

SWITCHING HANDS

I was very interested in "Can Training to become Ambidextrous Improve Brain Function?" by Michael Corballis [Ask the Brains]. I'm a professional trumpet player, and for many years I've spent some of my practice time playing left-handed, rather than the usual right. The theory is, if you practice a tough passage left-handed, it will be easier when you go back to your right hand—perhaps because the right side of the brain can now help the left. I hope that it will also open up new synapses and eventually help to stave off dementia.

In the meantime, my left-handed practice has paid off in a very practical way when I have injured my right hand and needed to play gigs left-handed.

Mike Kaupa
via e-mail

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ERRATUM

In "Shaping Perception," by Brian Mossop [Reviews and Recommendations, May/June 2013], the name of the author of *Drunk Tank Pink* is misspelled in two places; his name is Adam Alter. We regret the error.

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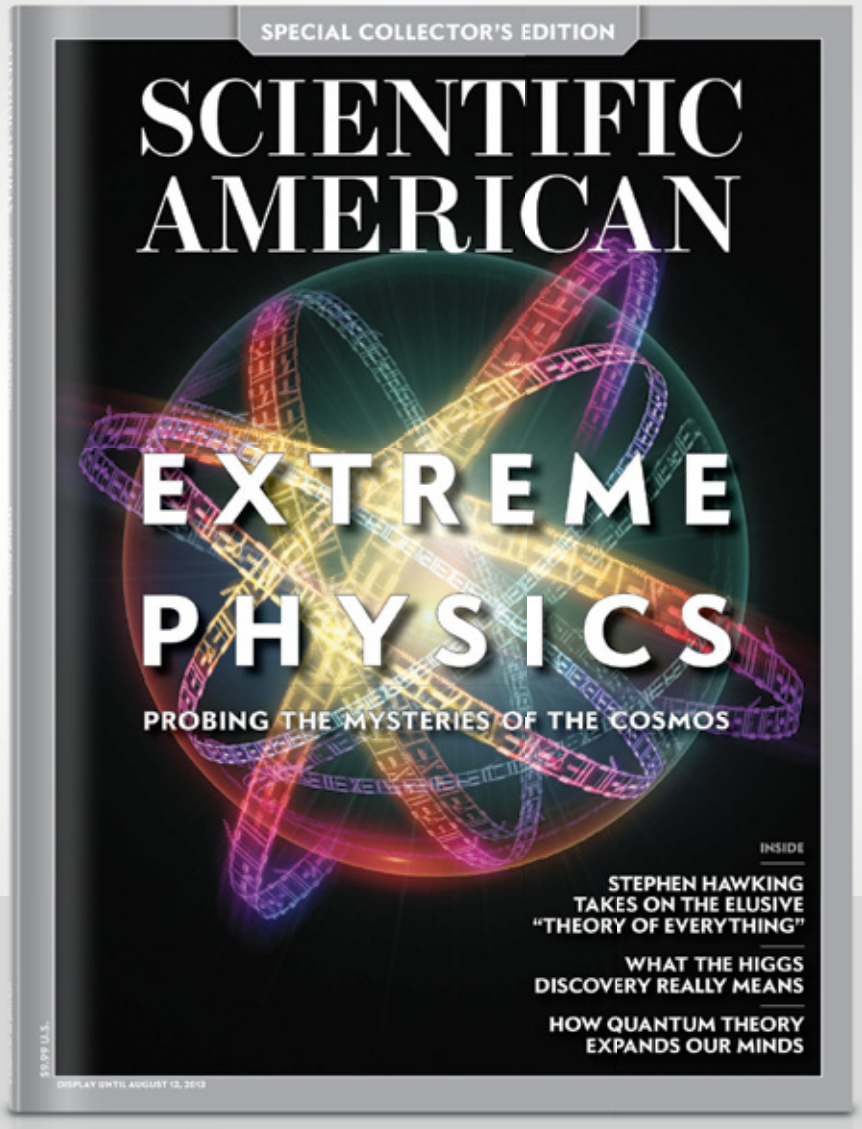

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Head Lines

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Who Are You (Today)?

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M NEWS FROM OUR WEB SITE Bullies suffer for their actions. They tend to feel guilt, shame, anger and a sense of social disconnection.

» **Temperament** How we grow over time

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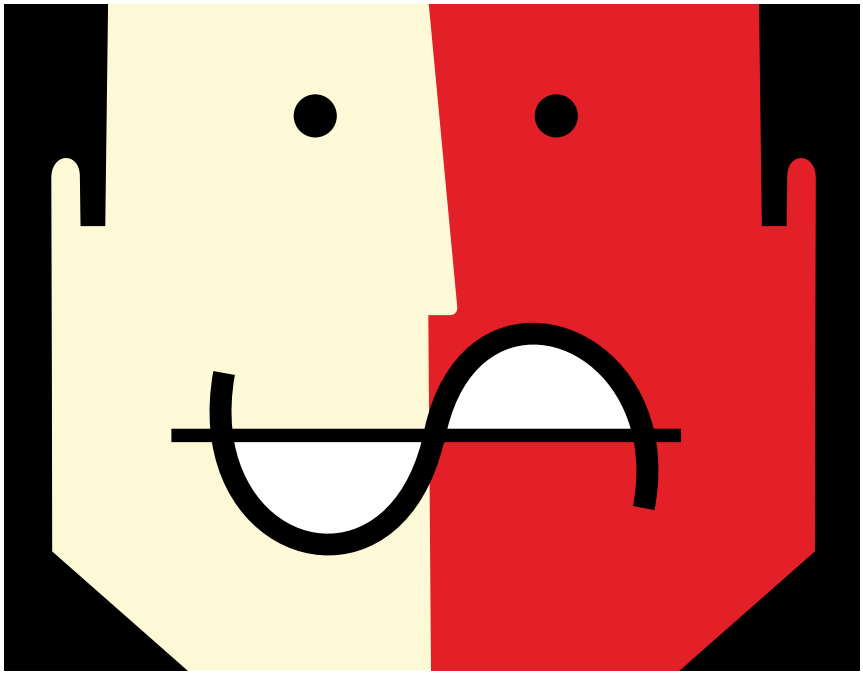
Life Satisfaction Linked to Personality Changes

Character trumps economic concerns to influence our happiness



Despite the long-held belief that personality traits are set in stone, numerous studies have found evidence to the contrary (*timeline below*). Now research reveals that a changing character can influence life satisfaction even more than economic upheaval.

Past studies have revealed that personality is the single biggest factor in how we perceive our own well-being, accounting for 35 percent of individual differences in life satisfaction. Research on well-being, however, has focused on less important factors, such as income and job status, because of the misperception that personality is generally fixed after early adulthood.

The new study, published in March in *Social Indicators Research,* investigated how evolving character traits relate to life satisfaction. Researchers at the University of Manchester in England assessed 8,625 people aged 15 to 93 at two points, four years apart. They measured the Big Five personality traits (openness to experience, conscientiousness, extroversion, agreeableness and neuroticism) and tracked fluctuations in external aspects of subjects' lives, including marital status, income and employment status.

The data reveal that the participants' character changed during those four years at least as much as demographic factors, such as marital status or employment. And those small personality shifts were more closely tied to life satisfaction than the other indicators were. For instance, people who grew less agreeable reported feeling less fulfilled in life than they had felt four years earlier, whereas those who became more open reported greater contentment.

This study did not attempt to find out

Flexible Facets Some personality traits may be more malleable than others. A study from the March *International Journal of Geriatric Psychiatry* found that 75-year-olds in the 1970s were less extroverted than 75-year-olds in the 2000s, though equally neurotic. The findings suggest that extroversion may be more susceptible to environmental influences than neuroticism is. —*T.R.*

Our Peripatetic Personality

Decades of studies slowly overturn the belief that our character is stable.

1976 Research confirms the widely held idea that a person's personality remains stable from early adulthood to old age.

1988 Self-reports from men and women aged 21 to 96 and ratings from spouses suggest that adult personality is static after about age 30.

1997 A study suggests personality may still be malleable in adulthood. Women aged 27 to 43 exhibited increases in industriousness, assertiveness and confidence after experiencing success at work.

2003 Further evidence emerges that personality changes over time. Adults aged 21 to 60 reported increases in conscientiousness and agreeableness with age and, in women, decreases in neuroticism.

M Creativity is often overlooked in schools. Only nine U.S. states include creativity as a criterion for gifted education. | Rats who were tickled once

what caused the subjects' personalities to transform, but other recent work has shown that certain experiences can change specific traits. For instance, psychological trauma—such as that experienced by combat soldiers—has been linked with decreases in agreeableness and conscientiousness (for more examples, see below).

Scientists have also successfully designed programs to increase openness, which tends to predict better health and a longer life. A December 2012 experiment published in *Psychology and Aging* found that a training program increased openness among older adults. A different study found that openness grew with the enhanced bodily awareness that comes from dancing and possibly other forms of physical activity.

"Not only does personality change occur, but it is an important influence and a possible route to greater well-being," says research psychologist Christopher Boyce, now at the University of Stirling in Scotland, lead author of the *Social Indicators Research* study.

—Tori Rodriguez

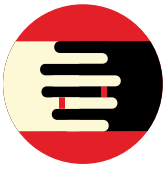
Forces of Personality Change

Greater job satisfaction
Decreases neuroticism and increases extroversion

Stronger relationships
Increase conscientiousness, agreeableness and extroversion and decrease neuroticism

Taking antidepressants
Increases extroversion and decreases neuroticism in depressed individuals; effects on personality were separate from those on depression

Divorce
Increases extroversion and openness in women



Remarriage
Decreases neuroticism in men

Intensive drug counseling
Enhances agreeableness and conscientiousness in addicts

SCOTT DUNLAP *iStockphoto (sun icon)*; ISTOCKPHOTO *(orange and yellow background)*

2006
A meta-analysis finds that throughout adulthood, people become more open, extroverted, conscientious and emotionally stable, but some of these traits—openness and extroversion—start to decline in old age.

2011
New work indicates personality changes may follow a bell-curve trajectory, with emotional stability, extroversion, openness and agreeableness increasing until midlife (aged 40 to 60) and decreasing after that; conscientiousness, however, rises with age.

2013
A study reveals that shifts in personality over time predict well-being and life satisfaction: increases in agreeableness and extroversion, for example, are linked to greater life satisfaction.

ON THE HORIZON

Nanotechnology That Detects and Treats Alzheimer's

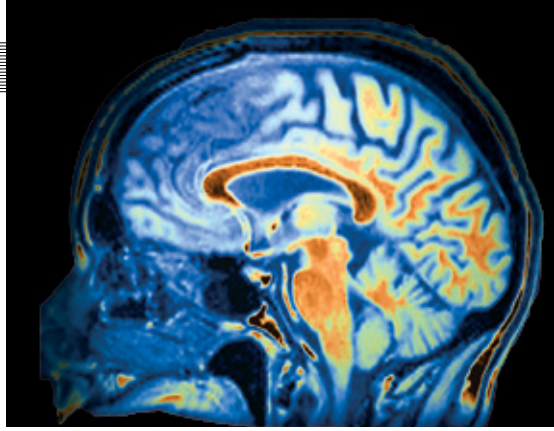
A quick sniff of a nasal spray sends microscopic metal particles into the brain, where they target and destroy the damaging proteins of Alzheimer's disease. No Alzheimer's? No problem—the metal particles pass out of the body safely. Such is the promise of technology being developed by neuroscientist William Klein and nanotechnologist Vinayak Dravid of Northwestern University. The pair has invented a nanotech-based early-detection system that might one day deliver targeted treatments.

Klein and Dravid created an antibody—an immune molecule that detects specific chemical structures—that binds to a particle implicated in Alzheimer's. They linked the antibody to a nanoscale arrangement of iron oxide compounds, similar to rust, which can be seen with magnetic resonance imaging. The brain scan could detect the disease early on, so patients can start treatment sooner than they can today. "Once the chain reaction of negative events starts, it's like a lit fuse. You want to intervene as soon as possible," Klein says.

Globs of beta-amyloid protein called plaques are a hallmark of Alzheimer's. But these days most neuroscientists agree that a tiny particle form of the same protein, called an oligomer, is the primary toxin in the illness. Eventually these smaller structures glom together to form plaques, but by then they have already damaged brain cells. The antibody created at Northwestern binds to the toxic oligomers and could one day deliver therapies to the brain or help clinicians evaluate how a patient is responding to a new medication.

So far the researchers have used the probe to distinguish between diseased and healthy human brain samples. The next step, slated for later this year, is to see if they can do the same in the brains of living mice. Already a nasal spray has successfully delivered the nanoparticles to a mouse's brain, most likely the same delivery method that would work for us humans. *—Stephani Sutherland*

a day for two weeks later responded less to stress. | In a major advance, scientists created a see-through brain by replacing its lipids with a hydrogel.



SCIENCE SOURCE (*brain scan*); ISTOCKPHOTO (*money*)

FACT CHECK

PUSHING THE LIMITS OF BRAIN SCANS

THE CLAIM: Mental illness can be diagnosed with brain scans.

THE FACTS: Currently the technique *might* be able to diagnose people with a single, unambiguous, chronic illness but not tougher clinical cases.

THE DETAILS

One common complaint about psychiatry is its subjective nature: it lacks definitive tests for many diseases. So the idea of diagnosing disorders using only brain scans holds great appeal. A paper published recently in *PLOS ONE* describes such a system, although it was presented only as an initial proof of concept. News reports, however, trumpeted the advent of "objective" psychiatric diagnoses.

The paper used data from several earlier studies, in which researchers outlined key brain regions in MRI scans of people with bipolar disorder, ADHD, schizophrenia or Tourette's syndrome; people with low or high risk of developing major depressive disorder; and a healthy group. The scans were also labeled with the disorder or depression risk level of the original study participant.

In the new study, scientists divided the scans randomly into two sets, one to build the diagnostic system and the other to test it. Their software then grouped the scans in the first set by the shape of various regions. Each group was labeled with the most common diagnosis found within it.

During testing, the system analyzed the shapes of brain regions in each test scan and assigned it to the group it most resembled. The scientists checked its work by comparing the new labels on the test scans with the original clinical diagnoses. They repeated the procedure several times with different randomly generated sets. When the system chose between two disorders or one ailment and a clean bill of health, its accuracy was nearly perfect. When deciding among three alternatives, it did much worse.

REALITY CHECK

Brain scans CAN identify:

- Brain cancer
- Damage to brain tissue or vessels, as well as skull fracture
- Bleeding or blood clots in stroke
- Some indications of Alzheimer's disease

THE CAVEATS

- **The brain-scan system will probably struggle with patients who have more than one diagnosis.** Only chronically ill patients with a single, unambiguous diagnosis were used in the study. In the real world, individuals often cope with confusing lists of symptoms and receive multiple diagnoses, some of which may change over time. Seth Gillihan, assistant professor of psychology at Haverford College, explains, "I'd expect [multiple diagnoses] would be a considerable problem, given the difficulty the system had trying to assign people to one of three [rather than two] categories." Because these patients would presumably benefit most from an objective method of diagnosis, the clinical usefulness of the system remains questionable.
- **Brain scans may not be able to detect early stages of a disease.** In theory, an objective method of psychiatric diagnosis could avoid the suffering and cost that an initial misdiagnosis and subsequent mistreatment might cause. The patients in this study, however, had been ill for an average of more than 10 years, so whether the system can detect a disorder in its early stages is unknown. Gillihan speculates that early diagnosis "is likely to be a harder problem assuming that these conditions change the brain."
- **The system uses diagnostic categories that might not be biologically valid.** Our understanding of brain disorders continues to evolve as genetics reveals how disorders overlap and relate to one another. For instance, some patients exist at the extremes of the distinction between schizophrenia and bipolar disorder, but "in the real world, a very large fraction have shared or overlapping symptoms," and the two disorders share a majority of their genetic risk factors, according to Steven Hyman, director of the Broad Institute's Stanley Center for Psychiatric Research in Cambridge, Mass. Hyman thinks we will eventually be able to classify disorders by their underlying biology, but our diagnostic system will likely undergo radical changes once that starts happening.

—*Simon Makin*

Average cost of a brain MRI scan in the U.S.: **$2,550**

Cost of a visit to a psychiatrist or mental health professional: **$200–$400 an hour**

COMMON COMORBIDITIES

70 Percentage of children with autism who are diagnosed with another mental disorder, most commonly social anxiety disorder or attention-deficit hyperactivity disorder

50 Percentage of people with schizophrenia who also receive a diagnosis of depression

38 Percentage of women with an anxiety disorder who are also diagnosed with a mood disorder; 30 percent of men are diagnosed with both

M Neuroscientists have recorded videos of zebra fish brains in action. The technology detected 80 percent of their 100,000 neurons.

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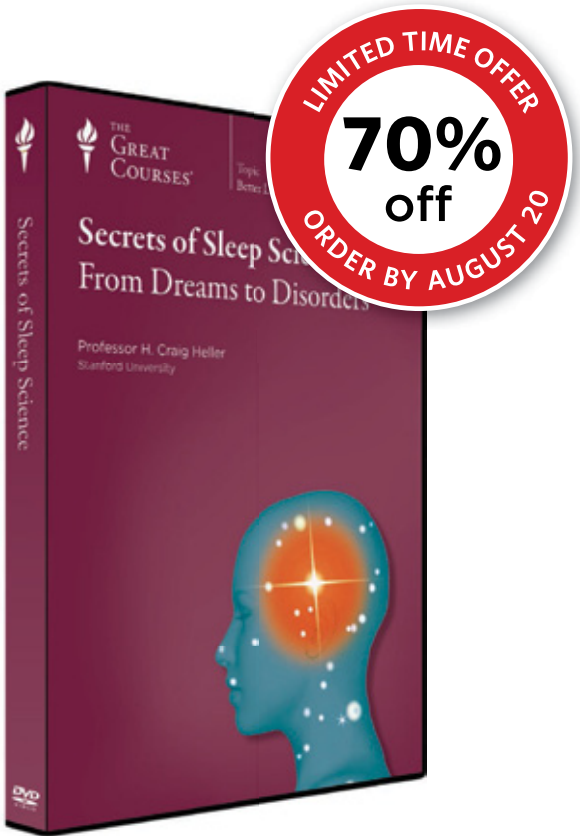

Why Do We Sleep?

For many of us, sleep is one of life's greatest pleasures. For others, it represents a nightly struggle. But what is sleep exactly, and why must we do it every night? Despite spending one-third of our lives in slumber, scientists still aren't certain. What *is* clear: Sleep impacts virtually every aspect of our lives, from our mood to the functioning of our organs.

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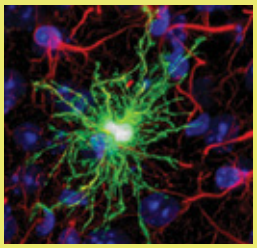
Human Cells Make Mice Smarter

Implanting our larger support cells allowed the rodents' brains to work faster



Astrocyte nerve cell

In spring a band of brainy rodents made headlines for zipping through mazes and mastering memory tricks. Scientists credited the impressive intellectual feats to human cells transplanted into their brains shortly after birth. But the increased mental muster did not come from neurons, the lanky nerve cells that swap electrical signals and stimulate muscles. The mice benefited from human stem cells called glial progenitors, immature cells poised to become astrocytes and other glia cells, the supposed support cells of the brain.

Astrocytes are known for mopping up excess neurotransmitters and maintaining balance in brain systems. During the past couple of decades, however, researchers started suspecting astrocytes of making more complex cognitive contributions. In the 1990s the cells got caught using calcium to accomplish a form of nonelectrical signaling. Studies since then have revealed how extensively astrocytes interact with neurons, even coordinating their activity in some cases.

Perhaps even more intriguing, our astrocytes are enormous compared with the astrocytes of other animals—20 times larger than rodent astrocytes—and they make contact with millions of neurons apiece. Neurons, on the other hand, are nearly identical in all mammals, from rodents to great apes like us. Such clues suggest astrocytes could be evolutionary contributors to our outsized intellect.

The new study, published in March in *Cell Stem Cell*, tested this hypothesis. A subset of the implanted human stem cells matured into rotund, humanlike astrocytes in the animals' brains, taking over operations from the native mouse astrocytes. When tested under a microscope, these human astrocytes accomplished calcium signaling at least three times faster than the mouse astrocytes did. The enhanced mice masterfully memorized new objects, swiftly learned to link certain sounds or situations to an unpleasant foot shock, and displayed unusually savvy maze navigation—signs of mental acuity that surpassed skills exhibited by either typical mice or mice transplanted with glial progenitor cells from their own species.

Alexei Verkhratsky, a glia researcher at the University of Manchester in England who was not involved in the mouse study, calls the work "truly remarkable," both conceptually and technically. He notes that the new results do not necessarily conflict with astrocytes' support role. Rather, Verkhratsky argues, the apparent advantages afforded by human astrocytes may be a consequence of their housekeeping abilities, underscoring the interdependence between glia and neurons. —*Andrea Anderson*

FROM "FOREBRAIN ENGRAFTMENT BY HUMAN GLIAL PROGENITOR CELLS ENHANCES SYNAPTIC PLASTICITY AND LEARNING IN ADULT MICE," BY XIAONING HAN ET AL., IN *CELL STEM CELL*, VOL. 12, NO. 3; MARCH 7, 2013. WITH PERMISSION FROM ELSEVIER

Mind/Body Crosstalk

Physical ailments are not as divorced from mental processes as we often think. Studies are turning up more and more instances in which treating the mind relieves physical symptoms (*below*) or treating the body can inadvertently skew our thoughts and feelings (*opposite page*).

When Talk Therapy Treats Tinnitus

Physical complaints often co-occur with certain psychological conditions. Treating the psyche in these cases seems to improve physical health, according to several recent studies.

Gastritis and Anxiety

People with gastritis—a blanket term for stomach and intestinal discomfort, including heartburn, nausea and abdominal pain—are nearly twice as likely as the general population to suffer from anxiety and mood disorders, according to a study published in the January *Journal of Psychiatric Research*. But even in patients with no known mental issues, psychotherapy improves gut health, as research published online in February in the *Asian Journal of Psychiatry* showed. Study participants with indigestion who received 16 weeks of a therapy aimed at helping them identify and correct dysfunctional interpersonal patterns, called core conflictual relationship theme (CCRT) psychotherapy, saw improvements in all their gastrointestinal symptoms—and their mental health—which lasted for at least a year.

Ulcers and Depression

Renee D. Goodwin, professor of psychology at Queens College and the City University of New York and co-author of the January gastritis study, and her colleagues are currently researching the relation between ulcers and depression and anxiety. Preliminary data, Goodwin says, suggest that patients treated for depression were much less likely to have an ulcer 10 years later, compared with those who were not treated.

Tinnitus and Stress

Tinnitus, or persistent ringing in the ears, affects 50 million Americans. A study published online in January in *Quality of Life Research* found that about half of tinnitus sufferers also have mental disorders, confirming the findings of previous research. A 2012 study found that emotional stress more strongly predicts tinnitus than other known risk factors, perhaps because the emotion-processing areas of the brain are closely connected to its auditory systems. A small study in the January *Mindfulness* found that reducing stress with mindful meditation alleviated tinnitus symptoms and lowered sufferers' perceived handicap.

Asthma and Depression

Research has hinted at a relation between asthma and depression. In a study published online in *Psychosomatic Medicine* last year, scientists found that a third of asthma patients also suffer from depression and that those individuals were more likely to have an asthma-related visit to the emergency room over the yearlong study period. The findings suggest that treating depression could make asthma attacks less severe for patients who have both conditions.

Migraine and Panic Disorder

A meta-analysis published in the January *Headache: The Journal of Head and Face Pain* determined that migraine sufferers are almost four times as likely as nonsufferers to have panic disorder, an anxiety condition characterized by disabling panic attacks. Patients who have both conditions experience more negative effects from migraine, including more frequent attacks and increased disability. Todd A. Smitherman, a psychologist at the University of Mississippi and co-author of the paper, says there is a "dire need" for studies investigating whether treating panic disorder can reduce the frequency or severity of migraines.

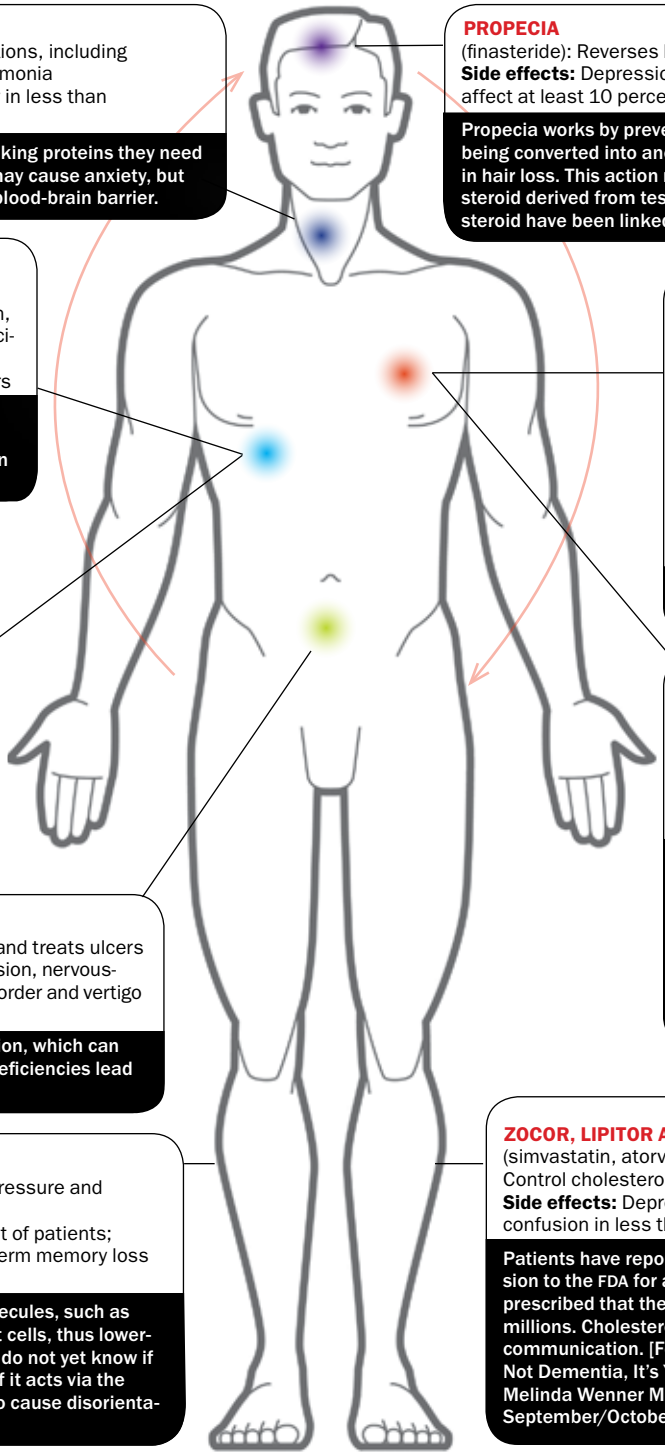
—*Tori Rodriguez*

M Contrary to popular belief, many highly successful people are classic "givers"—they focus on helping others. | We perceive the future

BODY DRUGS THAT AFFECT THE MIND

Bad mood? Sleep loss? Memory trouble? Check your prescriptions

Many drugs that treat bodily ills can alter mood, memory and other mental functions. Often the trials required to approve new drugs miss these uncommon side effects, but when the medications go on the market and are doled out to millions, thousands of people can be at risk. The drugs listed below are some of the most commonly prescribed in America; each one (including its generic versions) likely causes at least 10,000 patients—some, more than 100,000—to experience mental side effects every year. ***—Luciana Gravotta***



ZITHROMAX
(azithromycin): Treats bacterial infections, including strep throat, ear infections and pneumonia
Side effects: Aggression and anxiety in less than 1 percent of users

Zithromax prevents bacteria from making proteins they need to grow. It is unknown how the drug may cause anxiety, but research shows that it can cross the blood-brain barrier.

PROPECIA
(finasteride): Reverses baldness
Side effects: Depression and suicidal thoughts affect at least 10 percent of users

Propecia works by preventing testosterone from being converted into another hormone that is involved in hair loss. This action may lead to lower levels of a steroid derived from testosterone; low levels of this steroid have been linked to mood disorders.

SINGULAIR
(montelukast): Treats asthma
Side effects: Aggression, depression, disorientation, strange dreams, hallucinations, sleepwalking and suicidal thinking in less than 1 percent of users

Singulair hampers an immune molecule that causes swelling in the airways; how this action affects the brain is unknown.

NORVASC
(amlodipine): Lowers blood pressure
Side effects: Insomnia, nervousness, depression, abnormal dreams, anxiety and depersonalization (the feeling of watching yourself and having no control over your actions) in less than 1 percent but more than 0.1 percent of users

How Norvasc acts on the brain is unknown.

ADVAIR DISKUS INHALER
(fluticasone and salmeterol): Treats asthma
Side effects: Aggression and depression in less than 1 percent of users; more rarely, hyperactivity in children

The inhaled agent relaxes muscles in the airways by increasing levels of a signaling molecule called cAMP. High levels of cAMP are implicated in attention-deficit hyperactivity disorder (ADHD) and dementia.

LANOXIN
(digoxin): Treats arrhythmia and heart attacks
Side effects: Apathy, confusion, anxiety, depression and hallucinations in less than 1 percent of users

Lanoxin makes the heart beat stronger by keeping chemical messengers such as epinephrine and dopamine at nerve terminals for longer. Doing so could change the balance of these chemicals throughout the body, including the brain.

NEXIUM
(esomeprazole): Relieves acid reflux and treats ulcers
Side effects: Anorexia, apathy, confusion, nervousness, impotence, insomnia, sleep disorder and vertigo in less than 1 percent of users

Nexium blocks stomach acid production, which can inhibit nutrient intake. How nutrient deficiencies lead to mental symptoms is unclear.

LOPRESSOR
(metoprolol tartrate): Lowers blood pressure and treats heart attack
Side effects: Depression in 5 percent of patients; confusion, disorientation and short-term memory loss in less than 1 percent

Lopressor prevents fight-or-flight molecules, such as adrenaline, from reaching their target cells, thus lowering the stress response. Researchers do not yet know if the drug directly affects the heart or if it acts via the brain. Other drugs in its class can also cause disorientation and short-term memory loss.

ZOCOR, LIPITOR AND CRESTOR
(simvastatin, atorvastatin and rosuvastatin): Control cholesterol levels
Side effects: Depression, memory loss and confusion in less than 1 percent of users

Patients have reported memory loss and confusion to the FDA for all statins, which are so widely prescribed that the mental effects probably affect millions. Cholesterol is essential to rapid neuron communication. [For more information, see "It's Not Dementia, It's Your Heart Medication," by Melinda Wenner Moyer; Scientific American Mind, September/October 2010].

ISTOCKPHOTO (*pill icon*); EVGENIY IVANOV *iStockphoto (male body)*

as being closer to us than the past. | If you are in a bad mood, eating either too much or too little can make you even crankier.

» **Gender** Decisions under Duress

Men and Women Gauge Risk Differently

Whose strategy is better depends on what is at stake

Small gains now or big rewards later? The conundrum plagues every decision we make, whether we are investing or dieting. Now researchers find that men and women use different strategies to make such choices.

Researchers use gambling games to understand what we do when immediate rewards are pitted against long-term gains. Most of these games find no major differences in how men and women play. An experimental setup called the Iowa Gambling Task (IGT), however, finds consistent—and large—differences between the behavior of men and women: men are better at figuring out the strategy that reaps the bigger payoff.

When making financial decisions, men are more likely to focus on the bigger picture, whereas women more often pay closer attention to details.

Players are given four decks of cards, and they choose one card at a time from any deck they want. Each card has a win or loss amount on it, and each deck has its own unique payout pattern. Two of the decks contain cards that dole out large or frequent rewards, but consistently choosing cards from these decks leads to losses in the long run. The other two decks provide a modest amount of cash per win but less loss over time, so they offer long-term gains for players who pick from them most frequently. These patterns are carefully obscured so that the winning strategy is not obvious.

A review published in February in *Behavioural Brain Research* finds that men focus on the big picture, watching their total earnings and quickly homing in on which of the decks will lead to gains in the long run. Women focus on details such as the frequencies of wins and losses for each deck, missing the overall impact each deck has on their total balance. Sensitive to losses, women tend to switch to a different deck as soon as they are pinged with a setback, making it more difficult for them to identify the prize deck.

The strategies reflect underlying differences in activation in the orbitofrontal cortex, a region involved in decision making and the associated expectation of positive or negative consequences. During the task women have more activity in the medial part of this region, involved in regular patterns and immediate reward, whereas men preferentially engage the top, dorsal area, implicated in irregular patterns and long-term reward.

"When people think women make errors in these tasks, it's more that they're gathering information," says lead author Ruud van den Bos, a neurobiologist at Utrecht University in the Netherlands. Women's detailed exploration makes them more attuned to changes. If, for example, the rules of wins and losses for the decks were switched midtask, women would clue in to the new patterns more quickly than men. Van den Bos says the IGT happens to be designed so that the long-term strategy is best, but in decisions where knowing the details counts, women may have the advantage.

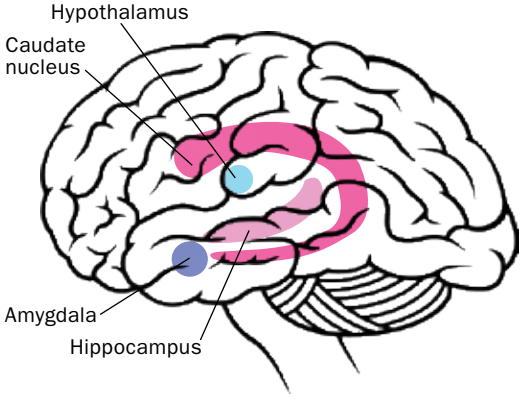
Because real decisions are much more complex than lab games, van den Bos emphasizes that neither strategy is inherently better; both are necessary and useful in daily life. He also points out that in the IGT some women perform like men, and vice versa. The dividing line is often blurry when it comes to female- and male-typical behaviors. "By disentangling the biological from the societal, we can understand how differences can be turned into advantages," van den Bos says. —*Luciana Gravotta*

Gender and the Emotional Brain

Brain structures in each sex reflect differences in how they respond to stressful or exciting situations.

Women have a larger caudate nucleus and hippocampus, both key for learning and memory. These areas help to inform future decisions by processing the pros and cons of recent actions.

Men have a larger amygdala and hypothalamus, emotional centers of the brain. Scientists do not yet know how this size difference translates to behavior.



ANDERSEN ROSS *Getty Images (man)*; TOM MERTON *Getty Images (woman)*; JAMIE CARROLL *iStockphoto (brain)*

M An analysis of recent neuroscience studies rated their statistical power at a meager 21 percent, meaning results are more likely to be false

Learning Is Tougher for Stressed-Out Men

In contrast, some women may form memories better under pressure

Stress can help or hurt learning depending on when the stressor hits. As psychologists well know, exposure to brief stress just before an event can enhance long-term memory of that occurrence. Had the stressful experience descended 30 minutes prior, learning would instead have been impaired. A new study published in the February *Neurobiology of Learning and Memory* now finds that the effect is sex-dependent.

Male and female participants were randomly assigned to one of two groups: For three minutes, one group submerged a hand in ice-cold water, while the control subjects placed their hand in warm water. Thirty minutes later they attempted to memorize a list of words on which they were tested 24 hours later.

Men who exhibited a robust physiological response to the stress of the ice bath, as measured by levels of the hormone cortisol in their blood, could not recall as many words as men who were less fazed by the cold, men in the control group, or women in both groups. Women who had a minimal cortisol response to the ice water performed better than the control groups, although the difference was small. "Males appear to be more sensitive to stress- and cortisol-related impairments of learning and memory," says Phillip R. Zoladz, co-author of the study and professor of psychology at Ohio Northern University. Some studies suggest that in women, stress effects may be mediated by stages of the menstrual cycle, which can alter sensitivity to stress hormones, but the new study did not investigate that variable.

Only a physiological test can truly determine whether your memory is vulnerable to prelearning stress, but signs such as a racing heart and sweaty palms may be clues that you might be prone to this effect. If so, tried-and-true memory-boosting techniques can help. "If stress is causing forgetfulness, it can be helpful to use reminders—like sticky notes placed where they will catch your attention—to trigger a memory," Zoladz says.

—Tori Rodriguez

Staying Sober under Pressure

Addicts of either sex struggle with different situations that may trigger a relapse

About one third of Alcoholics Anonymous (AA) members are women, and although the organization helps both sexes recover from addiction, a new study suggests that it does so in different ways—in part because male and female alcoholics drink for different reasons. John Kelly, a psychiatrist at Massachusetts General Hospital, and his colleague Bettina Hoeppner analyzed data collected over the course of 15 months from 1,726 AA members about their social networks, their drinking habits and how confident they were in their ability to stay sober in various situations. They found that male alcoholics typically relapse when they are in social-drinking situations and that AA largely helps them stay sober by inducing them to spend time with nondrinking friends and by helping them cope when they do find themselves with friends who are drinking.

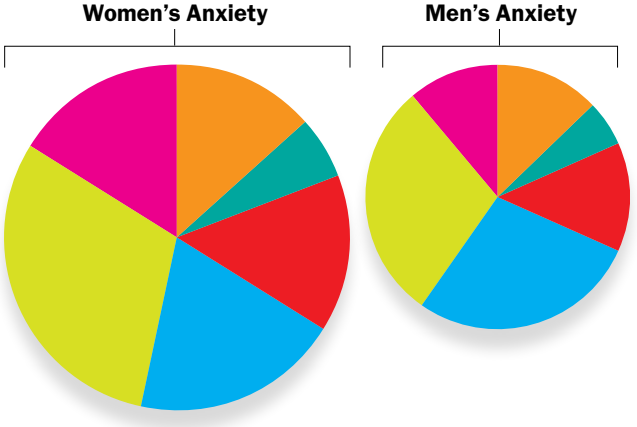
Female alcoholics, on the other hand, are more likely to drink when feeling down, yet AA does little to help them handle such emotion-driven cravings. "The findings really underscore gender-based differences in relapse risk," Kelly says. If AA addressed these needs in its programs, he adds, it could become even more effective.

—Melinda Wenner Moyer

GETTY IMAGES (*glass*); SCIENTIFIC AMERICAN MIND (*pie charts*)

The Anxious Sex

The lifetime rate of diagnosis of anxiety disorders is higher in women, with 33 percent experiencing an anxiety disorder in their lifetime, as compared with 22 percent of men. Experts believe this difference arises from a combination of hormonal fluctuations, brain chemistry and upbringing: women more often feel responsible for the happiness of others, such as their children or their spouse.



than in most areas of biology. | Scientists deciphered the shapes of two serotonin receptors, which could aid in designing new antidepressants.

Surprising Triggers of Mental Illness

We all experience the occasional life-changing event—a new baby, a cross-country move, a serious injury. In rare cases, such events can precipitate a mental disorder. The problem is compounded because people often assume their suffering is par for the course after such upheaval. In reality, relief is probably a short treatment away, via therapy or medication.

PTSD after a Hospital Stay

The flashbacks, nightmares and sleep problems that mark post-traumatic stress disorder (PTSD) are usually associated with combat or other violent experiences. Now psychiatrists have found that PTSD can also result from being a patient in the intensive care unit (ICU) at a hospital, according to a recent study in the journal *Psychological Medicine.*

Researchers at Johns Hopkins University checked in with survivors of a life-threatening lung injury for two years after they were discharged from the ICU. The investigators found that slightly more than one in three in the group suffered from the oft-debilitating anxiety disorder. Patients who had a history of depression were more likely to end up with PTSD after their hospital stay.

As is common in PTSD, the patients had flashbacks of their experiences, such as thinking they were going to die. But these cases were also unusual because the delirium caused by sedation and organ failure led to "nightmarelike" delusions and "distorted memories," explains study lead author Joseph Bienvenu. The patients mistook a catheter in the bladder, for example, as a sexual assault, and reported "memories" of events that never occurred, such as plots to murder them.

The researchers say the high prevalence of PTSD after an ICU stay underscores the importance of following up with patients after they leave the hospital. Bienvenu says that he would not hesitate to prescribe treatment—either drugs or cognitive-behavior therapy—for an ICU patient with a history of depression while the person is still in the hospital. *—Harvey Black*

OCD in New Moms

For a new mother, dealing with a newborn is fraught with anxieties. Did I fasten the car seat properly? Is the baby still breathing? In more than one in 10 new mothers, these normal worries can escalate into more serious obsessions that can interfere with her ability to care for herself and her baby.

Most of the research on postpartum psychiatric problems has focused on depression and psychosis. Obstetricians such as Emily Miller of Northwestern University, however, were also noticing a range of anxiety-related disorders, including intrusive thoughts and repetitive behaviors. "It's good to check that your baby is strapped into the car seat," Miller notes. "But these women aren't just doing it once. They're doing it over and over, and it's interfering with their lives."

With her colleagues, Miller followed 461 women after they gave birth. Eleven percent said they had obsessions and compulsions two weeks after delivery that the researchers found to be the equivalent of mild to moderate obsessive-compulsive disorder (OCD)—a sharp increase over the 2 to 3 percent rate of OCD in the general population. Half of these women's symptoms continued six months' postpartum, and an additional 5.4 percent developed new OCD symptoms in that time. The afflicted women indicated that their symptoms were distressing, taking up a significant amount of time and otherwise interfering with their daily life.

Nearly three quarters of the women with OCD also showed signs of postpartum depression. As with depression, therapy would probably help new moms cope with OCD, according to Miller. "If OCD symptoms are mild and resolve by six weeks' postpartum, they may be normal," Miller says. "But if they interfere with a patient's daily functioning and persist, she should talk to her doctor." *—Carrie Arnold*

More Unusual Causes of Mental Symptoms

Common life events occasionally lead to mental distress. If you think any of these scenarios might describe you or a loved one, tell a doctor: treatments today are more effective than ever.

Reading or hearing about a traumatic event may lead to a specific phobia, the persistent fear of a certain situation or object. Targeted exposure therapy has been shown to diminish, and perhaps erase, such phobias in a few sessions.

Bacterial infections, such as strep throat, may cause symptoms of obsessive-compulsive disorder in kids. Only a small subset of all OCD cases, which affect 3 percent of children, are thought to be caused by infections. Treatment with antibiotics cures most infected kids.

Eating more processed foods may be linked to experiencing greater levels of anxiety and depression. Avoiding grocery items with trans fats (hydrogenated oils) may help lift your mood.

Moving to a new house or school may trigger anorexia or bulimia in teens. Treatments such as talk therapy usually reverse the eating disorder.

IAN HOOTON *Corbis (man)*; JUSTIN PAGET *Corbis (woman)*; ISTOCKPHOTO *(brain icon and newspaper)*; BARIS SIMSEK *iStockphoto (virus)*; THINKSTOCK *(cheese and box)*

M Conspiracy theorists tend to express feelings of powerlessness. Their theories may grant them a sense of control. | Scientists have succeeded

How Pesticides Can Cause Parkinson's

Foreign chemicals may prevent the brain from disposing of its own toxic waste

Many studies over the past decade have pointed to pesticides as a potential cause of Parkinson's disease, a neurodegenerative condition that impairs motor function and afflicts a million Americans. Yet scientists have not had a good idea of how these chemicals harm the brain. A recent study suggests a possible answer: pesticides may inhibit a biochemical pathway that normally protects dopaminergic neurons, the brain cells selectively attacked by the disease. Preliminary research also indicates that this pathway plays a role in Parkinson's even when pesticides are not involved, providing an exciting new target for drug development.

Past studies have shown that a pesticide called benomyl, which lingers in the environment despite having been banned in the U.S. in 2001 because of health concerns, inhibits the chemical activity of aldehyde dehydrogenase (ALDH) in the liver. Researchers at the University of California, Los Angeles, U.C. Berkeley, the California Institute of Technology and the Greater Los Angeles Veterans Affairs Medical Center wondered whether the pesticide might also affect levels of ALDH in the brain. ALDH's job is to break down DOPAL, a naturally forming toxic chemical, rendering it harmless.

To find out, the researchers exposed different types of human brain cells—and, later, whole zebra fish—to benomyl. They found that it "killed almost half of the dopamine neurons while leaving all other neurons tested intact," according to lead author and U.C.L.A. neurologist Jeff Bronstein. When they zeroed in on the affected cells, they confirmed that the benomyl was indeed inhibiting the activity of ALDH, which in turn spurred the toxic accumulation of DOPAL. Interestingly, when the scientists lowered DOPAL levels using a different technique, benomyl did not harm the dopamine neurons, a finding that suggests that the pesticide kills these neurons specifically because it allows DOPAL to build up.

Because other pesticides also inhibit ALDH activity, Bronstein speculates that this pathway could help explain the link between Parkinson's and pesticides in general. What is more, research has identified high DOPAL activity in the brain of Parkinson's patients who have not been highly exposed to pesticides, so it is possible that this biochemical cascade is involved in the disease process regardless of its cause. If that is true, then drugs that block or clear DOPAL from the brain could prove to be promising treatments for Parkinson's.

—Melinda Wenner Moyer

Video Games for Dyslexia

Honing visual attention boosts reading ability

Attention training might trump language practice in treating dyslexia, and video games might provide just that, according to a recent study in *Current Biology*. Researchers at the University of Padua in Italy found that 10 kids with dyslexia who played an action-filled video game for nine 80-minute sessions increased their reading speed, without introducing mistakes. These reading gains lasted at least two months and outpaced gains measured in 10 children with dyslexia who played a nonaction version of the same game, as well as trumping the expected improvement that naturally occurs in a year for a child with dyslexia.

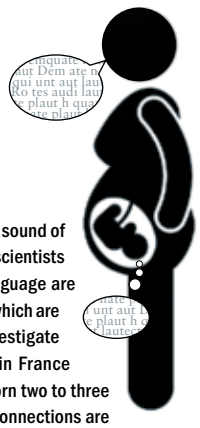
Though small, the study bolsters evidence that dyslexia stems in part from problems in focusing attention onto letters and words in an orderly way. Last year the same team reported that preschoolers who struggled to quickly and accurately shift their attention—which can be thought of as a spotlight—were likely to have reading difficulties three years later. Because action video games require players to constantly redirect their attention to different targets, neuroscientist Simone Gori and his colleagues thought the video games might fine-tune that spotlight so as to avoid jumbling letters on a page. [For more on the cognitive benefits of video games, see "Brain-Changing Games," by Lydia Denworth; SCIENTIFIC AMERICAN MIND, January/February 2013.]

The training honed visual attention skills and reading hand in hand, and the reading improvements even exceeded those obtained in children after traditional therapies for dyslexia, which focus on building language skills. Gori does not advocate abandoning the older methods but says that training visual attention could be a vital, overlooked component. He also notes that kids are prone to quit traditional dyslexia therapies, which he says can be demanding and even boring; not a problem in his video-game experiment. "Our difficulty was in getting the kids to stop playing," Gori says.

—Michele Solis

Born to Talk

Premature infants reveal how our brain is primed for language



Newborn babies can recognize the sound of their mother's voice at birth. But scientists are unsure which aspects of language are built into our brain through genetics and which are learned by listening in the womb. To investigate this question, a group of researchers in France studied 12 preterm infants, who were born two to three months' premature. At this stage brain connections are just beginning to form, meaning the infants' brain activity reflects the brain's initial organization rather than connections strengthened by learning, according to the researchers.

In the study, the scientists placed functional optical-imaging bands on the babies' heads to noninvasively monitor brain activity by passing infrared light through the infants' thin skulls. The light is absorbed or scattered depending on oxygen levels in the blood, which is a proxy for brain activity. The infants listened to male or female voices speaking simple sounds, such as "ga" or "ba." The optical imaging revealed that the premature baby's brain could distinguish not only a speaker's gender but also the similar syllables. "What's really interesting is that the baby's brain can use the same sound networks we use later as an adult," says neuroscientist Fabrice Wallois of INSERM at the University of Picardy Jules Verne in France.

This finding suggests that the neural connections used in adult language processing are present from very early in development, supporting the hypothesis that we are hardwired to understand some aspects of speech.

—Daisy Yuhas

GETTY IMAGES (*pesticide spraying*); THINKSTOCK (*game icon*); ISTOCKPHOTO (*pregnancy icon*)

in a rudimentary form of mind reading. After extensive training, they could identify what a person was imagining while undergoing a brain scan.

A GUIDE TO MASTERING YOUR WORLD

How to Be a Better **Boss**

I took on my first "boss" role a couple of years ago while overseeing a tiny cadre of junior-level editors at a national women's magazine. The media industry isn't exactly known for having easy managers—ever read *The Devil Wears Prada*?—and I hadn't had any formal management training in my 10 years in the business. So I governed mostly by the Golden Rule and by asking myself, "WWWD?" as in "What would Wendy—a great former boss of mine—do?" Modeling my behavior on a successful mentor worked, and when I left my management post, the staffers seemed genuinely sorry to see me go. As I looked into what research has to say on the matter, it's clear why Wendy's tactics worked. The key to being a good boss is a combination of humility, confidence and the right kind of carrots.

#1 **Rein in your ego.** A group of organizational psychologists at Michigan State University and the University of Akron became interested in workplace arrogance during the global banking implosion, back when private-jetting, hotheaded leaders at doomed institutions like AIG were always in the news. They dug into existing research and found that arrogant bosses—those who blow off feedback, disrespect employees' ideas and avoid blame by pinning it on others—are destructive to business. That kind of behavior leads to a stressful work environment and more employee turnover. Humble leaders, however—those who are open to new ideas and able to admit when they are wrong—are more likely to garner employee loyalty. You can't expect your staff to always love or even like you—but at least as a humble boss, you'll get them to stick around.

#2 **Give employees some control.** Psychologists who study management talk about job stress a lot because of all the ways it can affect a company: medical costs, sick days, morale and turnover. Time after time, researchers find that one of the most consistent ways to reduce stress among workers is to offer them a little more autonomy—a sense of control over their own job. Not everyone can set their own hours or cherry-pick duties, but you can offer choice to employees in many other ways, says Edward Deci, a psychology professor at the University of Rochester who has done some of the seminal research on self-determination at work. "If we don't get rigid as managers or business owners, we can allow for employees to work some things out in terms of what feels good for them," he says. Allow them to vote on changes as a group, for instance, or ask which of two available shifts they would prefer. The best bosses, Deci says, "make employees feel understood and as if they have some choice in what they do and how they do it."

#3 **Take the weekend off.** Most of us have had a moment late at night or over the weekend when something important comes to mind, and we dash off a quick e-mail to a colleague or subordinate. That's fine—as long as employees don't think you expect an immediate reply. YoungAh Park, now at Kansas State University, studied the use of technology at home and found that workers who used phones or computers for work-related stuff during off-hours had less psychological "detachment" from the office, and it left them less happy and more stressed because of it. A separate study at Portland State and Bowling Green State universities showed that employees who thought about and engaged with work the most during off-hours were less effective than average. People who never checked in or thought about their job when away from it tended to perform poorly, too. Apparently—as in everything else—moderation is key when it comes to answering work e-mails from home. As a boss, it's your job to establish a culture that allows people to unplug when they're off the clock.

#4 **Use carrots, not sticks.** It's pretty well accepted in the work-psychology world that fear of punishment isn't a great motivator. But there is still some debate about whether "tangible" carrots such as bonuses and prizes truly inspire either. One carrot that nearly always works, according to a large meta-analysis by Deci and his colleagues, is positive feedback. "Most managers don't give much positive feedback—but it's something that feels good to anyone who's getting it," Deci says. "It really means supporting someone's sense of competence. When people are highly motivated, engaged in their work and committed to it, they do it well. And when they do it well, that gives positive results for the company."

That's one piece of advice I'll definitely take into my next boss role: When employees do a good job, remember to tell them so. It's easy and doesn't cost a thing. —*Sunny Sea Gold*

Cuteness Inspires Aggression

The universal desire to squeeze baby animals, *hard*

Whether we are pinching the cheeks of an adorable toddler or enveloping a beloved pet in a bear hug, most of us have experienced the strange drive to give something cute a gigantic squeeze. New research by two Yale University psychologists details how the sight of something cute brings out our aggressive side. Rebecca Dyer and Oriana Aragon investigated "cute aggression" by showing study participants slide shows of either cute, funny or normal animal photographs. As they watched, the participants held bubble wrap. The researchers, attempting to mimic the common desire to squeeze cute things, told subjects to pop as many or as few bubbles as they wished. People watching the cute slide show popped significantly more bubbles than those viewing the funny or control pictures, according to results presented at the Society for Personality and Social Psychology annual meeting in New Orleans. "Some things are so cute that we just can't stand it," Dyer concludes.

Cute aggression's prevalence does not mean that people actually want to harm cuddly critters, Aragon explains. Rather the response could be protective, or it could be the brain's way of tamping down or venting extreme feelings of giddiness and happiness. The scientists are currently conducting additional studies to determine what drives the need to squeeze. —*Carrie Arnold*

PAUL PANTAZESCU *iStockphoto (world icon)*; THINKSTOCK *(people icon)*; HANNAH MENTZ *Corbis (girl with puppy)*

M Losing sleep several nights in a row can lead to overeating and weight gain. **For full stories: ScientificAmerican.com/Mind/jul2013/stories**

Vanished without a Trace

Fading illusions play hide-and-seek with your perception

BY SUSANA MARTINEZ-CONDE AND STEPHEN L. MACKNIK

"I don't think there is anything wrong with white space. I don't think it's a problem to have a blank wall."

—Annie Leibovitz

ACCORDING TO a legend that one of us (Martinez-Conde) heard growing up in Spain, anybody can see the Devil's face. All you need to do is to stare at your own face in the mirror at the stroke of midnight, call the Devil's name and the Prince of Darkness will look back at you. Needless to say, I was both fascinated and terrified by the possibility. And I knew this was an experiment I must try. I waited a day or two to gather my courage, then stayed awake until midnight, got up from my bed, and into the bathroom I went. I closed the door behind me so that my family would not hear me calling out loud for Satan, faced my wide-eyed reflection, made my invocation, and … nothing happened. I was disenchanted (literally) but also quite relieved.

Now, three decades later, a paper entitled "Strange-Face-in-the-Mirror Illusion," by vision scientist Giovanni B. Caputo of the University of Urbino in Italy, may explain my lack of results. Caputo asked 50 subjects to gaze at their reflected faces in a mirror for a 10-minute session. After less than a minute, most observers began to perceive the "strange-face illusion." The participants' descriptions included huge deformations of their own faces; seeing the faces of alive or deceased parents; archetypal faces such as an old woman, child or the portrait of an ancestor; animal faces such as a cat, pig or lion; and even fantastical and monstrous beings. All 50 participants reported feelings of "otherness" when confronted with a face that seemed suddenly unfamiliar. Some felt powerful emotions.

After reading Caputo's article, I had to give "Satan" another try. I suspected that my failure to see anything other than my petrified self in the mirror 30 years ago had to do with suboptimal lighting conditions for the strange-face illusion to take place. Caputo recommended dim lighting, so that observers might see their facial features in detail but experience attenuated color perception. So this time I turned off the bathroom lights and turned on my cell phone's flashlight, then placed it on the floor behind me, so that I could not see its reflection on the mirror. Then I looked at myself and waited.

My efforts were rewarded quickly. Portions of my face started to disappear, contract or expand, and suddenly all the features would come back, giving me a bit of a start. I was particularly thrilled to experience some of the dissociative identity effect that the experimental participants reported, feeling as if the face staring back at me was both mine and yet not mine. Disappointingly, I did not see any monstrous creatures or ghosts of ancestors calling me from the beyond (or even Satan, for that matter), but I think I came close to seeing one of the "archetypal" faces. Weirdly, halfway through the experiment, my face appeared to morph into a sepia portrait of an old Native American warrior. But as soon as it arrived, it was gone.

ART WOLFE www.artwolfe.com

VANISHING ACT

Camouflage and Troxler fading can pair up to great effect. Look around the image for the leopard. Hint: His head is hiding in the tall grass near the lower right corner. Once you locate it, hold your gaze on the tree trunk while paying attention to the animal's location. He's gone! Look straight at the leopard to revive your perception.

Fade to Gray

Why does this happen? To explain, we need to start with Erasmus Darwin, the English natural philosopher and physician and grandfather of Charles Darwin. In the late 18th century he described how objects can fade after steady gazing: "On looking long on an area of scarlet silk of about an inch in diameter laid on white paper … the scarlet color becomes fainter, till at length it entirely vanishes, though the eye is kept uniformly and steadily upon it." Swiss philosopher Ignaz Paul Vital Troxler later corroborated

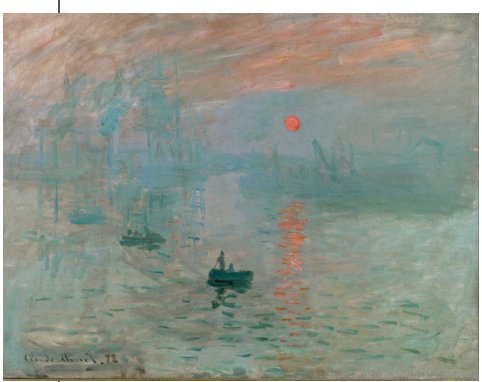
Darwin's observations, using colored patches on a wall. The phenomenon became known as Troxler fading.

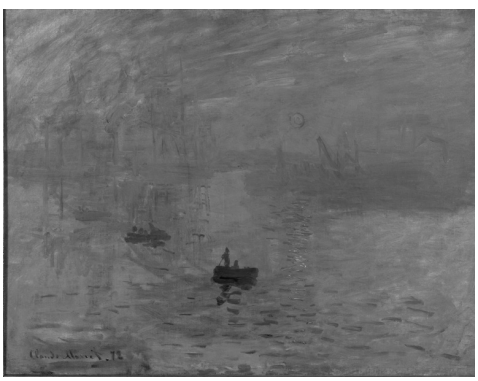
Neural adaptation, the mechanism by which neurons decrease or stop their response to unchanging stimulation, is thought to underlie perceptual fading during prolonged gazing at an object or scene. Once the target of interest has vanished, blinks, gaze shifts and even microscopic involuntary eye movements called microsaccades can restore it to perception instantly [see "Shifting Focus," by Susana Martinez-Conde and Stephen L. Macknik; Scientific American Mind, November/December 2011].

Troxler fading and neural adaptation may partly explain Caputo's strange-face illusion. As we gaze long and steady into our reflected face, the unchanging nature of the visual stimulus causes facial features to disappear and then reappear, as we blink or make involuntary eye movements, thereby "refreshing" our neuronal responses. In the absence of visual information, our brain will "fill in" the gaps according to our experiences, expectations, best guesses, and even hardwired neural mechanisms involved in shape and face perception. The result can be amusing or disquieting.

A few years ago I had the opportunity to collaborate with cognitive scientist Daniel Simons (author, with Christopher Chabris, of *The Invisible Gorilla,* Random House, 2010) and his colleagues at the University of Illinois at Urbana-Champaign on an experiment to investigate visual fading in entire scenes. You can experience the effect by focusing your gaze precisely at the center of the blurry image, while paying attention to the entire scene. Careful staring for just a few seconds will minimize your eye movements, causing the scene to fade to gray. Now stop focusing your gaze, and the scene will come right back. Scientists can make nonblurred scenes fade in the laboratory by completely removing or by compensating for the observer's eye movements. M

SUSANA MARTINEZ-CONDE and STEPHEN L. MACKNIK are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee, now available in paperback (http://sleightsofmind.com). Their forthcoming book, *Champions of Illusion,* will be published by Scientific American/Farrar, Straus and Giroux.

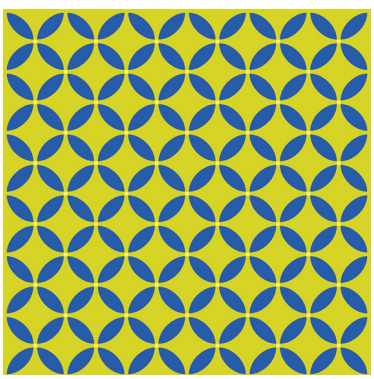




A FADING IMPRESSION

Impression, Sunrise, **by French painter Claude Monet in 1872, gave its name to the Impressionist movement. The subject of the painting is the harbor of Le Havre in France, as seen from Monet's window. It was not, however, Monet's actual view of the scene, as he later explained, but his "impression"—hence the title. Indeed, *Sunrise* does not accurately represent reality: the rising sun appears much brighter than the surrounding sky, as it should in real life, but that perception is an illusion. Monet used pigments of matching luminance, or brightness, but different chromatic content, or hues, to represent the sun and the sky. Harvard University neurobiologist Margaret Livingstone has proposed that this equiluminant quality, where objects in the image have the same luminance as the background, is what gives the sun its eerie, almost pulsating, lifelike appearance. A black-and-white reproduction reveals that the sun has the same physical luminance as the background clouds.**

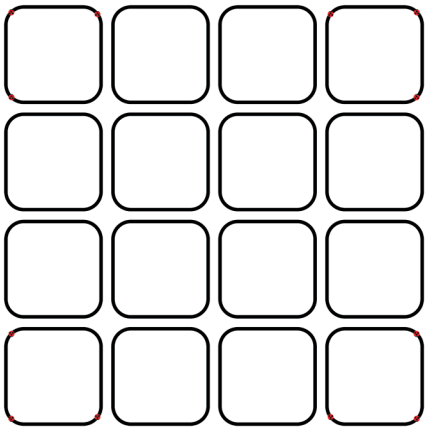
Equiluminant objects are somewhat difficult to see, which makes them more susceptible to Troxler fading. Neuro-ophthalmologists Avinoam B. Safran and Theodor Landis of Geneva University Hospital in Switzerland noticed that if you fix your gaze on the image of the sailor in Monet's painting for several seconds, while paying attention to the sun, the solar disk will disappear progressively, being replaced by the surrounding sky.

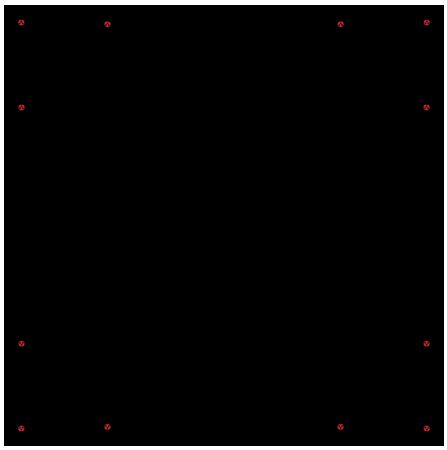


HOW MANY DOTS?

This pattern, generated by vision scientist Akiyoshi Kitaoka of Ritsumeikan University in Japan, contains a yellow dot at the center of each set of four blue "petals." That makes a total of 61 yellow dots! To prove it to yourself, examine each "flower" in turn and see that all of them contain a central yellow spot. The problem is that you can see only one spot at a time. The others disappear when you are not looking at them directly.

COURTESY OF DANIEL SIMONS *University of Illinois at Urbana-Champaign (top);* ERICH LESSING *Art Resource, NY (left);* COURTESY OF AKIYOSHI KITAOKA *Ritsumeikan University (right)*



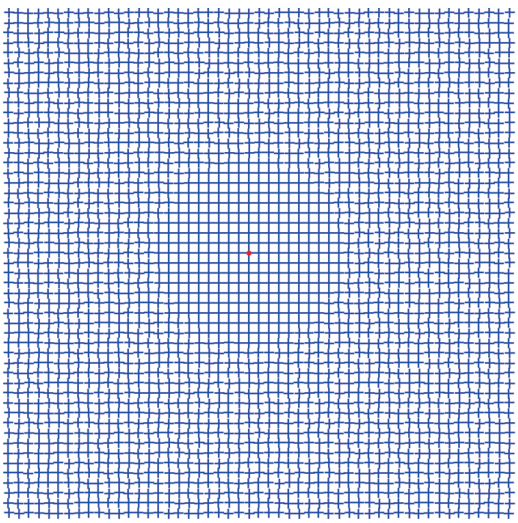


LURKING LADYBUGS

In the left image of the pair that makes up this illusion, also by Kitaoka, each of the four squares in the corners has three ladybugs. The little insects are easy to see as you look around the image, but when you stare at the center of the pattern they vanish immediately. The right-hand image shows they do not become invisible by virtue of the small size: in the absence of the squares, all 12 ladybugs are perceptually prominent, no matter where in the image you look.

THE HEALING GRID

This illusion, created by cognitive neuroscientist Ryota Kanai, then at Utrecht University in the Netherlands, was a top-10 finalist in the 2005 Best Illusion of the Year Contest (http://illusionoftheyear.com). Explore the image freely, and you will see a regular pattern of intersecting horizontal and vertical lines in the center, flanked by an irregular grid of misaligned crosses to the left and right. Choose one of the intersections on the center of the image and stare at it for 30 seconds or so. You will see that the grid "heals" itself, becoming perfectly regular all the way through. The illusion results from both perceptual fading and the ensuing neural guesstimates that our brain imposes to "fill in" the outer parts of the image based on the available information from the center, in addition to our nervous system's intrinsic tendency to seek structure and order, even when the sensory input is fundamentally disorganized.



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BEAUTY IN THE EYE OF THE BEHOLDER

Artwork may contain "errors" that are obvious to our central vision but become invisible when viewed from the corner of our eye. Neuroscientist Denis Pelli of New York University discovered that Pablo Picasso's *Maquette for Guitar* (1912) appears absurd only when we look at it directly: the strings are torn and twisted, the neck is crooked, and the body is split into disconnected pieces. But now focus on the cross, while still paying attention to the guitar: all you can see is the smooth curves and elegant angles of a beautiful instrument. Pelli hypothesizes that the illusion works because our peripheral vision confuses the locations of the parts. Failure to notice the errors in the maquette produces the perception of a real guitar. Picasso's paintings of Nusch Éluard, a French acrobat, show a similar phenomenon. When viewed directly, the portraits are grotesque, but when seen peripherally, the young woman looks exquisite. Pelli suspects that Picasso was well aware of this effect.

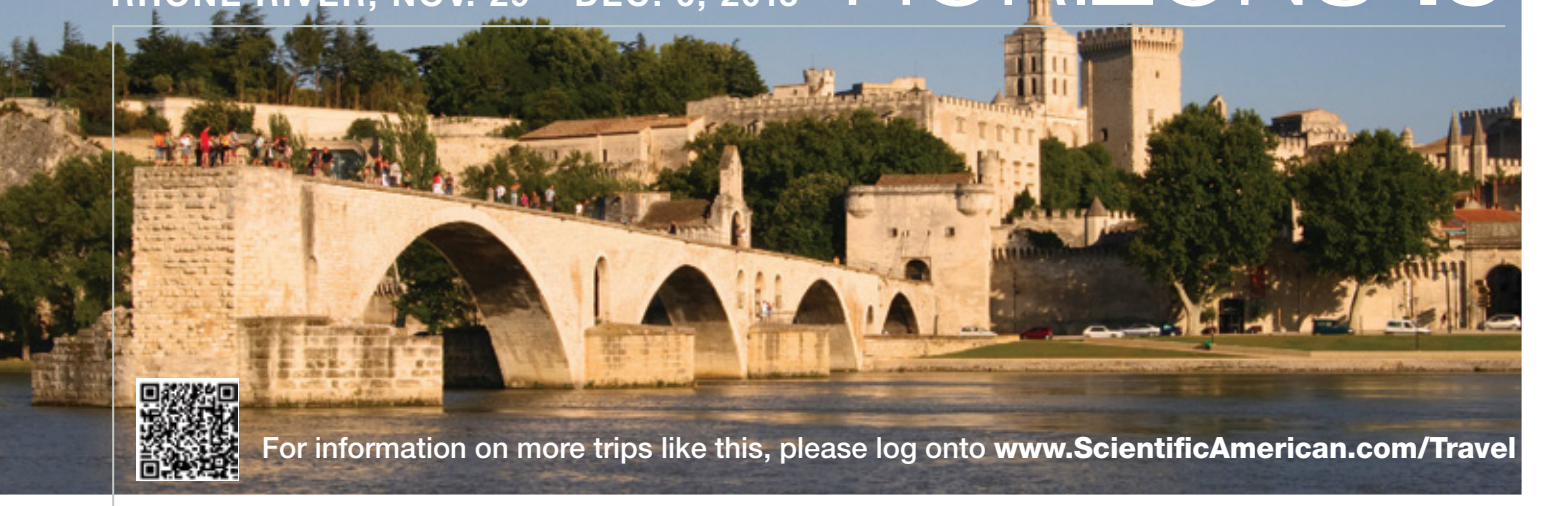
(Further Reading)

- **The Vanishing of the Sun: A Manifestation of Cortical Plasticity.** A. B. Safran and T. Landis in *Survey of Ophthalmology,* Vol. 41, No. 5, pages 449–452; March–April 1998.
- **The Moving Tablet of the Eye: The Origins of Modern Eye Movement Research.** Nicholas J. Wade and Benjamin W. Tatler. Oxford University Press, 2005.
- **Vanishing Act.** Art Wolfe and Barbara Sleeper. Bulfinch, 2005.
- **Induced Visual Fading of Complex Images.** D. Simons, A. Lleras, S. Martinez-Conde, D. Slichter, E. Caddigan and G. Nevarez in *Journal of Vision,* Vol. 6, No. 10, pages 1093–1101; September 26, 2006.
- **Vision and Art: The Biology of Seeing.** Margaret Livingstone. Abrams, 2008.
- **Strange-Face-in-the-Mirror Illusion.** G. B. Caputo in *Perception,* Vol. 39, No. 7, pages 1007–1008; 2010.
- **Shifting Focus.** S. Martinez-Conde and S. L. Macknik in *Scientific American Mind,* Vol. 22, No. 5, pages 48–55; November/December 2011.

SCIENTIFIC AMERICAN™ Travel

BRIGHT HORIZONS™ 18

RHONE RIVER, NOV. 29 – DEC. 6, 2013



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In November, the tourists are gone from Provence. The harvest's been gathered. The south of France exhales, resuming her essential rhythms, manifesting her ancient uniqueness, effortlessly. It's the perfect time to relax, recharge, and revel in the latest with Scientific American Bright Horizons 18 on a Rhone River cruise from November 29 to December 6, 2013. We'll explore developments in cosmology, cancer, and wine science, and plumb Roman engineering.

Experience river cruising's panoramic charms on Bright Horizon 18's voyage on AmaWaterway's AmaDagio, sailing from Lyon to Arles, France. The light, colors, and flavors of France await.

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The cruise fares start at $2,799 for a Category E. French Balcony cabins start at $3,378. A Junior Suite is available for $4,498. Cruise fares include six half-day excursions. For those attending our educational Program, there is a $1,395 fee. Additional per-person fees include: government taxes and fees ($147) and gratuities are €15 per day. The Program, Cruise pricing, and options are subject to change. For more info please call 650-787-5665 or email us at concierge@insightcruises.com.

Quantum Physics

Speaker: Frank Linde, Ph.D.

The Wild World of Subatomic Particles

Explore the realm of electrons, protons, quarks, and Higgs bosons — a world where the normal rules don't apply. Dr. Linde will lead a tour of the smallest constituents of matter, illuminating the theories of quantum mechanics and relativity that govern the subatomic universe. You'll also learn about the mysteries of dark matter, missing antimatter, and the origin of mass.

The Story of the Higgs

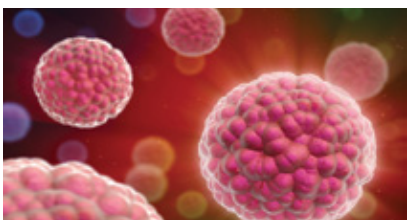
A tiny particle called the Higgs boson was predicted 50 years ago to explain the quandary of why particles have mass. After decades of searching, physicists finally tracked down the Higgs in 2012, inside the world's largest particle accelerator. Learn why this one particle is so important, and how its discovery will shape the future of physics.

The Mystery of Dark Matter

Dark matter is thought to make up about a quarter of the universe, yet scientists don't know what it is. Learn the history of this mysterious stuff, as well as the best guesses for what it might be made of. Dr. Linde will explain how researchers study something that can't be seen, and the ongoing searches aiming to detect dark matter for the first time.

Particle Physics and You

Subatomic particle experiments deep underground and inside giant accelerators can seem far removed from everyday life. But the knowledge gained about the universe's smallest building blocks has real-world consequences. Dr. Linde will stir your curiosity about particle physics and answer the common question: What use is it?



Targeting Cancer

Speaker: David Sadava, Ph.D.

Know the Enemy: A Biography of the Target

Set the stage for understanding the attack on cancer by looking at is cellular biography. In most cases, cancer starts off as perfectly normal cells. And then something happens. Find out what those "somethings" may be, and how they transform the cell.

The War on Cancer: Then and Nowadays

In 1972, the U.S. declared war on cancer. Learn the scientific background that led to this bold declaration, and why victory has been elusive.

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We see progress in extending the lives of cancer patients, and even cures. But the result is not victory but a long war of attrition. Find out why.

Targeting the Cancer Genome

Knowing the cancer genome in detail leads to precise targeting of potential cancer triggers in the cell. Two spectacular recent successes in targeting certain types of leukemia and breast cancer led to a proliferation of very expensive drugs similarly targeted to specific cancers. Are these drugs worth it? Explore the scientific accomplishments and ethical issues involved in medical progress.

Natural Medicine and the War on Cancer

Faced with a dreadful diagnosis, many cancer patients supplement or substitute their doctor's recommendations by "going alternative." Turns out that some common cancer-fighting drugs originated in traditional medicines. Learn about the process of transforming a traditional treatment to a mainstream therapy. How are alternative medicines evaluated? Are they effective? Join Dr. Sadava and make some surprising discoveries.

Archaeology

Speaker: Lynne Lancaster, Ph.D.

Introduction to Culture and Technology in Gaul

Gaul was influenced by the Iberians, Celts, Greeks, and Romans. Each culture brought skills and technologies such as town planning, architecture and construction, mining of salt and metals, and the adoption of coinage. Get an overview of the technology, culture, and politics of the Greek and Roman colonization of France.

Fire-Based Technologies in Gaul: Terracotta Production and Metal-Working

Terra cotta and metal artisans had to master techniques of balancing chemical interaction to achieve the desired results. Find out how the Romans adopted Greek methods to mass produce pottery. In contrast to this imported knowledge, learn about Celtic metal-working skills, which the Romans assimilated and put to military use.

Building an Amphitheater

Along with bath buildings, the construction of an amphitheater was one of the greatest investments a community could take on. Dig into the engineering and construction process: site preparation for enormous loads, quarrying and transporting great numbers of stone blocks, erecting the structure and distributing loads. Enrich your appreciation of ancient architecture in the Roman world and beyond.

Aqueducts, Baths and Water Mills

The Romans exploited water technology much earlier and on a greater scale than has been realized. This was all possible due to the mastery of aqueducts. We will explore the principles behind the laying out and functioning of Roman aqueducts, including the use of inverted siphons, tunnel cutting, and arch construction.

Cosmology

Speaker: Mark Whittle, Ph.D.

The Birth of Our Universe: Evidence for the Big Bang

Is the current evidence for the Big Bang strong enough to consider it a fact? Survey the contents of the Universe and scrutinize the six key pieces of evidence for its birth in a "Hot Big Bang."

Billion Years of History: the Birth and Maturation of Galaxies

Study the natural history and structure of galaxies directly, from infancy to maturity. Orient yourself to our own Milky Way, and the types of galaxies that form a web of galaxies filling the Universe. Contemplate dark matter and black holes, and get the latest thought in cosmology.

The Universe's First Million Years: Primordial Light and Sound

Take a trip back in time to explore the incandescent fireball of the infant Universe, just ½ million years after the Big Bang. Learn the astounding qualities of its light and how cosmologists use the primordial sound of this period to measure a number of the Universe's properties. Listen, think, and wonder at the cosmological Dark Age before the first stars.

Cosmic Inflation: Making Universe(s) from Nothing!

How was our expanding Universe created? We'll look to cosmic inflation theory for answers and food for thought. Using the astonishing fact that the total mass/energy of the Universe is zero, and its implications, we can begin to understand how cosmic inflation both creates and launches our expanding Universe — out of nothing! Examine cosmic puzzles, possibilities, and intriguing speculation.

Oenology

Speaker: James Kennedy, Ph.D.

Climate Change and Impact on the Wine World

Wine's chemical composition varies widely across different areas of the world. Much of a wine's uniqueness stems from the impact of place on wine composition. Discover how the climates in the wine regions of the world are changing, and what this means for wine as we know it. In a lab session, we'll taste wine from warm regions.

The Rhone and Its Wines

The Rhone River region produces some of the finest wines in the world. As the Rhone River flows south to the Mediterranean, the grapes and the wines produced from them change considerably. Combining a lecture with a wine tasting, Dr. Kennedy will discuss this amazing wine-growing region and the wines it produces.

Wine and Health

From the French Paradox to resveratrol and beyond, Dr. Kennedy investigates the composition of wine and the role that wine plays in human health. Is wine the wonder beverage as often portrayed in popular media, or is the fascination just a means to feel good about alcohol consumption?

Advances in Grape and Wine Production

Wine labels often evoke the tradition, romance, and history of winemaking. The flowery language and imagery obscures the technological progress made over the past century in viticultural and winemaking practices. Discover how some of the finest wines in the world are produced using sophisticated, state-of-the-art technology and science.

SCIENTIFIC AMERICAN Travel **HIGHLIGHTS** RHONE RIVER NOV. 29 – DEC. 6, 2013

INSIDER'S TOUR OF CERN

Pre-cruise: November 28, 2013—From the tiniest constituents of matter to the immensity of the cosmos, discover the wonders of science and technology at CERN. Join Bright Horizons for a private pre-cruise, custom, full-day tour of this iconic facility. (If the LHC is still undergoing its scheduled maintenance it is anticipated we will go into the LHC Cavern.)

Whether you lean toward concept or application there's much to pique your curiosity. Discover the excitement of fundamental research and get a behind-the-scenes, insider's look at the world's largest particle physics laboratory.

We'll have an orientation, visit an experiment, get a sense of the mechanics of the Large Hadron Collider (LHC). If at all possible, we'll go down inside the LCH tunnel (picture left), then make a refueling stop for lunch, and have time to peruse the grounds and exhibits on the history of CERN and the nature of its work. And if you're so inclined, you can visit the CERN gift shop.

The price is $899 per person (based on double occupancy). This trip is limited to 50 people.
NOTE: CERN charges no entrance fee to visitors.

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BRIGHT HORIZONS™ 19

SOUTHEAST ASIA, FEB. 3RD – 17TH, 2014

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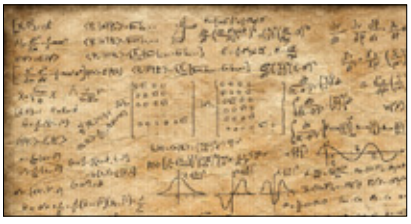


THEORETICAL PHYSICS

Speaker: Sean Carroll, Ph.D.

The Hunt for the Higgs Boson

For decades, particle physicists have searched for the elusive Higgs boson, the missing piece of the "Standard Model" that explains the world we see. Last year, scientists at the Large Hadron Collider announced that they'd found it. Learn why the Higgs boson is so important, and what the future of particle physics might hold.

Our Preposterous Universe

In the last century scientists learned that the universe is over 10 billion years old, that it is expanding, and that ordinary stars, planets, and people represent less than five percent of the universe. We'll discuss the rest, which is in the form of mysterious substances called "dark matter" and "dark energy."

The Arrow of Time

We can turn an egg into an omelet, but not an omelet into an egg. That's the arrow of time, which can be explained by assuming that the universe has been increasing in disorder since it began. We'll discuss the nature of time, the origin of entropy, and what happened before the Big Bang.

The Many Worlds of Quantum Mechanics

Despite the success of quantum mechanics, most physicists would agree that we still don't understand what it means. Learn about the source of this puzzlement, and why an increasing number of scientists think the world we experience is constantly branching into different versions, representing the many possible outcomes of quantum measurements.

MINDFULNESS

Speaker: Ronald Siegel, Psy.D.

Introduction to Mindfulness

Mindfulness has been practiced for thousands of years, and holds promise for alleviating anxiety, depression, stress and addiction. This workshop will draw upon ancient wisdom and the discoveries of modern science to help you cultivate mindfulness — both to deal with everyday difficulties and to live a richer, happier, more fulfilling life.

The Science of Happiness

Though most human beings want to be happy, few of us know how to achieve happiness. Learn why popular pathways to happiness don't work, and how mindfulness can lead toward wisdom, compassion, meaning and connection. We'll look to modern science, as well as ancient Buddhist insight, to explore pathways to happiness.

Mindfulness for Relationships

Ancient Eastern meditative techniques, originally solitary practices refined by hermits, monks, and nuns, are remarkably useful for facing interpersonal challenges. Learn how mindfulness meditation can help you develop the emotional intelligence, self-regulation, and empathy necessary for successful relationships, and how to use mindfulness to react less defensively to the inevitable ups and downs of interpersonal life.

The Neurobiology of Mindfulness

As psychotherapists adapt ancient contemplative practices to the challenges of treating modern psychopathology, researchers are using FMRI, EEG, and other brain imaging techniques to investigate the neurobiological mechanisms by which mindfulness practices work. This presentation will explore the implications of these investigations for learning how to change our brains.

ARCHAEOLOGY

Speaker: John R. Hale, Ph.D.

A Land of Natural Wonders

Learn about the spectacular natural wonders of Southeast Asia, from ancient rainforests to stunning coral reefs. We'll cover the wealth of unique plant and animal species native to this region, as well as the history of the first domestication of rice, chicken, and pigs here. It's a trove of geology, biology, and natural history.

Cradle of Human Evolution

Find out why Southeast Asia is at the forefront of evolutionary research, and why 19th century scientists believed the human species originated here. We'll cover some of the most game-changing fossils found in the region, from "Java Man" to "Peking Man" to Gigantopithecus and "Flores Man."

Land of Lost Kingdoms

Fascinating kingdoms, from the Khmer rulers who built Angkor Wat to the Siamese kings who defied European colonialists, once reigned in Southeast Asia. Though always living under the threat of Chinese takeover, these powers nonetheless created unique cultures and artistic traditions. We'll discuss this rich history and the monuments they left behind.

Faiths in Collision

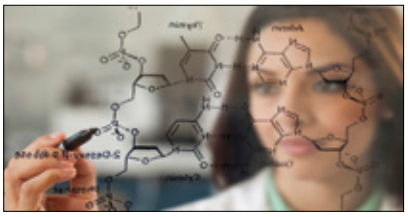
Learn how three of the world's major religions — Hinduism, Buddhism, and Islam — gained firm footholds in Southeast Asia, eventually overcoming the region's native animistic religious cults. We'll discuss the remarkable architecture — temples, monasteries, mosques — of these religions, as well as the ways their beliefs continue to permeate everyday life.

The Story of the Spice Trade

The spices of Southeast Asia — pepper, cinnamon, cloves, nutmeg, cardamom, and others — led Europeans to forge sea-routes seeking out these treasures, and even motivated Columbus' search for a shortcut to Asia (which led him to stumble on America). Learn how the global trade that we take for granted today had its origins in the spice trade.

Shipwrecks of Southeast Asia

Beneath the seas of Southeast Asia lies a museum of Arab dhows, Chinese junks, European trading ships, and World War II warships that were lured by commerce or war. Learn how ancient coins, woodcarvings, bronzes, and the wooden hulls of ships themselves helped archaeologists reconstruct the trade routes that linked East and West.



GENETICS & EVOLUTION

Speaker: John Mattick, Ph.D.

The Story of the Molecular Biology Revolution

Learn about the heady days when enzyme chemists joined physicists to decipher the genetic code, and later joined the bacterial geneticists to develop the tools that launched the gene cloning and genomic revolutions that are laying bare the programming of life. It's a story of great characters, rivalries and debates, pioneering vision and crippling hubris.

The Origin of Life

The story of life is a dramatic, mysterious tale, originating in a primordial soup of organic molecules, and ultimately resulting in species that can remember, learn, sing, think, and write. Learn how evolution navigated cellular biology, and probe the complex innovations that must have occurred along the way.

Junk DNA: Challenging the Dogma

Non-coding sequences of DNA were dismissed as junk when discovered, but scientists now are realizing that these segments are copied into RNA in precise patterns that orchestrate gene expression during development. Learn how what once was thought to be junk actually holds the secret to understanding human evolution, development, diversity, and cognition.

Evolving Evolution

We'll contrast two early views of evolution by Charles Darwin and Jean-Baptiste Lamarck, and discuss how scientists' understanding of evolution has itself evolved over time. The traditional picture, that mutation is random and selection acts only on the progeny, may be incorrect. Evolution, it seems, has learned how to learn, and we're the result.

Your Genome and You

Gene sequencing, once a costly and difficult process, is set to become routine in the near future. Medicine is evolving from the art of crisis management to the science of good health, increasingly tailored to individuals' genetic and environmental circumstances. Learn what we stand to gain, and what surprises may be in store.

HISTORY OF SCIENCE

Speaker: Steven Goldman, Ph.D.

The Global Roots of Modern Science

Learn how modern science emerged in Western Europe in the 17th century, and grew to maturity in the 19th century. We'll also discuss how the development of modern science is deeply indebted to important contributions from China, the Arabic-speaking lands, and India, as well as from ancient Greece and Rome.

Order Out of Chaos

We'll discuss the profound change the natural sciences underwent in the late 1900s, when scientists in multiple disciplines simultaneously discovered the power of top-down systems thinking, as opposed to bottom-up world building. In this session, become familiar with systems thinking and investigate the possibilities it offers.

The Mind, the Brain, and You

Learn how theories of the mind have evolved throughout time, from the 19th century, when philosophical speculation gave way to the sciences of psychology and physiology, to the late 20th century, when psychology and physiology converged with cognitive neuroscience and computer-based artificial intelligence technologies.

Innovation, Globalization and the Future of America

The steam power-based Industrial Revolution of the mid-19th century quickly gave way to economies that critically depend on continuous technological innovation and access to global markets for growth and sustained prosperity. We'll discuss what America's people, institutions, and policy need to compete in global markets.

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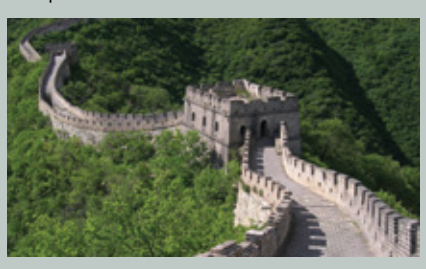

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Is It Possible to Recover from Autism?

New research says yes, but how to spark recovery remains a mystery

BY JENNIFER RICHLER

PHIL ASHLEY Getty Images

WHEN I WAS training to be a clinical psychologist, telling parents that their child had autism was a regular part of my job. Now that I'm a parent, I understand better the pained expression that came over their faces as they contemplated this news. Among the many questions taking shape in their minds, I can imagine the one looming largest: Could their child ever be like other children?

A recent study, published in February in the *Journal of Child Psychology and Psychiatry,* suggests that for some people, the answer is yes. The researchers found that some individuals who had been diagnosed with autism as young children no longer had symptoms—such as difficulty interacting and communicating with others, rigid adherence to rituals and routines, and repetitive movements of their bodies and objects—when they were older.

This finding is not the first to suggest that some young adults with autism lose their symptoms. A 2008 literature review reported that 3 to 25 percent of affected people eventually recover. But the recent study was especially rigorous. The researchers recruited three groups of eight- to 21-year old subjects: 34 of them had apparently recovered from autism, 44 had high-functioning autism, and another 34 were control subjects with no developmental issues.

An expert diagnostician thoroughly reviewed the early records of all recovered participants to confirm that they truly had autism when they were younger, and she correctly rejected 24 reports from kids with nonautism diagnoses (such as language disorders) that had been slipped in as foils, verifying that her diagnostic technique was sound. These measures made researchers confident that the now typically functioning children had not initially been misdiagnosed. The team also set a relatively high bar for recovery: participants not only had to be free of autism symptoms, as indicated by a battery of tests—they also had to have typically developing friends and be fully included in regular education classrooms.

The study's findings were encouraging: those who recovered were on a par with the typically developing individuals and better than the group with high-functioning autism in their social and communication skills and in their ability to go about daily life, such as taking care of themselves and doing housework. These findings, according to some experts, represent a watershed moment in autism research, "clearly demonstrating the possibility of leaving behind the symptoms of [autism] and emerging into a state of healthy functioning," writes University of California, Davis, psychologist Sally Ozonoff, who was not involved in the study.

Not Autistic, Not Quite Typical

As exciting as these results might be, I believe we should interpret them with caution. For one thing, about 20 percent of those in the recovered group still showed mild difficulties with eye contact, gestures and facial expressions. According to the study authors, "these difficulties were judged … not to have an autistic quality." But those doing the judging were not "blind," as researchers are in rigorous clinical trials—they knew if a participant was typically developing, had autism or had supposedly recovered.

It is easy to imagine how this knowledge could have colored their interpretations of participants' behaviors. Even if those in the recovered group did actually lose their symptoms, "the majority still have serious issues," including depres-

sion, anxiety and inattention, notes Elizabeth Kelley, a psychologist at Queen's University in Ontario and one of the study's authors.

Kelley points out another limitation of the study: it looked back at recovery after it had happened. The retrospective design cannot reveal what proportion of kids will shed their diagnosis or why. Parents often try a variety of interventions, including behavioral treatment, speech and occupational therapy, and medication—and they do not always keep detailed records. Until researchers report on the outcomes of children they starting following very early in life, "we have no idea why some people recover," Kelley says.

Fortunately, scientists are starting to do those studies. For example, Catherine Lord, director of the Center for Autism and the Developing Brain at Weill Cornell Medical College, has been following a group of about 100 people with autism from the time they were diagnosed at age two through their early 20s. Study participants completed a large battery of tests every few years as children and again at age 18, and parents have been filling out questionnaires every year.

Like Kelley and her colleagues, Lord has found that a handful of participants lose their autism symptoms. Moreover, she says, "their eye contact, gestures, the way they hold their body, the way they talk about their friends"—behaviors that have long been thought to be difficult to improve on—are indistinguishable from those of typically developing adults. They are also functioning well in daily life, holding down part-time jobs while attending college. The researchers fittingly refer to this group as having a "very positive outcome." A more sizable group is considered "more able" than the remaining adults in the sample—they have no cognitive impairment and are generally doing well academically, although they still have clear autism symptoms. A paper presenting these results is currently under consideration at a peer-reviewed journal.

Who Recovers and How?

Although Lord's study has not resolved the question of why some people with autism improve radically, it has found early signs that may help identify those who will. For example, at a very young age, individuals in the "very positive outcome" group had rapid gains in verbal skills and decreases in restricted and repetitive behaviors, such as flapping their hands and lining up toys. Parents whose children show these early improvements have reason to be hopeful about prognosis.

Interestingly, neither Lord nor Kelley found that those with the best outcomes received more behavioral treatment than the others, as one might expect. This finding does not mean that behavioral treatment is ineffective for autism—in fact, many studies suggest the opposite is true. Researchers simply do not yet know how the amount and type of treatment relate to prognosis. For example, applied behavioral analysis, which focuses on using reinforcement to help children learn and attend to another person, could be especially effective for some youngsters, whereas social skills training, which emphasizes capabilities such as holding a conversation and turn taking, might help others. Similarly, some children might require much more intensive intervention to make gains. The unpredictable effect of treatment could be related to underlying genetic differences; autism most likely has many variations, rather than a single genetic cause.

Until there are more definitive answers, Kelley says, "parents should do as much as they can for their individual child," within their means. She firmly cautions parents against bankrupting themselves or running themselves emotionally ragged trying to get help for their child, because there may be factors leading to better outcomes that are completely outside parental control. "It may be a genetic variant—who knows?" Kelley remarks.

As exciting as these positive outcomes are, we do not yet know if they will last. As people with autism begin to face the challenges of adulthood, old symptoms might recur and new ones could surface. Studies of adults with autism have consistently found that many struggle to live independently, get and keep a job, and form friendships and romantic relationships. Lord and her colleagues want to keep following study participants to see if those in the "very positive outcome" group continue to flourish.

Of course, people with autism can thrive even if they don't recover. Lord recalls an adult with autism who put it well: "If I'm independent, have a good job and have relationships with other people, why am I not as good as someone else?" Researchers and clinicians alike should keep working to understand how all people who have autism can achieve the best possible outcome: a happy, fulfilling life. M

Their eye contact, gestures, **the way they talk about their friends** were indistinguishable from the behavior of typical adults.

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

(Further Reading)

- **Can Children with Autism Recover? If So, How?** Molly Helt et al. in *Neuropsychology Review*, Vol. 18, No. 4, pages 339–366; December 2008.
- **Optimal Outcome in Individuals with a History of Autism.** Deborah Fein et al. in *Journal of Child Psychology and Psychiatry*, Vol. 54, No. 2, pages 195–205; February 2013.

The Brain of Buddha

An encounter with His Holiness the Dalai Lama and the scientific study of meditation

BY CHRISTOF KOCH

CHRISTOF KOCH (*Koch*); COURTESY OF MIND AND LIFE INSTITUTE (*meeting*)

His Holiness the Dalai Lama listens to the author talking about the brain basis of consciousness during a six-day encounter between Tibetan Buddhism and science.

Knowledge can be communicated, but not wisdom. One can find it, live it, do wonders through it, but one cannot communicate and teach it.

THIS LINE FROM Herman Hesse's 1922 novel *Siddhartha* came unbidden to me during a recent weeklong visit to Drepung Monastery in southern India. His Holiness the Dalai Lama had invited the U.S.-based Mind and Life Institute to familiarize the Tibetan Buddhist monastic community living in exile in India with modern science. About a dozen of us—physicists, psychologists, brain scientists and clinicians, leavened by a French philosopher—introduced quantum mechanics, neuroscience, consciousness and various clinical aspects of meditative practices to a few thousand Buddhist monks and nuns. As we lectured, we were quizzed, probed and gently made fun of by His Holiness, who sat beside us [*see photograph above*]. We learned as much from him and his inner circle—such as from his translator, Tibetan Jinpa Thupten, who has a doctorate in philosophy from the University of Cambridge, and from the French monk Matthieu Ricard, who holds a Ph.D. in molecular biology from the Pasteur Institute in Paris—as they and their brethren from us.

> As we lectured, we were quizzed, probed and **gently made fun of** by His Holiness, who sat beside us.

What passed between these representatives of two distinct intellectual modes of thinking about the world were facts, data—knowledge. That is, knowledge about the more than two-millennia-old Eastern tradition of investigating the mind from the inside, from an interior, subjective point of view, and the much more recent insights provided by empirical Western ways to probe the brain and its behavior using a third-person, reductionist framework. What the former brings to the table are scores of meditation techniques to develop mindfulness, concentration, insight, serenity, wisdom and, it is hoped, in the end, enlightenment. These revolve around a daily practice of quiet yet alert sitting and letting the mind settle before embarking on a specific program, such as "focused attention" or the objectless practice of generating a state of "unconditional loving-kindness and compassion." After years of daily contemplative exercise—nothing comes easily in meditation—practitioners can achieve considerable control over their mind.

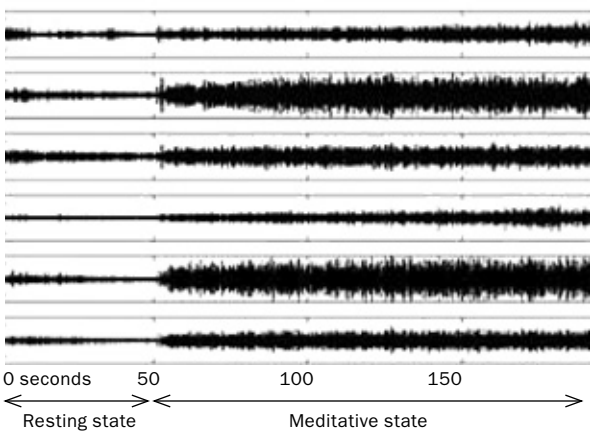
Twelve years of schooling, four years of college and an even longer time spent in advanced graduate training fail to familiarize our future doctors, soldiers, engineers, scientists, accountants and politicians with such techniques. Western universities do not teach methods to enable the developing or the mature mind to become quiet and to focus its considerable powers on a single object, event or train of thought. There is no introductory class on "Focusing the Mind." And this is to our loss!

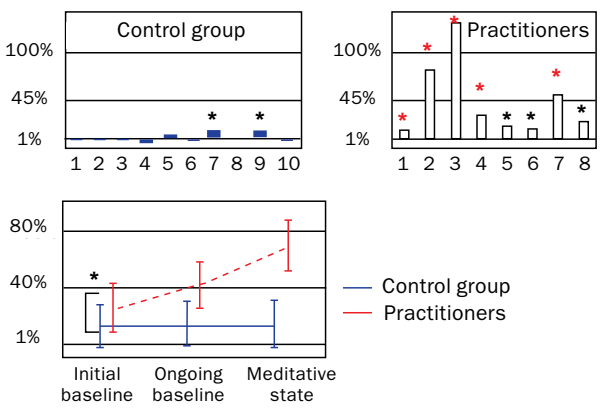
From introspection, we are all familiar with the mental clutter, the chatter that makes up our daily life. It is a rapid fire of free associations, of jumping from one image, speech fragment or memory to the next. Late-night lucubrations are particularly prone to such erratic zigzagging. Focusing on a single line of argument or thought requires deliberate, laborious and conscious effort from which we flee. We prefer to be distracted by external stimuli, conversations, radio, television or newspapers. Desperate not to be left alone within our mind, to avoid having to think, we turn to our constant electronic companions to check for incoming messages.

Yet here we had His Holiness, a 77-year-old man, who sat during six days, ramrod straight for hours on end, his legs tucked under his body, attentively following our arcane scholarly arguments. I have never experienced a single man, and an entire community, who appeared so open, so content, so happy, constantly smiling, yet so humble, as these monks who, by First World standards, live a life of poverty, deprived of most of the things we believe are necessary to live a fully realized life. Their secret appears to be mind control.

Among the more extreme cases of mind control is the self-immolation of the Vietnamese Buddhist monk Thich Quang Duc in 1963 to protest the repressive regime in South Vietnam. What was so singular about this event, captured in haunting photographs that are among the most readily recognized images of the 20th century, was the calm and deliberate nature of his heroic act. While burning to death, Duc remained throughout in the meditative lotus position. He never moved a muscle or uttered a sound, as the flames consumed him and his corpse finally toppled over.

I am filled with utter bewilderment in the face of this singular event and would have found it difficult to accept as real, were it not captured in the testimony of





Experienced meditators produce synchronized high-frequency gamma waves in the brain, detected by EEG. At the left, as a monk starts to meditate, gamma-band activity (between 25 and 42 cycles a second) initiates. Right panels illustrate the difference between 10 novice and eight long-term meditators in gamma-band activity (relative to more slowly changing brain waves). This increase in synchronized high-frequency electrical activity is also present when the monks are quietly resting and reflects a pronounced change in their brain architecture.

FROM "BUDDHA'S BRAIN: NEUROPLASTICITY AND MEDITATION," BY RICHARD J. DAVIDSON AND ANTOINE LUTZ, IN *IEEE SIGNAL PROCESS MAGAZINE*, VOL. 25, NO. 1; JANUARY 1, 2008

East meets West in this group shot of the two communities present at the gathering organized by the Mind and Life Institute.

COURTESY OF FATMA IMAMOGLU

hundreds of onlookers, including jaundiced journalists with their cameras.

Brain Basis of Mind Control

A step toward a brain-based explanation of this extraordinary phenomenon comes from a recent scanning experiment by Fadel Zeidan, Robert C. Coghill and their colleagues at the Wake Forest School of Medicine. Fifteen volunteers were recruited to lie in a scanner while a small metal plate was attached to their right calf. As its temperature varied from pleasant (near body temperature) to painful (49 degrees Celsius), subjects had to rate both pain intensity and pain unpleasantness of the noxious stimulus. Predictably, the hot probe triggered increased hemodynamic activity in structures that are known to be involved in pain processing, such as the primary and secondary somatosensory cortices that represent the leg, as well as more frontal structures, the anterior cingulate cortex and the insula. Subsequently, the volunteers underwent four days of 20 minutes' daily practice of mindfulness meditation involving focused attention or the Buddhist mind-calming practice called *shamatha*. In the latter, the practitioner focuses attention on the changing sensations of her breath, noting thoughts, pictures and memories as they arise from their inner source, but without any emotional engagement. This exercise frees her to quickly disengage from them to return attention to monitoring her breathing.

Practicing mindfulness during the noxious stimulation reduced the unpleasantness of the pain by a whopping 57 percent and its intensity by 40 percent. And this after only minimal training (four times the 20 minutes). Of course, it is a far cry from attenuating

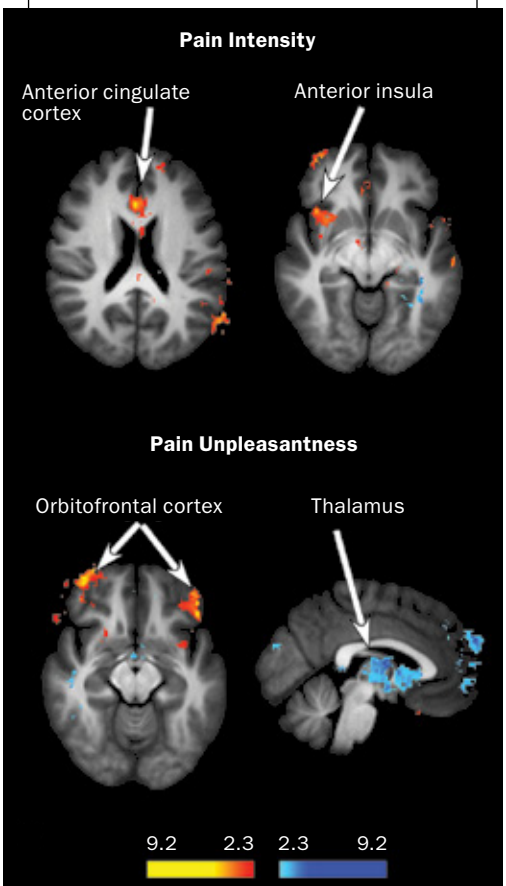
(Mindfulness reduced the **unpleasantness of pain** by a whopping 57 percent and its intensity by 40 percent.)

the unthinkable agony of burning to death, but still. Mindfulness exerts its effect by promoting a sense of detachment and by reducing the subjectively experienced saliency of the heated metal plate. Yet how does it work in the brain?

Pain-related activity in the primary and secondary somatosensory cortices was reduced by the meditation. Those subjects who experienced the greatest reduction in the intensity of their pain had the largest increase of activity in their right insula and both sides of their anterior cingulate cortices. Subjects with the greatest reduction of the unpleasantness of the pain—which is what most people care about—exhibited the greatest activation of regions in the orbitofrontal cortex and the largest reduction in the thalamus (gating the incoming sensory information).

Think of mindfulness, think of all meditations, as mental skills to control emotions and to shape the impact that external events, such as sight, sound or heat, have on the sensory brain. Select prefrontal regions in the practitioner's brain reach all the way down to the thalamus to reduce the flood of incoming information from the periphery, leading to a lessening of the pain. These skills to steer the mind are not magical, otherworldly or transcendental. They can be learned by sufficiently intensive practice. The only question is whether our instruments are always sufficiently sensitive to pick up their footprints in the brain.

In 2008 Richard J. Davidson and his group at the University of Wisconsin–Madison published a classic study with the active participation of Ricard and other Buddhist monks. The cognitive scientists fitted skullcaps with 128 electroencephalographic (EEG) electrodes to the heads of eight long-term Buddhist practitioners and 10 student volunteers. The former were asked to attain a state of "unconditional loving-kindness and compassion" (a form of meditation that does not focus on a single object and is sometimes referred to as "pure compassion"), whereas the volunteers thought about somebody he or she deeply cared about and then tried to generalize these feelings to all sentient beings.



In experiments, the more strongly the mindfulness meditation reduced the pain of the hot metal on the right calf, the higher the brain activity in frontal structures involved in cognitive control and the lower the activity in the thalamus (*lower right panel*). This activity most likely gates, or reduces, the arriving noxious information before it even reaches the cortex. Yellow-red denotes an increase and blue a decrease in activity.

The onset of meditation in the monks coincided with an increase in high-frequency EEG electrical activity in the so-called gamma band (spanning 25 to 42 oscillations a second), which was synchronized across the frontal and parietal cortices. Such activity is thought to be the hallmark of highly active and spatially dispersed groups of neurons, typically associated with focusing attention. Indeed, gamma activity in these monks is the largest seen in nonpathological conditions and 30 times greater than in the novices. The more years the monks had been practicing meditation, the stronger the (normalized) power in the gamma band.

More important, even when the monks were not meditating, but simply quietly resting, their baseline brain activity was distinct from that of the students. That is, these techniques, practiced by Buddhists for millennia to quiet, focus and expand the mind—the interior aspect of the brain—had changed the brain that is the exterior aspect of the mind. And the more training they had, the bigger the effect.

Yet knowing about meditation and its effect on the brain is not the same as benefiting from it and not the same as achieving wisdom. So just like the young Siddhartha in Hesse's novel, I left the monastic community richer in knowledge about a different way to look at the world but continuing to strive. M

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

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READY FOR *ANY*THING

Scientists have compiled evidence-based tactics for building resilience. Among them: rethink adversity, forge close friendships and tackle novel challenges

By Steven M. Southwick and Dennis S. Charney

PHOTOILLUSTRATION BY AARON GOODMAN

As a college student at Brown University, Jerry White spent his junior year abroad studying in Israel. On a sunny day during the Passover holiday in April 1984, White and two friends set out for a camping trip in the Golan Heights. "I was walking out ahead of my friends with a song in my heart. I like being the leader, the one out in front," he recalls. "Then, boom! A huge explosion." He had stepped on a land mine. As blood poured from his leg, White screamed, "I have no foot! I have no foot!"

Wartime injuries need not be devastating. Many veterans learn and grow from their traumatic experiences.

White's friends wrapped his stump with a shirt, tied a makeshift tourniquet around the injured leg and carried him through what they now knew was a minefield. For the next four months White lived in two Israeli hospitals where he felt helpless, sad and alone. "People were trying to introduce themselves, but they were all missing arms, legs, eyes, or they were burn victims. I felt sick and afraid," he says.

Eventually White returned home, completed college and worked as a substitute teacher before becoming an activist working on behalf of fellow victims. In 1995 he, along with his friend and colleague Ken Rutherford, who had lost both legs to a land mine in Somalia, founded the Landmine Survivors Network (renamed Survivor Corps). This group played a leading role in the International Campaign to Ban Landmines, which was awarded the Nobel Peace Prize in 1997.

White's transformation from frightened victim to passionate survivor demonstrates resilience, the "process of adapting well in the face of adversity, trauma, tragedy, threats or even significant sources of stress," according to the American Psychological Association. A resilient person may bend but does not break when confronted with adversity, enabling him or her to bounce back relatively quickly.

Biologically, resilience is the ability to modulate and constructively harness the stress response—a capacity essential to both physical and mental health. Unchecked, chronic stress can impair the immune system and contribute to illnesses such as gastric ulcers, asthma, depression, diabetes and heart disease. Stress can also spawn unhealthy behaviors such as smoking and excessive alcohol use.

Success appears to hinge on resilience. Setbacks are part of any endeavor, and those who react to them productively will make the most progress. In a 2002 *Harvard Business Review* article, Dean M. Becker, a founder of the resilience-training firm Adaptiv Learning Systems, is quoted as saying, "More than education, more than experience, more than training, a person's level of resilience will determine who succeeds and who fails. That's true in the cancer ward, it's true in the Olympics, and it's true in the boardroom."

Whether a person hangs tough or gives up in hard times depends on influences at multiple levels, from molecules to neighborhoods. Resilience is determined by both inborn traits and environmental factors that affect the capacity to adapt to stress. Although some of these environmental influences, such as poverty, are difficult to alter, a person can increase his or her level of resilience by developing mental and physical habits that foster positive adaptation to stress and trauma.

KAREN BALLARD *Redux Pictures*

FAST FACTS

Armed against Adversity

1» **Resilience is the ability to modulate and constructively harness the stress response—a capacity essential to both physical and mental health.**

2» **Success can hinge on resilience. Setbacks are part of any endeavor, and those who react to them productively will make the most progress.**

3» **A person can boost his or her resilience. Strategies include reinterpreting negative events, enhancing positive emotions, becoming physically fit, accepting challenges, maintaining a close social network and imitating resilient role models.**

STEPHEN MARKS *Getty Images*

Resilience is critical to success. The ability to keep working toward a goal in the face of difficulty separates the CEOs from the ne'er-do-wells.

Standing Up to Stress

Browse through the magazine section of any bookstore or drugstore, and you will find an assortment of books and articles on how to reduce stress: "7 Rules for a Stress Free Life," "Leave Your Stress Behind," "How You Can Reduce Your Stress and Your Dress Size," and so on. The basic message is that stress is bad—but it is not always. Some stress is actually good. Without stress, we would weaken. Difficulty that can be mastered, on the other hand, facilitates growth, self-esteem, self-efficacy and resilience. A resilient person is thus not someone who avoids stress, but someone who learns how to tame and master it.

A body of data, including studies of identical twins, suggests that certain personal characteristics that foster resilience may be at least partly inherited. These traits include a temperament that leads a child to confidently take on novel tasks and interact with unfamiliar people, as well as a good-natured, sociable personality and an ability to accept yourself, including your faults. Researchers are now uncovering some of the basic biology of resilience that facilitates our adaptive responses to stress [*see box on page 38*].

Beyond biology, several environmental variables affect resilience, among them family support, the stability and quality of schools, and the services in and safety of a neighborhood. For example, a loner who is unemployed will have more trouble dealing with stress and trauma than a financially secure individual in a supportive family. Weak leadership in a community and insufficient first-responder and financial resources can also compromise responses to adversity.

Some of these situational factors, along with specific character traits, may be hard to change. Nevertheless, people can learn to think and act in

A resilient individual is not someone who avoids stress but someone who learns how to tame and master it.

ways that greatly enhance resilience. Virtually anyone can become more resilient through disciplined, consistent practice. The more we activate specific brain areas through our behavior, the more neural connections form in those areas, enabling the neurons involved to transmit their messages more efficiently.

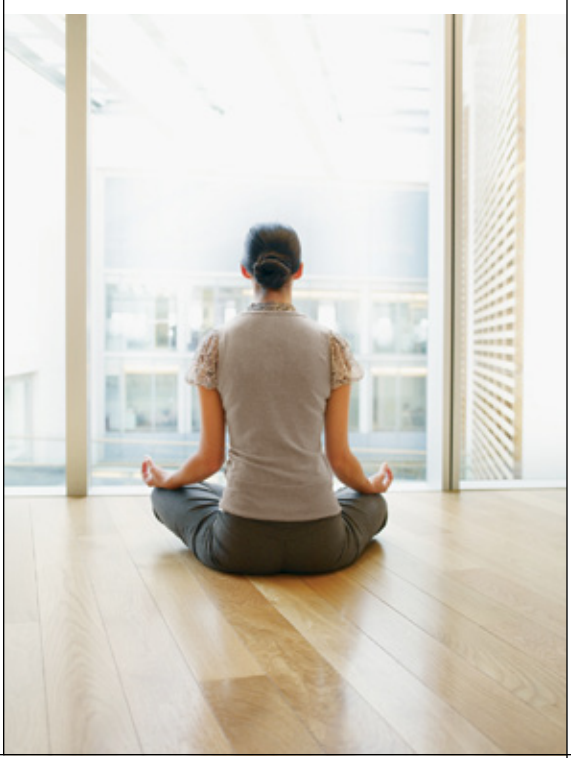
In our book *Resilience: The Science of Mastering Life's Greatest Challenges,* we identify 10 avenues for building resilience. Some of these strategies reduce stress. Others help you grow from the experience. Strategies to increase resilience include learning how to regulate your emotions, adopting a positive but realistic outlook, becoming physically fit, accepting challenges, maintaining a close and supportive social network, and observing and imitating resilient role models. We discuss each of these approaches below.

Emotional Rescue

The ability to regulate emotions such as sadness, anger and fear is critical for effectively coping with stress and trauma. Negative emotions are natural and often adaptive, but if left unchecked, they can seriously compromise our ability to think clearly and to make rational decisions in challenging situations.

Researchers have devised numerous strategies for regulating emotions and enhancing resilience. Two approaches that have received increasing scientific support in recent years are cognitive reappraisal and mindfulness meditation. Using reappraisal, individuals reinterpret the meaning of an adverse event so that they see it as less negative. Doing so tends to attenuate physiological and emotional reactions to the event. For example, psychologist Kevin Ochsner and his colleagues at Columbia University have shown that when people intentionally reinterpret a situation such as a rejection for a job or the loss of a friend as being less negative, they report a decrease in unpleasant emotions. Ochsner's team also found that this improvement in mood is accompanied by changes in the brain—in particular, an increase in activity in the prefrontal cortex, a center for planning, directing and inhibiting behavior, and a decrease in activity of the amygdala, a hub for feelings such as fear.

These former prisoners of war found meaningful ways in which they had grown stronger, wiser and more resilient.



Engaging in mindfulness meditation is an effective way of controlling stress.

CHRIS RYAN *Getty Images*

For years researchers have studied how people regulate their emotions. Individuals who frequently use cognitive reappraisal as a way to alter their emotional reactions to stress and trauma tend to report greater psychological well-being than those who do not look for neutral or positive ways to interpret their circumstances. For example, in a 2008 study we, along with psychiatrist Adriana Feder and other colleagues at the Mount Sinai School of Medicine, interviewed 30 former Vietnam prisoners of war about how they evaluated their wartime experiences. We found that most of these veterans, many of whom had been brutally tortured, had actively reappraised their imprisonment and found meaningful ways in which they had grown stronger, wiser and more resilient as a result of it. They also reported that they were now better able to see possibilities for the future, relate to others and appreciate life.

Training in cognitive reappraisal is a component of various therapies designed to enhance well-being, strengthen resilience and reduce distress. For example, cognitive-behavior therapies, which are effective for treating mood and anxiety disorders,

Using a coping strategy called cognitive reappraisal, a person revises his or her interpretation of a difficult experience to make it less negative.

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teach individuals to observe their own thoughts and behaviors, to challenge their negative assessments of stressful situations and of themselves, and to replace these with more realistic and positive points of view. When faced with a highly stressful or negative episode, you may find it helpful to ask yourself, "Is there a less destructive way to look at this situation?" "Am I catastrophizing or exaggerating its potential negative impact?" and "Is there something that I can learn from this experience, or is it possible to grow stronger as a result?"

Another strategy for controlling stressful emotions is to engage in mindfulness meditation. This exercise teaches practitioners how to consciously live in the present moment, rather than dwelling in the past or fretting about the future. The participant becomes an observer who learns to watch, but not judge, as the mind tends to automatically follow familiar conditioned patterns of thinking that often add to distress and maladaptive coping. Mindfulness meditation has been associated with improved ability to focus, more flexible thinking, greater psychological well-being, and better ability to cope with depression, anxiety and stress [see "Being in the Now," by Amishi P. Jha; Scientific American Mind, March/April 2013].

Brain-scanning experiments have revealed that both mindfulness meditation and training in cognitive reappraisal can increase activation of the left prefrontal cortex, a pattern that is associated with greater emotional control, a boost in positive emotions, and faster recovery from feelings such as anger, disgust and fear. Attending a workshop on mindfulness meditation is one good way to start learning how to modulate the stress response and successfully weather life's many challenges.

A Glass Half Full

In addition to attenuating negative emotions, a dedicated effort to bolster positive emotions can enhance a person's ability to bounce back from difficulty. Optimism and positive emotions are strongly associated with good mental and physical health, even longevity. In a remarkable study published in

(The Authors)

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2001 developmental psychologist Deborah D. Danner of the University of Kentucky and her colleagues examined autobiographical sketches composed by 180 nuns from School Sisters of Notre Dame in Milwaukee before they took their vows of commitment to the Church and God. They found that the degree of positive emotion expressed in the sketches, which had been written decades earlier, predicted longevity. Only 34 percent of nuns whose sketches were classified in the lowest quarter of cheerfulness were still alive at age 85 compared with 90 percent who had been classified in the most upbeat quarter.

The health benefits of positive emotions probably stem from a better ability to regulate the stress response. Psychologist Barbara L. Frederickson of the University of North Carolina at Chapel Hill and her colleagues have found that negative emotions tend to increase physiological arousal, narrow our focus of attention and restrict our behaviors to those essential for survival. Positive emotions, on the other hand, have been found to reduce arousal and broaden our focus, leading to more creative and flexible responses to stress and trauma.

Resilience is associated with realistic optimism, not the rose-colored form. Because the latter often involves ignoring negative information, people who adopt an overly buoyant outlook tend to underestimate stressful and risky situations. On the other

The Biology of Bouncing Back

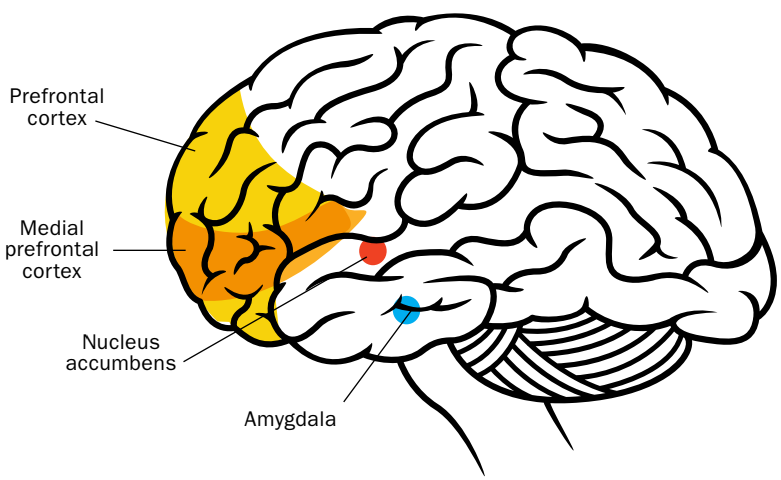
Researchers have traced resilience, the capacity to recover from adversity, to a network of brain regions and chemicals. Beginning early in life, an individual's genes and the interaction of those genes with the environment shape brain circuits that underlie the psychological strengths and behaviors of resilient people.

Critical to building resilience is the capacity to face fears, experience positive emotions, search for adaptive ways to reframe stressful events and benefit from relationships. Thus, resilience relies on neural circuits governing fear, reward, and social and emotional regulation. These circuits overlap at certain brain structures. For example, the amygdala not only regulates fear but also has a major role in reward, through the processing of positive emotions. The nucleus accumbens, the hub of reward, also influences social behaviors such as sociability and pair bonding. The medial prefrontal cortex has a role in all three circuits, helping to regulate social interactions and emotions and relaying that information to other regions to inform higher-level decisions. As a result of the overlap and connections among these circuits, how a person faces fear is correlated with his or her ability to remain upbeat under stress and generate rewarding social experiences in tough times.

The neural circuits of fear, reward and social behaviors are powered by a variety of neurochemicals and hormones. One of these, neuropeptide Y, is a short protein found in the amygdala and other regions that mediate anxiety and fear. Among people under severe stress, such as someone undergoing challenging military training, higher neuropeptide Y levels are connected to better performance. High levels of the stress hormone cortisol, however, are associated with depression. Norepinephrine, another stress hormone, helps us react appropriately to danger by readying us to fight or flee the scene. Unrestrained repeated increases in norepinephrine may create chronic anxiety, however. Dopamine and serotonin, meanwhile, help us stay positive under difficult conditions.

Resilience may also be related to activation of the left prefrontal cortex. When active, this region at the surface of the brain just behind the forehead sends inhibitory signals to the amygdala, quieting anxiety and fear-based emotions and leaving the frontal brain region free to plan and set goals. In this way, a person is better able to persevere, maintain a positive self-image, remain hopeful in stressful times, and plan and act without being overwhelmed by fear or other emotions. Understanding the biological underpinnings of resilience could help researchers and clinicians design psychological and pharmacological interventions that make people better able to overcome adversity.

—S.M.S. and D.S.C.



JAMIE CARROLL *iStockphoto*

hand, realistic optimists filter out unnecessary negative information but pay close attention to bad news that is relevant to dealing with adversity. Using a technique called cognitive-bias modification, you can, with repetitive training, learn to tune out negative words and occurrences and develop a habit of interpreting ambiguous situations in a more positive manner [see "The Essence of Optimism," by Elaine Fox; Scientific American Mind, January/February 2013].

Working Out Your Troubles

Physical activity can enhance resilience, too, by protecting people (and animals) against the negative effects of stress. During the past decade neuroscientist Benjamin N. Greenwood and his colleagues at the University of Colorado at Boulder have published a series of studies in rats showing that six weeks of voluntary wheel-running exercise can ward off anxiety and depressionlike behaviors, such as exaggerated fear, reduced social exploration and increased intake of morphine, that typically result from exposure to a variety of intense stressors.

In humans, aerobic exercise also has been shown to reduce symptoms of depression and anxiety. It improves attention, planning, decision making and memory, all of which are important for effectively managing stress. Exercise appears to promote resilience through a number of neurobiological mechanisms. For example, it boosts levels of endorphins as well as neurotransmitters such as dopamine and serotonin that may reduce symptoms of depression and elevate mood. It also suppresses the release of the stress hormone cortisol.

In addition, workouts seem to activate genes for proteins, such as brain-derived neurotrophic factor (BDNF), that promote the growth and repair of neurons, which prolonged stress can damage. In a study published in 2011 psychologist Arthur F. Kramer and his colleagues at the University of Illinois at Urbana-Champaign found that moderate-intensity aerobic exercise (three days a week for one year) increased the size of the hippocampus, a brain region involved in both memory and stress regulation, by 2 percent. This growth was associated with increases in BDNF and improved memory, suggesting that exercise can protect neurons in this area and may thus help people recover from difficult circumstances.

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Exercise can strengthen attention, decision making and memory, empowering people to better shoulder stress.

For general health, the Department of Health and Human Services has recommended at least one hour and 15 minutes a week of intense aerobic workouts such as swimming or running or twice as much moderately intense exercise—mowing the lawn, say, or walking fast—along with two days of muscle strengthening. (Those who work out more tend to reap greater health benefits, although very intense or prolonged athletic endeavors can actually be detrimental to physical and mental health.)

To enhance resilience, however, we recommend that you consult with your physician and then develop a schedule in which you gradually increase the intensity of your cardiovascular and strength training. Every workout should be challenging but manageable. In this way, in addition to getting the biological benefits of exercise itself, you are also care-

Workouts activate genes for proteins that promote the growth and repair of neurons, which stress can damage.

Taking on moderately stressful challenges, such as giving a lecture in front of a small group, can boost resilience.

fully calibrating your exposure to stress in a way that is known to increase resilience.

This general strategy is called stress inoculation. It is based on the notion that if a person deliberately takes on increasingly difficult challenges he or she will gradually learn to handle higher levels of stress. The inoculation principle of graded exposure can apply to a broad range of activities designed to increase physical, emotional and cognitive resilience. For example, practitioners of mindfulness can increase their ability to concentrate by gradually lengthening their periods of meditation. A person who is afraid to give speeches might sign up for a public speaking workshop and afterward accept speaking engagements in front of small, nonthreatening audiences, then gradually agree to stand up in front of larger and more challenging crowds.

Such experiences should be outside your comfort zone but not so intense as to be unmanageable or potentially harmful. You should also plan to progressively increase the intensity or difficulty of these endeavors. As noted in the *U.S. Army Combat Stress Control Handbook,* "To achieve greater tolerance or acclimatization to a physical stressor, a progressively greater exposure is required. The exposure should be sufficient to produce more than the routine stress reflexes.... In other words you must stress the system." Moreover, make training as realistic as possible. Pilots, firefighters, police and soldiers all enhance their physical, cognitive and emotional skills in realistic settings where they can obtain constructive feedback from instructors and colleagues.

As you gradually acclimate to greater levels of stress, you will need to recover and relax more. Psychologist James Loehr, who has written several books on resilience training, points out that insufficient recovery relative to the high volume of stress can be quite damaging and that one of the most important life skills may be knowing when high recovery needs to balance high stress.

Friends in Need

A particularly effective way to enhance resilience is to strengthen one's relationships because doing so can dampen your biological response to stress and bolster your courage in tense situations. High levels of social support have been associated with better psychological outcomes after many types of trauma, including childhood sexual abuse and combat. For example, in a 1998 study psychologist Lynda A. King of Boston University and her colleagues found that high levels of social support after returning from war were associated with significantly lower levels of post-traumatic stress disorder among a sample of 1,632 male and female Vietnam veterans. High social support has also been linked with better overall physical and psychological health in college students, new mothers, parents of children with serious medical illnesses, widows and unemployed workers.

Backing from others is powerful because it increases an individual's self-confidence, provides a safety net if we should fall, and bolsters our belief that we can overcome obstacles. As a result, we tend to more actively solve problems rather than passively avoiding challenges. After all, bonding with others does provide greater security; a group that works closely together is stronger than an individual. On a biological level, social ties stimulate the release of the hormone oxytocin. Oxytocin is known to reduce anxiety and fear in part by limiting the cortisol response to stress. (It also promotes affiliative behaviors and emotions, such as trust, that encourage continued socializing.)

Interestingly, social support may have an even stronger effect on coping with adversity in Latin American and other cultures that place great value

High levels of social support have been associated with better psychological outcomes after many types of trauma.

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Friendships can lift you up, provide security and prevent a precipitous fall.

LOUIS DEBENHAM *Getty Images*

on interdependence, extended kinship systems and collectivism. It plays a comparatively lesser role in more individualistic cultures such as ours, although relationships in all societies are vital.

To boost resilience through your relationships, first evaluate your social network. Make a list or map of the people you feel connected to. With whom do you interact daily? Who would help you without hesitation? To whom do you turn for advice? Who really understands you? And who can count on you for help?

If you find you need to bolster or simply maintain a supportive network, reach out to family, friends and colleagues. Join organizations that share your interests and concerns. Find ways to help others. As an adult, it is also important to teach children the skills needed to become socially competent, such as knowing how to listen to, empathize with and give support to others.

More Than Flattery

In your social circles, look for people who recover quickly from hardship whom you could learn from. Members of your own family, colleagues, teachers, coaches, or even historical figures or fictional characters could also serve as resilient role models.

Psychologist Albert Bandura, the highly influential emeritus professor at Stanford University, believed that modeling was most effective when the observer analyzed what he or she wished to imitate by dissecting it into segments and creating rules that could guide future action. For example, when a friend of one of us (Southwick) lost her job, I noticed that she immediately called fellow employees, former employers and friends to solicit their help in searching for a new position. When she fell ill with pneumonia, she moved in with her sister until she recovered. And when her mother died, she called her family and closest friends and asked them to spend time with her. Rather than going it alone in times of stress, she reached out for support from those who care about her, a pattern that can guide my own behavior.

White, the land-mine survivor, is an outstanding model of resilience. Through years of soul-searching (read: cognitive reappraisal), he began to see the loss of his foot as more opportunity than horrendous misfortune. Together with a group of like-minded individuals, he embarked on a quest to rid the world of land mines. Through thoughtful reassessment, social support and a problem-solving approach, White transformed his tragedy into a mission of hope. M

(Further Reading)

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THE PERFECT HIRE

TECHNOLOGY AND PSYCHOLOGY ARE RESHAPING THE SEARCH FOR THE BEST EMPLOYEES

By Tomas Chamorro-Premuzic and Christopher Steinmetz

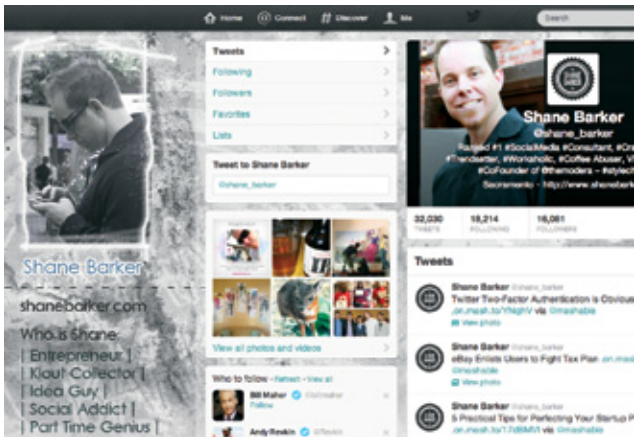
In 2012 Shane Barker set out to land a job managing social media for the San Francisco 49ers. He did not have any connections inside the company; he did not even submit his résumé. An avid user of social media since 2005, he used the social-networking tools at his fingertips to try to get the 49ers' attention.

First, Barker visited a Dallas Cowboys training camp and recorded a video of himself rooting for the 49ers in enemy territory, which he then posted to his YouTube channel. In August he published a blog on his personal Web site entitled "San Francisco 49ers Social Media: Why Hire Shane Barker?" in which he included the video and data demonstrating his online influence. He then shared the link to his blog on Twitter, Google+ and Facebook.

Barker soon had a job offer in hand—not from the football team but from a start-up in Uzbekistan that had noticed his efforts. Together he and the Central Asian entrepreneurs launched Modera, a fashion-themed photograph-judging Web site. Within months he had moved into a house in Sacramento with some of his new colleagues to focus on the enterprise full-time. Though a far cry from working for his favorite football team, Barker's change of fortune exemplifies some of the trends emerging in recruiting today.

Companies have long sought the best methods for identifying the next superstar employee. Now social media tools, online games and data-mining techniques that scour the Web for hints to an applicant's personality are joining the traditional

ILLUSTRATIONS BY GAVIN POTENZA



Shane Barker used social media, including his Twitter account, to land his latest job.

résumé, cover letter and interview. These innovations offer new opportunities for recruiters and job hunters alike, as Barker's story illustrates. In a 2012 survey by Jobvite, a recruiting software company, 93 percent of the 1,000 human resources professionals surveyed reported that they relied on LinkedIn to gather information about candidates. Two thirds of them used Facebook, and slightly more than half reported consulting applicants' Twitter accounts.

New ways to discover and screen candidates online have led psychologists to wonder: Are these technologies helping or hurting companies and job hunters? Intuition rather than science is driving the social media trend, and from what psychologists have studied so far, the outcomes are mixed. Before we can evaluate whether these new technologies are improving hiring, however, we need to consider the gaps in our traditional methods.

What Employers Want

The goal of a recruiter—whether a human resources administrator or a line manager—is to find the person who best fits the requirements and culture of a given job. Typically a recruiter crafts an advertisement for the position, posts it to the company Web site and some job boards, collects applications—résumés, cover letters and references—then selects a few candidates for interviews.

This process is rather flawed. It ignores some of the core findings of industrial and organizational psychology on how to screen candidates. Take IQ, for example. IQ has been shown to be the most consistent predictor of performance across a variety of jobs because it indicates a candidate's ability to learn and thus reflects how quickly a person can be trained. Yet it remains an unpopular selection tool [*see box on page 47*]. Administering IQ tests may be too onerous for most companies, but scores on standardized exams such as the SAT and the GRE are highly correlated with IQ scores and can be regarded as a proxy for learning potential.

Another powerful predictor of career success, the personality test, has gained a somewhat stronger foothold in employee selection. Hundreds of independent research studies have demonstrated that these tests are better indicators of future career success than letters of recommendation, interviews and educational credentials.

The personality tests that have been shown to forecast performance are based on the "five-factor model," a well-supported and thoroughly researched framework for understanding how our personalities differ. According to it, we can be analyzed along five continuous, nonoverlapping dimensions: openness, conscientiousness, extroversion, agreeableness and emotional stability. Conscientiousness and, to a lesser extent, high emotional stability are the most consistent predictors of success across jobs and criteria. (Although the Myers-Briggs Type Indicator is the best-known personality test, very few peer-reviewed studies have demonstrated that its results accurately predict a job candidate's performance.)

Yet neither of these psychometric tests fits seamlessly into the recruiting process. One reason is that evaluators tend to focus on the everyday behaviors of candidates because this information is easily accessible in an in-person interview. Another explanation, derived from numerous studies across several cultures, is that applicants tend to view such tests as less fair than face-to-face interviews and work samples. Perceptions of fairness matter; they can affect applicants' self-esteem, along with their motivation to continue pursuing employment and to ultimately accept the job.

Help from Social Networks

Recent findings suggest that aspects of personality can be gleaned from our digital footprints. In one early study by psychologists Simine Vazire and Samuel D. Gosling of the University of Texas at Austin, for example, people who perused 89 personal Web sites were equally good at detecting the conscientiousness and openness of the site owner as of a long-time acquaintance.

Blogs, too, can offer insight. A 2010 study by psychologist Tal Yarkoni of the University of Colorado at Boulder analyzed

FAST FACTS

Talent Tech

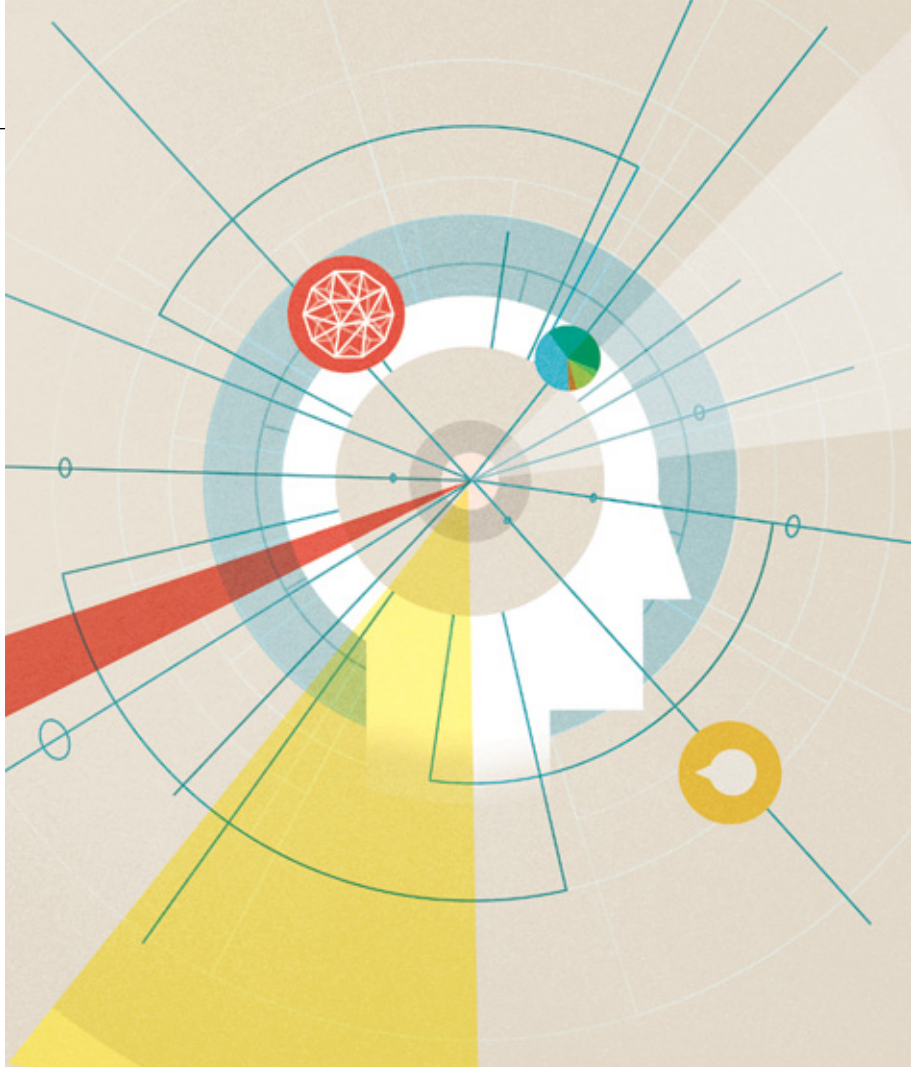
1» **Social media tools, online games and data-mining techniques promise to help companies find their next superstar employee.**

2» **A raft of new studies reveals that aspects of personality and intelligence, which can help predict success on the job, can be gleaned from our online data trails.**

3» **These online services may be able to overcome some of the psychological pitfalls of traditional recruiting methods.**

COURTESY OF TWITTER, WITH PERMISSION FROM SHANE BARKER

PERSONALITY TESTS ARE BETTER PREDICTORS OF FUTURE CAREER SUCCESS THAN LETTERS OF RECOMMENDATION, INTERVIEWS AND EDUCATIONAL CREDENTIALS.



the words used in 695 blogs and their owners' responses on a personality test. He found that neurotic bloggers commonly used words such as "awful" and "lazy," whereas agreeable writers were more likely to describe something as "wonderful" and conscientious word-slingers often used "completed."

These findings support the intuitions of most recruiters who Google a candidate's name and check for Facebook, Twitter and LinkedIn accounts in search of telling revelations. A 2011 study by psychologists Ralf Caers and Vanessa Castelyns of University College Brussels found that of 353 HR professionals polled, 43 percent admitted to drawing conclusions about applicants' personalities based on their Facebook profiles, such as extroversion and maturity. Herein lies some risk for recruiters: as they casually peruse an applicant's data trail, they may become biased at an earlier stage in the process by traits such as attractiveness, facial maturity, a handicap or obesity than if they had observed these details for the first time only in person. Recruiters may unconsciously decide against inviting someone in for an interview based on features that have nothing to do with job performance.

More useful metrics might emerge from software capable of categorizing Web data into personality dimensions. This field is in its infancy, but two examples are TweetPsych and YouAreWhatYouLike, both simple, free online apps. TweetPsych scores the emotional and intellectual content of a person's Twitter activity on a range of topics—such as learning, money, emotions and anxiety—as compared with others in its database. Consider a scenario in which a recruiter has shortlisted two candidates with comparable qualifications, but one of them has a much higher "negativity" rating than the other based on the tenor of his tweets. The recruiter may well be inclined to select the more upbeat person for the job.

YouAreWhatYouLike compiles personality profiles in line with the five-factor model based solely on what a person purports to "Like" on Facebook. The Like button is a way for Facebook users to express positive feeling toward online content, such as the profile page of an artist, a friend's photograph or status update, or even a category such as chihuahuas. A visit by a Facebook user to YouAreWhatYouLike.com can generate labels along several dimensions, such as "liberal and artistic," "calm and relaxed," and "well organized."

The research group behind this software, led by psychologist Michal Kosinski of the University of Cambridge, published a deeper analysis earlier this year of Facebook information from 58,000 volunteers. Participants granted the researchers access to their Likes; they also shared detailed demographic data and the results of several psychometric tests. By analyzing the associations between almost 56,000 "Liked" objects and the participants, they built models that could predict a person's traits and preferences, including IQ. They evaluated the accuracy of

(The Authors)

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SOCIAL MEDIA CAN INCREASE THE CANDIDATE POOL AND GIVE EMPLOYERS A WEALTH OF RELEVANT INFORMATION ABOUT PROSPECTIVE HIRES.

those predictions using the other data provided by the volunteers and found they could deduce gender, sexual orientation, political preference, religion and race with greater than 75 percent accuracy. For personality traits and intelligence, accuracy was lower but still significant. (The best predictors of high intelligence, by the way, were "thunderstorms," "*The Colbert Report*," "science" and "curly fries.") We are on the cusp of deriving those two highly predictive metrics—IQ and personality—from the digital breadcrumbs of our online wanderings.

In spite of the growing popularity of Twitter and Facebook, LinkedIn is the leading social network for recruiters, not least because it was specifically developed for professional purposes. One of LinkedIn's most recent additions, the "Endorsement" feature, is the digital equivalent of a traditional letter of recommendation. It allows individuals in your network to endorse you on a variety of skills. The obvious drawback is that most people end up reciprocating favorable references. Further, the site does not incorporate negative or even neutral evaluations. Still, this feature provides a quick, easily accessible overview of someone's strengths according to others. As Abraham Lincoln is said to have wisely noted, you cannot fool all of the people all of the time.

These public votes of confidence are valuable because, just as in the ink-and-paper world, LinkedIn self-evaluations tend to be less credible than peer reports. A 2012 study by psychologists Jamie Guillory and Jeffrey Hancock of Cornell University compared participants' reactions to traditional, offline résumés with either public or private LinkedIn résumés. They found that people are just as likely to lie on a LinkedIn profile as on a traditional résumé, but in different ways. Participants were more honest on their LinkedIn profile about prior work experience and responsibilities. Yet they were more likely to be deceptive about interests and hobbies. The researchers attributed this finding to the public nature of LinkedIn—your friends and family would question a false qualification on any résumé, but a traditional résumé might never reach their eyes. Interests and hobbies tend to be less widely known, so they are less likely to be disputed.

In short, social media can increase the candidate pool and give employers a wealth of relevant information about prospective hires. The challenge is to be aware of our own biases as we evaluate information from these sources, just as we are prone to bias in other aspects of daily life.

Wasabi Waiter, a game offered by Palo Alto, Calif.–based Knack, generates behavioral profiles for players with the intent of helping them find jobs that match their capabilities.

COURTESY OF KNACK www.knack.it

Videos and Games

After a résumé has passed muster, a successful candidate often comes in to meet with a potential employer for an in-person interview. Typically the bedrock of any talent search, interviews tend to be conducted in a free-form manner that can easily feed false perceptions. Studies have shown, for example, that interviews are often systematically biased against ethnic minorities, women and elderly individuals. Even an applicant's perfume can introduce bias.

A better, more predictive approach is to conduct structured interviews, in which every applicant answers the same list of questions. Using this method, different evaluators are more likely to reach similar judgments on a candidate than when the interviews are more conversational, research has found. Yet free-form interviews predominate, in part because of ignorance among hirers and in part because managers view the format as impinging on their autonomy.

A new batch of companies seeks to improve the selection process through structured online interviews that also save managers' time, thus winning them over. The recruiting companies EnRecruit and Spark Hire offer two such services. Corporations that sign up with them can invite candidates to record responses to a few questions using a webcam. For employers, the services standardize interviews and free up time—the length of the videos can be limited to a couple of minutes, and the people on the hiring end can watch the recordings at their leisure, without having to coordinate schedules.

Short, virtual interviews can help winnow down a larger candidate pool into a smaller group of potential employees without sacrificing the personal element. They also offer a more reliable way of comparing candidates. As the services gain popularity, their success will also depend on the skill of the recruiters in asking the right questions and properly interpreting responses.

Another major area of innovation is "gamification," the use

Are Our Selection Methods Valid?

Yes and no—it depends on who is asking. Predictive validity refers to whether scientific data support the use of the tool in hiring. Face validity captures whether practitioners consider the method valid. And social validity reflects whether applicants embrace the approach.

	Predictive Validity	Face Validity	Social Validity
Interview	Low	High	High
References	Low	Medium	Medium
IQ	High	Low	Medium
Personality Test	High	Low	Low

of video games in the hunt for talent. The advantage over traditional techniques, such as personality tests, is a more engaging user experience. Candidates might even have fun with a game, and the games themselves could go viral. By applying behavioral theories to a player's actions during the game, the software can generate a complex personality profile for that user.

In one game developed by a company called Knack, a player assumes the role of a waiter at a Japanese restaurant. This virtual waiter must juggle preparing sushi, serving dishes, reading and responding to customers' needs, and washing up, among other tasks. Every action is logged and translated into a behavioral profile with traits such as extroversion, creativity or impulsivity, among many others. Knack bases these profiles on psychological research from its team of behavioral scientists who have mapped responses within the game, such as the ability to keep track of multiple orders, to job skills—in this case, the ability to multitask.

The waiter game is a type of situational judgment test—another metric, in addition to IQ and personality tests, that researchers have found can predict performance on the job. A more familiar way that an interviewer might assess situational judgment is by asking, for example, a candidate for a teaching job how they would handle a student who is not paying attention. Such queries are popular because they can be molded to the specific job opening or corporate culture.

Two other examples of games are Insanely Driven, used by Reckitt Benckiser, a global consumer-goods firm, and Reveal, from the cosmetics company L'Oréal. Insanely Driven helps employers assess candidates' "fit" with the company's culture. Players of Insanely Driven must handle numerous tough situations as they race to an important meeting. The test is based on four measures of personality—adjustment, ambition, sensitivity and prudence—taken from the Hogan Personality Inventory, a widely accepted assessment that is based on the five-factor model. Reveal, available on L'Oréal's Web site, is used to identify people who might be suited to open positions throughout the organization. A player oversees the simulated launch of a new product as challenges arise from different divisions of the company. Decisions in the game might capture a player's risk-taking proclivity, strong analytical skills, and so forth.

These companies are betting that desirable young job hunters are more likely to pursue a job that asks them to play an online game than a job that requires hours of traditional evaluation. Given the sheer number of services being developed, more time and research are needed before these new approaches can be fully vetted. We will also need to hone our knowledge of how particular behaviors relate to performance across numerous jobs.

Bigger and Bigger Data

The latest breed of digital-recruiting tools uses algorithms that attempt to synthesize all existing information about a candidate. For example, Klout and Topsy are two Web-crawling services that quantify a candidate's online influence level, defined as the degree to which their online activity is examined, shared or discussed by others. Beyond the inevitable scouring of every social media platform, companies seeking talent will also want to comb through news articles, blog posts, shopping histories, e-mails, comment sections, forums, and anything else that becomes available online.

George Orwell may turn in his grave, but merging today's fragmented services could conceivably construct the most accurate psychological profiles yet. Companies could find their dream candidates before they even submit an application and target only the people who possess the right skills and style to perform well on the job—and who will enjoy it, too. These new tools will not only refine our talent-identification methods, they will also help more people find the perfect job for them. M

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ISTOCKPHOTO

A MAGIC TOUCH FOR STROKE PREVENTION?

Neurons cut off by a stroke may have the inherent ability to reroute blood flow and save themselves

By Stephani Sutherland

You are visiting your elderly aunt, and you notice her speech begin to slur. She seems to be having trouble staying upright in her seat, and she looks confused. You recognize the signs of a stroke. You shout for your uncle to call 911 as you help your aunt lie down in a comfortable position. You run your fingers gently over her lips, face and fingertips as you sing into her ear and continue talking to her. The EMTs rush in and outfit her in what looks like a bathing cap encrusted with electronic bling—a kind of defibrillator designed to deliver electrical stimulation to her brain. As they carry her out on a stretcher, your worry is slightly eased, knowing that the sensory stimulation you gave her in those first minutes may have saved her from serious disability.

Today we can do little to help stroke victims. But if new research bears out, such stimulation might reroute the brain's blood supply to prevent cells from dying—a much needed breakthrough for the nearly one million Americans every year who suffer a stroke. As of now, the only intervention available is a drug that breaks up blood clots, and only a small number of patients benefit from it. In other words, although scientists have been studying stroke for decades, brain damage is inevitable in most cases. Stroke remains the fourth-leading cause of death in the U.S. and the most common cause of long-term disability. "We have so few therapies for this problem. We need to move more of them forward," says Steven C. Cramer, a clinician who specializes in stroke at the University of California, Irvine.

The new research, though currently still in animal studies, offers the tantalizing possibility of a low-tech, inexpensive treatment that could be dispensed immediately, anywhere, by anyone. In Ron D. Frostig's U.C. Irvine laboratory, rats were saved from brain damage after stroke when neuroscientists simply touched their whiskers or played sounds in their ear. Although translating these interventions into human treatments means overcoming significant hurdles, the revolutionary finding has invigorated a field fraught with dead ends and lackluster results. "Frostig is looking at something now that in 10 years will be obvious that we should all be looking at," says Cramer, who is not involved in Frostig's work. "He's reading the tea leaves of the field."

ILLUSTRATION BY STUART BRIERS

ISTOCKPHOTO (*pointing hands*)

Stumped for Treatments

A stroke happens when a sudden loss of blood causes a part of the brain to stop working. The blood shortage may arise from either of two main causes: a blood clot or a hemorrhage. More than three quarters of strokes are clot-based or ischemic; the rest are hemorrhagic, in which a blood vessel bursts inside the brain. In both types, cells downstream of the clot or eruption are cut off from the vital supply of nutrients and oxygen.

By stimulating a single whisker immediately after stroke, the researchers had prevented any brain damage in the rats.

The paucity of treatments for stroke certainly is not for lack of research efforts. More than 1,000 compounds have been studied in animal models, but the dozens that have gone on to human clinical trials have all failed except one. Tissue plasminogen activator (tPA), the only treatment for stroke approved by the Food and Drug Administration, attempts to unblock a clogged blood vessel by breaking up the clot. It must be given in the first couple of hours after stroke, turning treatment into a game of beat the clock. Although tPA is potentially lifesaving for someone having an ischemic stroke, the clot-busting drug would spell disaster for someone with a hemorrhagic stroke, where clots must form to stop the bleeding. To make sure the wrong people do not get tPA, patients must undergo a brain scan before receiving the medication—a time-consuming step that delays treatment, disqualifying most patients.

Clot busters are one of the two main types of treatments that researchers have attempted to develop over the years. The other is neuroprotective agents, which employ a wide variety of brain-saving strategies, including dampening electrical activity and halting signaling molecules within brain cells. The wide range of approaches speaks to the complexity of the processes at work in the stroke-damaged and recovering brain. When brain cells go too long without access to oxygen-rich blood, catastrophe ensues: the balance of charged particles inside and outside cells is upset, a harmful amount of calcium flows into cells, and electrical activity runs rampant, leading to a dangerous state called excitotoxicity. Next, cell membranes break down, and free radicals—reactive particles that damage cells and DNA—build up. These events trigger programmed cell death, during which genetic material and cellular structures are destroyed. Even surviving cells surrounding the affected area are in danger; the sudden flood of oxygen and nutrients that follows a successful dissolution of a clot can further skew the delicate ecosystem of the brain and spread the damage wider.

Researchers have attempted to develop neuroprotective drugs aimed at certain elements of these destructive cascades, with little success thus far. Still, experts are hopeful; early failures could have been because of poor guesses about dosage or time frames. "We don't really know what went wrong. It could have been that the drugs themselves actually worked," explains Walter J. Koroshetz, deputy director of the National Institute of Neurological Disorders and Stroke. Efforts aimed at neuroprotection continue today; for example, a clinical trial called FastMag, headed by clinical stroke expert Jeffrey Saver of U.C.L.A., is in its final stages. In this trial, EMTs give patients an injection of magnesium ions in an attempt to quell the brain's hyperexcitability immediately after a stroke.

Stroke experts agree that the best form of neuroprotection is to restore blood flow to the area cut off by the stroke—and fast. To that end, an epiphany of sorts hit researchers when they realized that blood vessels in the brain look more like a connected matrix of loops than like a tree with branches. Vessel structure is "much like the streets of New York," according to David Kleinfeld of U.C. San Diego. "When there's a truck parked on 34th Street and you can't get through, you go up to 36th Street," Kleinfeld explains. Figuring out how to get blood rerouted through these existing networks in the brain could very well be the key to keeping cells

FAST FACTS

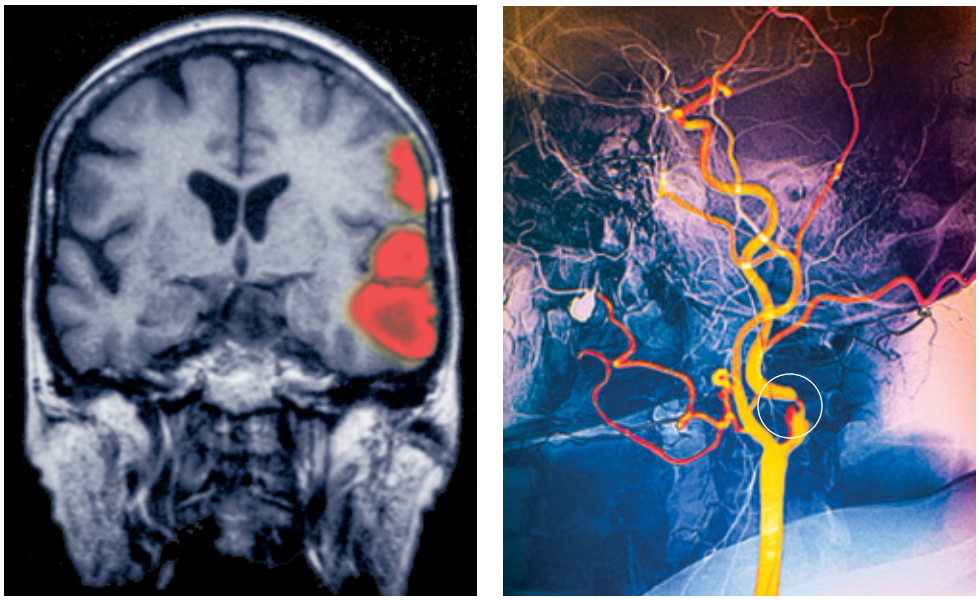
Saved by Caresses

1» **Stroke research has been stymied for many years by the complexity of the brain's response and promising but failed therapies.**

2» **An accidental discovery in lab rats revealed that stimulating their senses, by wiggling a whisker or playing a loud noise, activated the neurons cut off by the stroke and rerouted the blood supply to nourish them.**

3» **Treatments based on this approach are a long way off for people, but experts are hopeful that touching a stroke victim's hands and face could have a similar beneficial effect.**

The Two Types of Stroke



Most strokes are caused by a blood clot (*right image, circled area*). This type of stroke, if caught early, can be treated with a drug that breaks up clots. Before administering the drug, doctors must order a scan to make sure the stroke is not hemorrhagic (*left*). This imaging often uses up the time window in which the drug will work. New research suggests sensory stimulation might help victims of both stroke types.

alive—but until now, researchers had no idea how to harness this network.

Recruiting Nearby Blood Vessels

Serendipitously, neuroscientists at U.C. Irvine discovered that the brain's vasculature might be at the beck and call of the very neurons it serves, providing a built-in defense against stroke. Five years ago Frostig, who studies neuroplasticity, had set out to test whether rats that were allowed to actively explore a natural environment might recover better after a stroke. Enriched environments or experiences have been found to improve brain health and function in many settings, particularly in rehabilitation. To mimic the occurrence of a stroke, Frostig and his team cut the middle cerebral artery (MCA), a major blood supply route, in an anesthetized rat. Immediately after cutting the MCA, they wanted to get a baseline measure of stroke-damaged brain activity, so they used a mechanical device to wiggle one of the rat's whiskers and simultaneously gauged the activity of the corresponding neurons in the cortex. They expected this baseline activity to be utterly destroyed by the stroke, and they hoped it might improve over time as the rat recovered.

Instead, during the stroke and a day later, the neurons looked and acted completely normal. Frostig was shocked; even the most promising therapeutic agents typically provide just marginal defense against stroke in lab animals. Only half-joking, he asked postdoctoral fellow Christopher C. Lay whether he was sure he had cut the artery. But after the result held up in 30 animals, they realized that something important was going on. "The neurons were completely protected," Frostig says. Eventually the researchers concluded that by stimulating that single whisker immediately after stroke, they had prevented any stroke-related brain damage.

Once Frostig and his team were convinced their results were real, they looked for signs of damage, and they looked hard. As they first reported in *PLOS ONE* in 2010, they could find no difference between the brains of rats with a wiggled whisker and control rats that had no interruption to their blood supply. A staining technique revealed no damage; brain imaging showed functional blood flow to the affected area; even direct recordings of the neurons activated by whisker movement showed the area was electrically active and healthy. And the animals behaved normally on waking. But the rats were protected only when they were stimulated within an hour or two of

(The Author)

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SCOTT CAMAZINE *Science Source (left)*; GILLES PODEVINS *Corbis (right)*

the stroke—any later, and they actually suffered worse damage than unstimulated rats.

"The time window is critical," Frostig says. In subsequent research published in *Stroke* in 2011, he confirmed that timing—not duration or pattern—of stimulation is key. Past the three-hour mark, stimulation does more harm than good. "We don't know yet what is the underlying cause of the switch," Frostig says. Although other animal studies have revealed that some molecules are destructive early in an attack but required for remodeling and recovery at later stages, many questions remain.

So why does wiggling a whisker save the brain? Frostig suspected that the sensory experience activates the very cortex that was deprived of blood flow. "The key issue is neuronal activity," he says. This flurry of activity and its attendant demand for oxygen recruited an alternative blood supply, according to a 2011 paper by Frostig in the *Journal of Neuroscience*. Along with two other major arteries, the MCA supplies blood to the cerebral cortex, its trunk splitting into progressively smaller branches. At their tips, the fine branches of these vascular trees interconnect with one another, forming a vast network. Blood does not normally flow through these loops, but Frostig's investigation using advanced brain imaging showed that after the stroke the rats' neuronal activity indeed recruited blood via these alternative routes. When Frostig sealed off the MCA network's collateral branches—in addition to cutting their supply trunk—no amount of stimulation could save the cortex.

Researchers do not yet know how, exactly, neuronal activity evokes the change in blood flow. Current research is investigating nonneuronal cells called astrocytes, which are closely coupled to blood vessels in the brain and seem to be involved in signaling for oxygen and nutrients. In the meantime, Frostig and his colleagues are investigating whether other types of sensory input can protect the brain as well. In work presented in November 2011 at the Society for Neuroscience meeting in Washington, D.C., Frostig showed that auditory stimuli—bursts of white noise—also protected from stroke, though not as completely as whisker stimulation. This result is not too surprising, says Melissa F. Davis, a graduate student in Frostig's lab who worked on the study. Whereas whisker stimulation "tickles" much of the blood-starved cortex, she explains, sound activates only the auditory cortex at the edge of the affected area.

A Much Needed Breakthrough

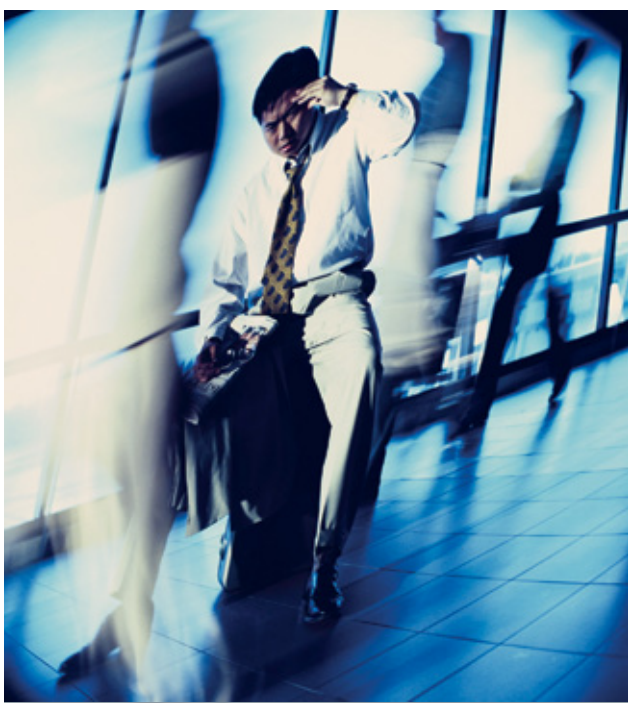
Moving from rodents to humans is a challenge for any therapy, and experts, including Frostig, are

How to Recognize a Stroke

Despite the best efforts of doctors and health agencies, the number of people getting to the hospital within two hours of a stroke has fallen in the past few years, according to a recent study by the U.S. Centers for Disease Control and Prevention. Study author Mary George, who presented the findings at the annual meeting of the American Stroke Association in February 2012, says that one of the biggest factors that delays stroke treatment is that people are using their own cars to get to the hospital rather than calling an ambulance. If you see these signs in yourself or someone else, call 911 immediately:

- Numbness or weakness of the face, arm or leg, especially on one side of the body
- Confusion or trouble speaking or understanding
- Disrupted vision in one or both eyes
- Dizziness, loss of balance or coordination, or trouble walking
- Severe headache
- The American Stroke Association recently revamped its efforts to get the word out with a mnemonic that spells out "FAST": Face drooping, Arm weakness, Speech difficulty? Time to call 911.

—S.S.



SPENCER ROWELL *Getty Images*

cautious about predicting a future of sensory-stimulated recovery for people. But hope-starved stroke researchers cannot help but be enthusiastic. "The beauty is that it's cheap and nontoxic," Cramer says. And the treatment remains effective even as Frostig's group has systematically expanded testing to address some of the differences between the response of humans and lab rats. The team has made sure that awake and anesthetized animals are protected because an estimated 70 percent of strokes occur in awake people. In a 2012 paper in the *Journal of the American Heart Association,* Frostig's team showed that elderly rats were protected as well as the juvenile animals commonly used in lab research; in humans, age is the number-one risk factor for stroke. Furthermore, the protection held up in rats that got sensory stimulation by exploring their environment and whose whiskers had been removed—a good thing for whiskerless humans. Most important, by studying ischemic attack in the territory of the brain supplied by the MCA, Frostig is investigating the conditions that account for the vast majority of human strokes.

One big challenge for this treatment to overcome is that humans do not have an exact analogue to the barrel cortex, the area in a rat's brain dedicated to sensing whisker movements. This area is huge in rats; in humans, the closest equivalent would be the cortical real estate dedicated to the fingers and lips. Because the relative size of our sensory cortex is much smaller than that of rats, Frostig predicts sensory stimulation of more than one type might be required. "Sing to them, stroke their hands, their face—while you're calling the ambulance," Frostig says. Engaging someone in whatever stimulation possible might increase the chance of activating—and thereby protecting—more cortex. As for that ambulance ride, which itself is noisy, it alone may not help, because EMTs do not necessarily make a point of actively engaging a patient. Taking sensory stimulation to that next level, such as by caressing the patient's face and hands, might make all the difference.

If even salient stimuli such as touch and sound are not enough to protect a human brain, direct brain stimulation might work, Frostig speculates. Transcranial direct-current stimulation excites neurons by delivering a small amount of electricity through the skull. The apparatus could conceivably fit in an ambulance alongside the defibrillator. Frostig's manipulation, however, "is really physiological," Koroshetz cautions—it is rooted in physical sensation—so attempting to mimic the stimulus with cortical stimulation would take "a little leap of faith," he says. "The key thing is to figure out the mechanism, then figure out ways of activating that mechanism," Koroshetz says. Those ways might range from sensory or electrical stimulation to new kinds of drugs.

Frostig's work shows promise for circumventing some of the other inherent problems in stroke treatment, too. Sensory stimulation is unlikely to be detrimental to someone with a hemorrhagic stroke, eliminating the need for time-consuming brain scans. If the treatment indeed reroutes blood flow, it could aid in the delivery of therapeutic drugs, including tPA—a major challenge in stroke treatment today. And the new finding underscores the importance of timing. People who miss the critical window for treatment, for instance, because they wake up from a night's sleep having had a stroke, might benefit from little or no stimulation at all—no sirens wailing, no medical team barking orders, no constant barrage of questions and tests.

The flurry of neuronal activity and its attendant demand for oxygen recruited an alternative blood supply.

Human trials based on Frostig's work are still far away—first the idea needs to be tested in larger animals such as monkeys or pigs. It could be years before we know if sensory stimulation can do for people even a fraction of the good it does for rats. But as the quest continues for clot busters and neuroprotectants, for new techniques and technology, stroke experts across the board agree that fresh ideas are welcome. So go ahead, sing to your aunt and caress her hands and face; if nothing else, she will feel comforted at a scary time. And you might just save her brain. M

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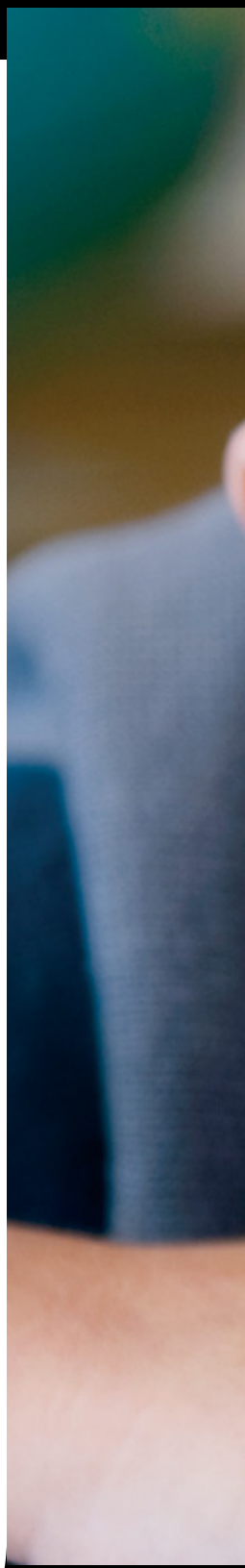
Descent of the Doldrums

Boredom has been linked with undesirable mental and physical conditions. But what exactly is this puzzling condition?

By James Danckert



NICOLE S. YOUNG Getty Images

In *The Hitchhiker's Guide to the Galaxy,* by Douglas Adams, a desultory robot named Marvin struggles to get through his days. Possessed of "a brain the size of a planet," he is 50,000 times more intelligent than a human, yet he cannot solve his own biggest problem: an unshakable ennui.

"The first ten million years were the worst," Marvin recounted at one point. "And the second ten million years, they were the worst too. The third ten million years I didn't enjoy at all. After that I went into a bit of a decline."

We all have suffered episodes of tedium, if not on the same scale: a dinner date that drags on, a meeting conducted in monotone, an interminable wait for a bus. As the minutes tick by, a slight anxiety may pervade your thoughts. You drum your fingers quietly on your knee. You bounce in your seat. But nothing—not playing the guitar nor heading to the gym nor reading a new detective novel—seems up to the task of shaking boredom's death grip on your mind.

The nature of boredom has long puzzled thinkers in literature, philosophy and psychology. German philosopher Martin Heidegger described it as "drifting hither and thither in the abysses of existence like a mute fog." Others have likened it to nausea. Recent research suggests that chronic boredom is often, but not always, accompanied by depression. It also seems to manifest in one of two forms, which my colleagues and I refer to as apathetic and agitated boredom. By studying groups of people who tend to suffer this condition more acutely—including individuals who have sustained traumatic brain injuries—we are beginning to identify the cognitive processes and brain regions that may support the experience. Although boredom is commonplace, we are now learning that excessive amounts of it can harm our health. Before we can address these concerns, though, we need to look more closely at the phenomenon itself.

The Milquetoast Mind

Humans have likely weathered stretches of tedium for as long as our forebears have had free time. The growth of leisure time, often seen as a product of the industrial revolution, heightened the odds of a mind coming up empty when tasked with entertaining itself. In Charles Dickens's novel *Bleak House,* set during this time of societal transition, Sir Dedlock tenderly asks his wife, "Is it still raining, my love?" To which she replies: "Yes, my love. And I am bored to death with it. Bored to death with this place. Bored to death with my life. Bored to death with myself." Through Lady Dedlock's plight, Dickens introduced a new English word into the written canon—boredom.

In 1885 Sir Francis Galton casually measured boredom in a meeting, which he reported in an article in *Nature* entitled "The Measure of Fidget." He claimed that when the audience was transfixed by the speaker "each person forgets his muscular wea-

Despite a growing body of research showing the negative effects of boredom, we still lack one critical thing: a clear-cut definition.

riness and skin discomfort, and he holds himself rigidly in the best position for seeing and hearing." When the spell was broken, "several individuals cease to forget themselves and they begin to pay much attention to the discomforts attendant on sitting long in the same position." He even tracked the amplitude and period of swaying heads and trunks as the audience's attention fluctuated.

Today when measuring boredom, we tend to use a variety of questionnaires, the first of which was published in 1986 by Richard Farmer and Norman Sundberg, then both at the University of Oregon. Using their boredom proneness scale and other tests, psychologists have found that boredom is linked with worse performance at work and school, lower job satisfaction, more frequent lapses in attention, and heightened rates of drug and alcohol abuse. It also appears to have detrimental effects on the treatment and rehabilitation of mental disorders.

Despite a growing body of research showing the negative effects of boredom, we still lack one critical thing: a clear-cut definition. Part of the challenge is that boredom for one person may only loosely resemble another's ennui. The placid but unmotivated couch potato looks nothing like the agitated child pleading for something interesting to do. The nature of any one person's episodes of boredom may also vary.

Resolving some of these ambiguities has been the focus of recent work in my laboratory at the University of Waterloo. In a study published in 2011 my graduate student Yael K. Goldberg and our collaborators asked 823 students to fill out questionnaires that assessed several aspects of boredom, such as how prone they are to it and how well they cope with it. We also administered widely used questionnaires for measuring apathy, anhedonia and depression. To make sense of all their answers—and to see how boredom might differ from those other states—Goldberg used structural equation modeling, a statistical technique that examines the relations between concepts.

We found that the more bored a volunteer was, the more likely he or she was to express both depressive symptoms and low motivation. Yet boredom did not always co-occur with a lack of motivation, nor was it always a sign of depression. Despite these overlaps, it seemed to occupy its own psychological space. Earlier work supports this idea. In a 2003 study psychiatrist Dale Theobald, now at Community Home Health near Indianapolis, and his colleagues administered citalopram, a common antidepressant, to cancer patients who were suffering from depression. They found that the symptoms of boredom and depression abated at different rates, suggesting that the two conditions involve distinct mechanisms.

Unpublished data from our 2011 study indicates one component of boredom that may drive the correlation with depression. The boredom proneness scale can be divided into two subscales that measure a person's capacity for being satisfied by internal versus external sources of stimulation. An internally stimulated person, for example, would tend to agree with statements such as "In any situation I can usually find something interesting to do," and "I often wake up with a new idea."

An externally stimulated person is more likely to find resonance with sentiments such as "I am often trapped in situations where I do meaningless things," and "It takes a lot of change and variety to keep me very happy." Most people fall between these two extremes—often able to amuse ourselves but from time to time itching for something new from the outside world. Our data suggest that people who rely heavily on external stimulation and fail to secure sufficient amounts of it are more likely to also report symptoms of depression.

In work published in 2012 and led by one of my students, Ela Malkovsky, we have found that the division between inter-

FAST FACTS

Rage Spread Thin

1» **Boredom most likely manifests in two forms: apathetic boredom and agitated boredom.**

2» **People who are afflicted with agitated boredom tend to rely heavily on external stimulation. They expect the world to deliver fulfilling experiences rather than attempting to amuse themselves.**

3» **Those who have suffered traumatic brain injuries often report high levels of boredom. Recent research on brain trauma suggests that a particular brain region, the orbitofrontal cortex, may play a central role in the experience of boredom.**

Sometimes boredom may arise from a failure to fully engage with our surroundings, making a once rewarding jam session now seem less scintillating.

nal and external stimulation can help us define two distinct subtypes of boredom. In this study we had people complete questionnaires exploring boredom proneness, lapses in attention and adult symptoms of attention-deficit hyperactivity disorder (ADHD).

We could cluster our subjects into two groups based on their propensity to experience boredom and more specifically on their need for either internal or external stimulation. People of the first subtype, which we might colloquially label the couch potato, do not report gaining much satisfaction from internal sources of stimulation and show no motivation to seek gratification externally. We labeled this condition apathetic boredom. Suboptimal as their state may be, these individuals tend not to fret about it.

The second subtype involves considerably more distress. People in this category rely heavily on external stimulation, and when life falls short they experience intense inner turmoil—we termed their condition agitated boredom. It coincided more with symptoms of ADHD, in particular signs of hyperactivity, than did apathetic boredom. Observations such as Galton's suggest that people afflicted with agitated boredom feel a physical discomfort, a drive to expend energy through motor actions to shake off the boring experience. The jittery knees bobbing up and down and the restless fingers drumming on the desk both signal that agitated boredom is afoot. Whereas the apathetically bored individual does little to change his or her state, the agitatedly bored person is highly motivated to escape this plight. These people would likely agree with a quip attributed to theologian Paul Tillich: "Boredom is rage spread thin."

Some psychologists, including my Waterloo colleagues Daniel Smilek and J. Allan Cheyne, have suggested that the answer may lie in failures of one's ability to control attention. The idea is that lapses in focus, such as pouring orange juice on your cereal, reflect disengagement from one's surroundings. Boredom could turn out to be the product of a disconnection between our thoughts and the external environment. We may go to a jazz club expecting a fun-filled night of music, yet an inability to focus our attention on it drains all color from the evening. This lack of immersion in the world outside our head could lead us to evaluate our experiences as meaningless. Research on people with traumatic brain injuries, who are at a greater risk of experiencing boredom, is hinting that this might be the case.

Tedium and Trauma

You might wonder what could prompt an academic psychologist to study, of all things, boredom. Just like most parents, I have no trouble summarily dismissing my children when they claim they are bored, and I, too, end up telling them to go find something to do. If only it were so easy.

I started down this path after my brother got into a car crash. To say he was badly injured is a supreme understatement. After a prolonged medication-induced coma and months

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THINKSTOCK

People who are experiencing agitated boredom have an urge to shake off the feeling with physical activity, such as fidgeting.

of recovery—much of which he cannot recall—he began piecing his life back together.

His one true love has always been music. A wrist injury made it physically challenging to get back to drumming, but it was boredom that compounded the challenge. He told me one day, with intense frustration in his voice, that after the crash he was always bored. The challenge to find anything that was stimulating would become a defining feature of life for him.

Some years later, while working with an organization that helped people who had sustained traumatic brain injuries (TBIs), I happened to ask some of the clients if they were more often bored after their injuries. Many of them practically leaped out of their chairs at the question. It turned out boredom was one of the most salient aspects of their present lives, yet no one had ever asked them about it before.

So I set out to explore the relation between boredom and depression in people who have suffered brain traumas. The most common causes of TBIs are incidents involving rapid acceleration and deceleration, such as car accidents or, with less severity, concussions. An injury that shakes the brain around inside the skull can lead to widespread brain damage.

In one experiment with my research group, we asked 14 TBI patients, as well as 33 people who had suffered concussions and 88 healthy individuals, to complete questionnaires that measured their depression and boredom. We found that the people who suffered the most from both maladies also reported the greatest need for external stimulation. This relation was statistically strongest in the TBI group.

People who have suffered an intense blow to the head often demonstrate impulsive, risk-taking behavior postinjury. For example, data suggest that they are more likely to use drugs and alcohol, practice unsafe sex and drive recklessly. We theorized that TBI patients may seek out more extreme activities to find an experience they will evaluate as enjoyable, as if their threshold for satisfaction has been raised.

From a scientific perspective, the optimal experiment to discern whether TBI patients become more reckless after an injury would be to observe healthy people and then evaluate them again after they sustained a TBI. We could never do that, of course, so instead we looked at whether TBI patients generally display more novelty-seeking actions than healthy people.

We had patients perform a simple task, developed by psychologist Elkhonon Goldberg of the New York University School of Medicine and his colleagues, called the cognitive bias task. This admittedly rather boring activity involves showing people geometric shapes that differ in color, shape, size, number or outline. Study participants are repeatedly shown a single shape followed by two different ones. They are asked to rate which of the two subsequent shapes was more like the original and then to decide which figure they prefer. The goal is to see both how well people can recognize the similarities and differences between objects and whether they tend to prefer novel versus familiar objects.

We found that TBI patients had a harder time discriminating between new and familiar things. This result agrees with earlier work on patients with frontal lobe damage, who also struggled more than healthy people when detecting novelty. More important, our study showed that this deficit was greatest in those experiencing agitated boredom. Although the number of patients tested was relatively small, the results were consistent in all three groups—people who were prone to agitated boredom also tended to have a harder time recognizing an object's newness. This hints at an intriguing possibility. Life becomes dull when we cannot distinguish what is fresh and therefore interesting from what is old and familiar—everything gets painted with the same gray brush.

One brain region commonly damaged during acceleration-deceleration injuries is a part of the frontal lobe known as the orbitofrontal cortex (OFC), situated just above the eyes. Scien-

GETTY IMAGES

tists have shown that this region is critical for associating events, actions or decisions with their cognitive and emotional evaluations. It helps us mentally code our experiences with a reward value—a process that is essential to how we learn. Your desire to return frequently to your favorite Chinese restaurant involves patterns of neural firing in the OFC, which reflect your evaluations of prior visits and your fondness for the spicy kick of the kung pao chicken. We also make negative associations that might turn out to be erroneous later on—I still avoid creamed corn because of an episode in my youth that ended poorly. Almost certainly some bug or virus led me to feel ill, but my brain labeled creamed corn as the culprit and doomed it to the "do not eat" pile for eternity.

TBI patients, similar to the people with agitated boredom described earlier, may experience a recurring mismatch between their expectations for an event and its actual payoff. This line of inquiry is still young, but therapies may ultimately train patients to better recognize when an event is in fact novel. The goal would be to help them both alter their expectations of rewards and improve their sensitivity to novelty. Although I question the wisdom of viewing boredom as pathology, in some extreme cases it might pose a significant obstacle to a healthy life.

Bored to Death

In a recent British study, epidemiologists Annie Britton and Martin Shipley of University College London examined data collected from civil servants for self-reported boredom and several cardiac risk factors. The civil servants were first assessed in the 1970s on a range of topics, including job satisfaction and boredom. In a follow-up in 2010 they found that those people who reported more ennui were more likely to die younger and to experience cardiac health issues. Literally, people were being bored to death.

The researchers acknowledged the myriad factors that may have contributed to this finding, including poor fitness and unhealthy diet in those reporting high levels of boredom. Boredom may not be the smoking gun, but it is at least a contributing factor or perhaps a warning sign of poorer health outcomes. Another graduate student in my lab, Colleen Merrifield, recently explored physiological responses to boredom by inducing the state in healthy undergraduates. We had people watch either a scene from a tear-jerker movie or a film of two men hanging laundry—a scintillating viewing experience if ever there was one—while measuring their heart rate and levels of cortisol, the hormone most commonly used to assess stress response. We found that the participants who had watched the boring laundry scene had a higher heart rate and higher cortisol levels. Clearly, boredom is not good for your health.

Patients with traumatic brain injuries may seek out more extreme activities to find pleasure, as if their threshold for satisfaction has been raised.

Data on the detrimental effects of boredom hit home for me. Another reason I have devoted myself to this topic is that I have been a poster boy for agitated boredom for most of my life. What the recent research highlights is that the topic is not simple academic curiosity. Boredom appears to represent a key, hitherto unheeded, component of depression, a disorder that afflicts approximately one in 10 of us at any given time. It most likely complicates life for people recovering from brain injuries. Yet it is also a feeling that descends on many of us from time to time, and we have all encountered children tormented by tedium, if not been one of them ourselves. Discovering why we sometimes disengage from life and why once scintillating activities suddenly lose their luster could help us understand the dynamics of everyday living and, perhaps, permit us to bend them to our will. M

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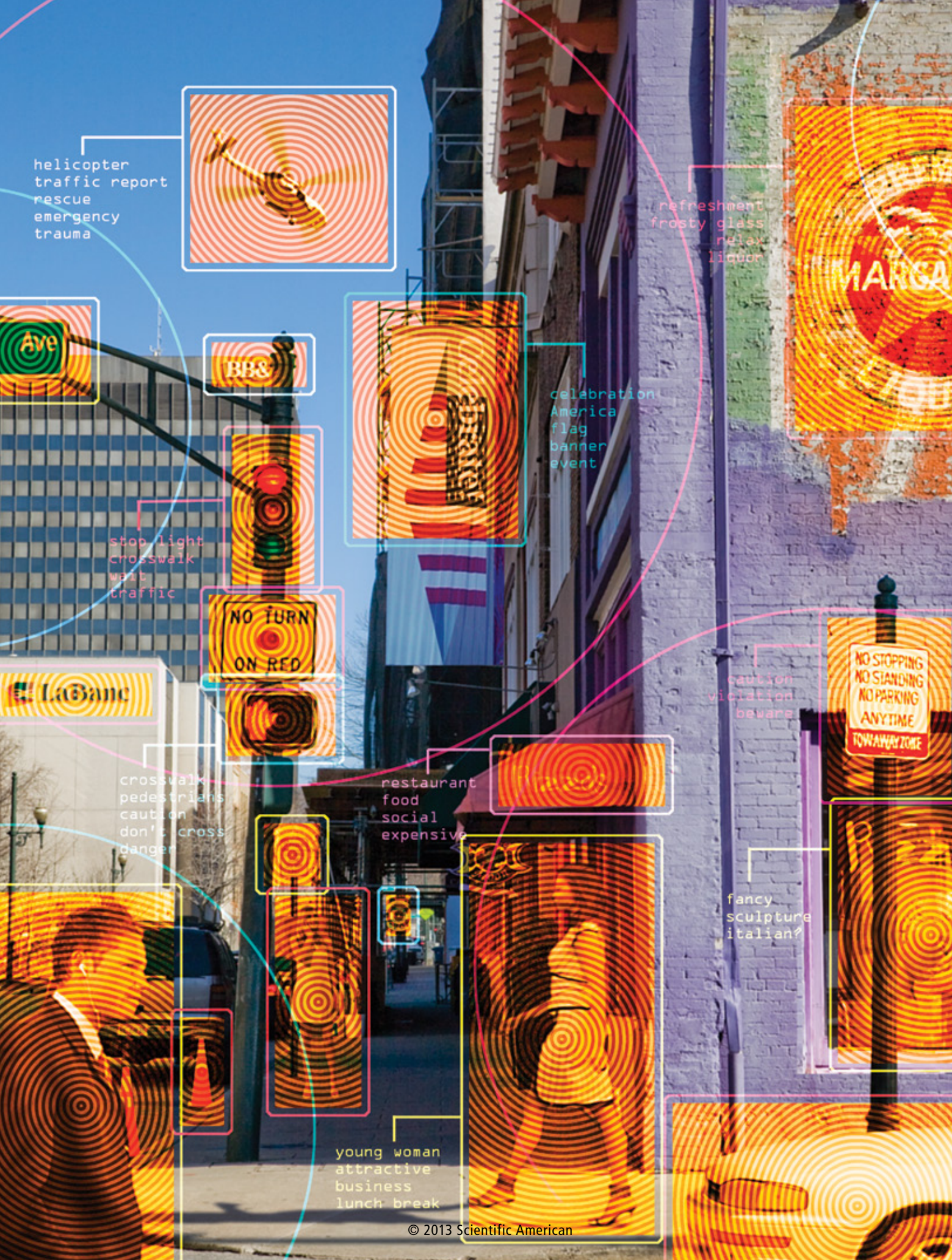
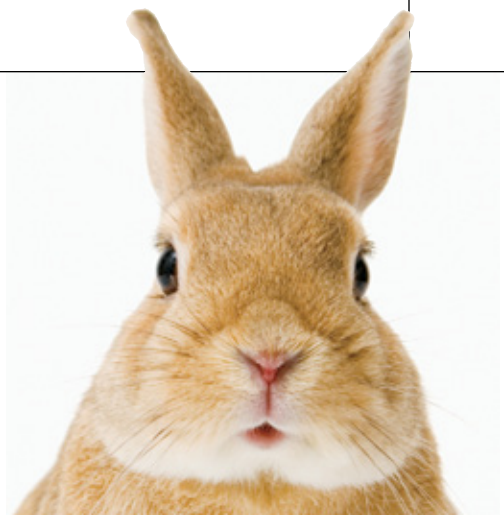


To See or Not to See

Spotting what we are looking for seems simple. It isn't

BY MICHAEL C. HOUT AND STEPHEN D. GOLDINGER
PHOTOILLUSTRATION BY LONNIE BUSCH

Consider this scenario: You are making dinner. You reach into a crowded kitchen drawer to find a paring knife. As you peel potatoes, you glance over at the basketball game on television to check out your team's performance. When your cell phone buzzes with a text message, you dry your hands and reply, picking out the letters one by one on the screen. These three actions—finding a knife, a moving basketball and letters of the alphabet—seem distinct, but all are examples of what is known in cognitive psychology as visual search—the ability to locate specific items in a crowded scene.



With eyes on the sides of their heads, rabbits can spot potential threats from almost anywhere. Eagles (and humans) have forward-facing eyes. The benefit is better acuity, but we see less of the world at any one time. Praying mantises' eyes are fixed, so they jerk their heads, much the way that humans move their eyes.

We find things so often and so effortlessly that we take this skill for granted, yet identifying what we are looking for is actually a complex psychological feat. The eyes gather tremendous amounts of sensory information—about color, motion, orientation, shape, light and shadow. The brain's task is to synthesize and prioritize all these data, helping us explore the world safely and profitably. Visual search involves not just sight but memory and abstract thought. We have to hold in mind what we are seeking, acquire a range of visual information, remember what we have seen and compare every new object with our mental target.

It cannot be overstated how much we rely on the ability to quickly and effectively search our surroundings. We do it thousands of times a day. Anyone who has spent time around young children knows that they can have a tough time finding a book or toy, even when it is right under their noses. But as we age, we develop useful shortcuts. For example, you know the next word in this sentence will be a short distance to the right. Moreover, when you visit the zoo you look up in the trees to spot a monkey and down toward the rocks to spot a snake. Such habits of mind make most searches easy, but as anyone who has ever opened a *Where's Waldo?* book knows, searches can also be vexing.

Several factors influence ease of search. The more similar a target is to its background, the trickier it is to find. Suppose you are walking through a snowy winter forest, and a red cardinal is perched on a bare branch. It will immediately "pop out" at you. But if you are looking for a wren in summer, when the bird is the same mottled brownish color as its woody surroundings, your task will be much more effortful. Finding unfamiliar objects—say, your parked rental car or someone else's lost earring—is also challenging for your brain, as is trying to locate multiple things at once.

Although we sometimes must work harder at visual search, we typically succeed. Yet for professional searchers, such as airport baggage screeners and the doctors who examine patients' routine x-rays on the lookout for incipient tumors, search is a high-stakes and often problematic endeavor. It is rare for a baggage screener to find a weapon or for a firefighter to find a living person in a pile of rubble. But the decision to stop looking is difficult because the cost of missing something could be tragic.

New investigations are suggesting ways to make those expert searches more reliable. And whereas habits and even personality determine how successful individuals are at finding what they seek, the latest studies indicate that people can train their visual systems to work more efficiently. Humans are adept visual searchers, and now psychology appears poised to reduce even our occasional failures.

What You See Is Not What You Get

People typically feel that their eyes move smoothly across the landscape of the world, continuously

FAST FACTS

Sight-Specific

1» Isolating one item from the crowded visual environment—such as a favorite brand of cereal in the supermarket or a deer in the forest—is a sophisticated psychological feat, but people accomplish it routinely thousands of times every day.

2» To search effectively, the brain focuses on a few select attributes, such as color and shape, ignoring other kinds of input. When you are looking for the ketchup bottle, your eyes alight on other red and cylindrical things.

3» Our eyes jump around, rarely fixating on anything for more than one third of a second. The brain protects us from this disorienting reality by suppressing vision when our eyes are moving.

LEFT TO RIGHT: CORBIS; YASUHIDE FUMOTO *Getty Images*; DAMON WILDER *Corbis*

If we actually **saw everything** our eyes take in, the world would be **a chaotic place.**

taking in what they are looking at, like a video camera. But that intuitive sense of how vision works is an illusion, carefully constructed by the brain.

In reality, our eyes are constantly roving in quick, jerky movements, rarely resting on any one part of the visual scene for more than about a third of a second before jumping to focus on something else. Human vision is a rhythmic alternation between looking intently and rapidly finding a new target, looking intently at that target, then rapidly shifting yet again. We take in a scene in multiple scattered snapshots that the brain stitches together into a seamless image. Scientists refer to these alternating eye movements as fixations and saccades. Fixations are the brief periods of looking, and saccades are the even shorter spans when our eyes are moving to their next target [see "Shifting Focus," by Susana Martinez-Conde and Stephen L. Macknik; Scientific American Mind, November/December 2011].

If we actually saw what our eyes take in, the world would be a chaotic place. But the brain suppresses vision during saccades, so we do not experience the blurriness of those rapid eye movements. This is a seemingly unremarkable fact, until you consider its bizarre corollary: for much of our lives, and without realizing it, we are functionally blind.

Even within the small snapshots that our eyes provide, we cannot fully process all the visual information. The structures in the human eye that support high-resolution vision, called cones, are clustered in a central area of the retina known as the fovea. The other photosensitive structures, called rods, offer much less detail. As a result, we only clearly see the small region in the center of whatever we are looking at. Everything around it is indistinct. For a quick demonstration, try maintaining your focus on this point (*) while reading the words above or below it. Chances are, you can only parse the words situated one or two lines away.

Moving our eyes all around compensates for how little we see at any one time. When searching for a target, such as the login button on a Web site or the soccer ball during a game, you can bring potential areas of interest into focus, obtaining information in bite-size chunks. Your brain makes use of the indistinct information from the periphery of each snapshot to decide where to fixate next.

Also aiding your search is something known as selective attention. The brain focuses on isolated

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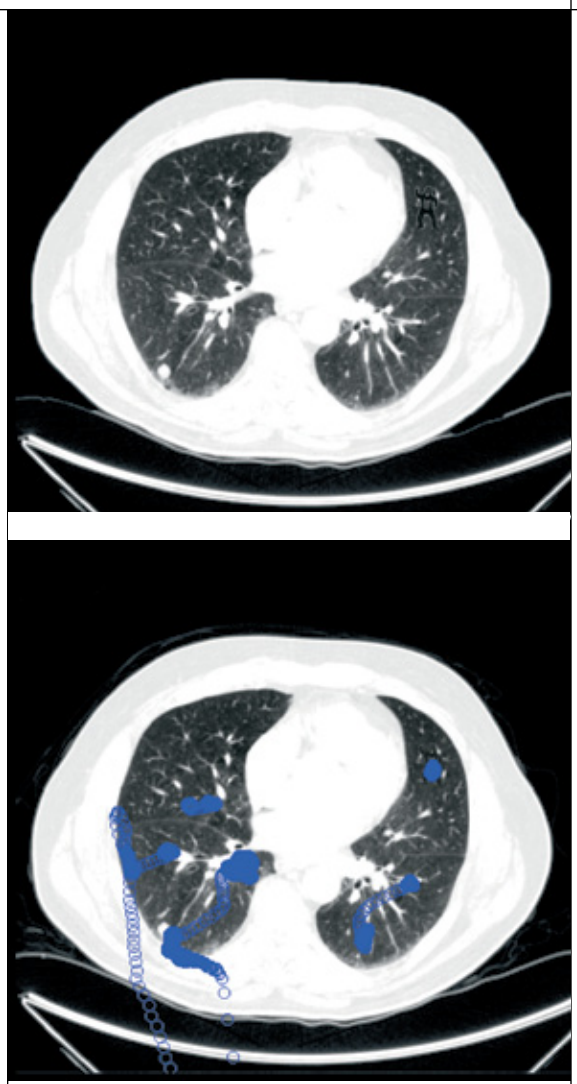
To find the camouflaged stonefish, first search actively: move your attention deliberately all around the image. If that does not work, try a passive approach: let intuition guide your gaze and see if the fish pops into view. The latter strategy is often best for this type of search.



Psychologists embedded an image of a gorilla in a chest x-ray (*top right, above*), then asked radiologists to look for lung cancers. Eighty-three percent of the doctors missed the gorilla, even when staring directly at it. At the right, blue circles show the eye movements of one of the doctors who did not see the gorilla.

characteristics of the target—its color or shape or movement—and pays attention to those specific aspects of the environment, suppressing the rest. For example, let's say you have misplaced something, such as the ever elusive remote control. In scanning for this object, you will not spend much time gazing at a lampshade, the cat or anything bright or colorful. Instead your eyes will be drawn to other small, drab, rectangular objects, such as a cell phone or eyeglasses case. Whereas if you are in the park on a crowded Sunday looking for a friend whom you know is jogging, your attention will be drawn to moving people rather than those lazing around enjoying a picnic. To sift through the dozens of joggers, you further narrow your attention to someone with a beard and a Red Sox cap. The brain customizes every visual search, recruiting its independent faculties for recognizing shape, color, motion and size to swiftly zero in on the desired target.

Knowing what you are looking for dramatically improves success at visual search. There are situations, however, when expectations become a hindrance rather than an aid.

Out of Mind, Out of Sight

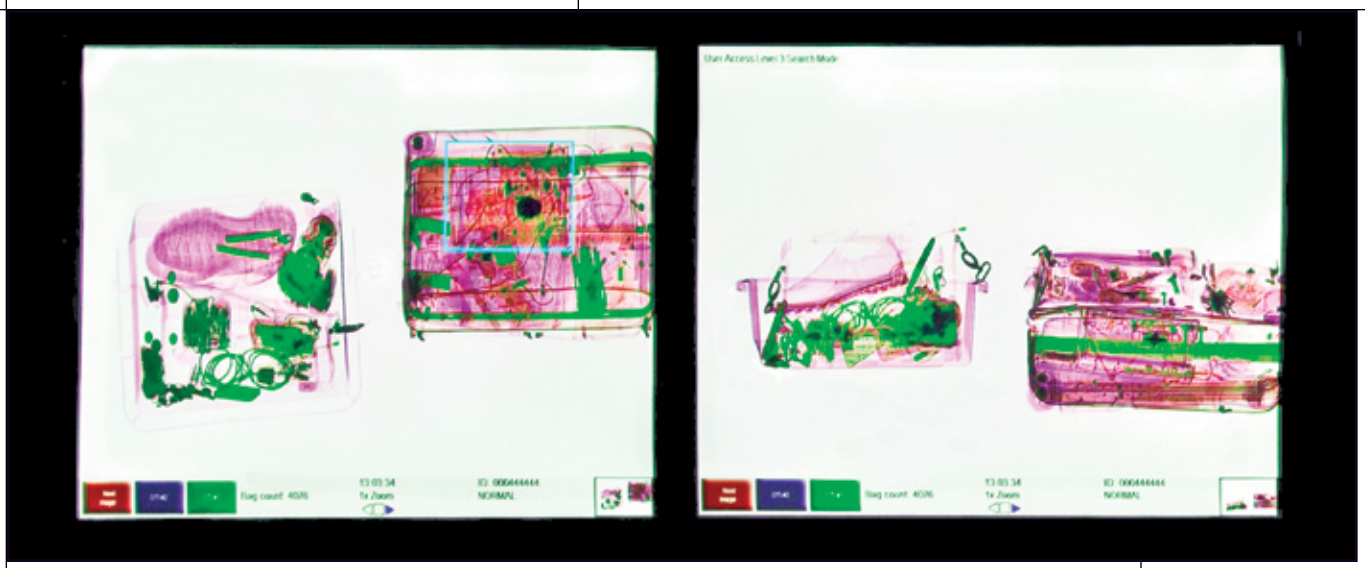
Professional searchers, such as the crews who look for survivors in storm wreckage, face a thornier problem than the rest of us. They are looking for something that they are unlikely to find—something that in the overwhelming majority of instances will not be present. Their predicament is dubbed the low prevalence effect, and it can greatly reduce accuracy. Indeed, a 2010 Norwegian study suggested that the rate of misses for the radiologists who pore over mammogram films looking for tumors is between 20 and 30 percent—a lot higher, we would presume, than your personal failure rate for finding your keys, and a lot more significant.

Miss rates were even greater when a team led by psychologist Trafton Drew of Harvard Medical School and Brigham and Women's Hospital asked 24 experienced radiologists to scan lung x-rays to look for tumors. Unbeknownst to the doctors, the research team had inserted a small picture of a gorilla into one of the slides. Yes, a gorilla. The primate was a reference to the well-known 1999 experiment by psychologist Daniel Simons in which people who were asked to count the passes during a ball game were often so absorbed in their task that they did not notice a person in a gorilla suit who walked through the game. The same kind of thing happened in Drew's lung-scan experiment, which was published earlier this year: a full 83 percent of the doctors failed to notice the gorilla image because they were looking for something else.

The gorilla findings are examples of inattentional blindness—the fact that people often do not notice what they are not paying attention to. The low prevalence effect is slightly different, in that the misses are because of an unconscious mental calculation, not lack of attention. In a series of experiments in 2007 psychologist Jeremy M. Wolfe, who heads the laboratory at Brigham and Women's Hospital

When **a weapon does show up,** it may not register in a screener's mind, precisely because **it is unexpected.**

FROM "THE INVISIBLE GORILLA STRIKES AGAIN: SUSTAINED INATTENTIONAL BLINDNESS IN EXPERT OBSERVERS," BY TRAFTON DREW, MELISSA LE-HOA VO AND JEREMY M. WOLFE, IN *ASSOCIATION FOR PSYCHOLOGICAL SCIENCE* (IN PRESS)

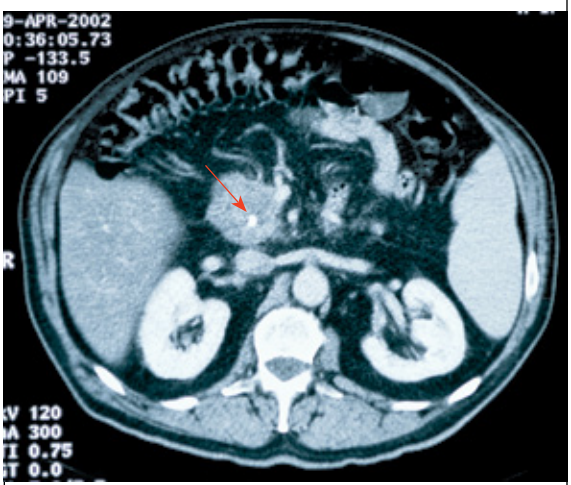


where Drew is affiliated, investigated how the low prevalence effect complicates the work of airport baggage screeners.

In one study, the team asked 10 people to view collages consisting of semitransparent photographs of toys, birds, fruit, clothes and tools. (The participants were not baggage screeners, just assorted volunteers.) Subjects were told to find a tool, but 99 percent of the collages did not contain any. Under these conditions, individuals missed the target 39 percent of the time. But when half the displays contained a tool, the same people made mistakes just 6 percent of the time. That is a huge difference—and a troubling one. Simply put, when targets are rare, people often fail to see them because their visual attention systems learn not to expect anything.

The human mind automatically keeps track of how often a certain kind of thing is found in a specific location—probably because over evolutionary time, having realistic expectations led to more efficient hunting and foraging. But this useful mental habit plagues people such as baggage screeners who are tasked with the high-pressure responsibility of finding potentially catastrophic anomalies. These workers view hundreds (possibly thousands) of x-rayed bags without finding dangerous items, all the while unconsciously building up background knowledge that nothing unusual will be found. When a weapon *does* show up, then, it may not register in the screener's mind, precisely because it is unexpected.

Wolfe and his colleagues tried to counteract the low prevalence effect. First, they paired people with partners, hoping that if one person missed the target, the other would find it. Misses remained high. Next, they forced subjects to search more slowly, by giving them time warnings. That did not work either. The team also had people search simultaneously for common and rare targets. By increasing how often people found *something*, they hoped to lower their likelihood of missing anything. But this tactic also failed: misses remained high for the rare targets.



Airport baggage checkers and doctors who search for tumors (such as the one in a human pancreas at the left) face a predicament called the low prevalence effect. When you repeatedly look for a target without finding it, your brain begins to assume nothing is there, making you less attuned and watchful.

We want to emphasize that the participants in these experiments were not careless, incompetent or unmotivated. Nor are the doctors who miss cancers on x-ray films. The low prevalence effect cannot be counteracted by conscientiousness or sheer willpow-

(The Authors)

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SCOTT GOLDSMITH *Getty Images (top)*; P. MARAZZI *Science Source (bottom)*

er. It is a quirk of human brain processing, and it happens to everyone. Wolfe's team eventually found, however, that it is possible to diminish this pernicious effect through training.

In their final experiment, they interspersed the search for rare items with brief periods during which the targets became common and searchers learned whether their decisions were correct. These interludes shifted people's expectations, making them more cautious and better prepared to find unusual targets. Miss errors were substantially reduced. The work suggests it might be useful to briefly retrain baggage screeners from time to time, by asking them to search x-rays in which half the bags contain weapons, then giving them feedback on their accuracy.

Duke University scientists teamed with Nike to test eyewear that fine-tunes vision. The goggles alternate, strobelike, between transparency and opacity, forcing athletes to make more efficient use of the visual information they do receive.

COURTESY OF DUKE UNIVERSITY PHOTOGRAPHY

Professional searchers are not the only ones who can be trained to improve. New experiments suggest that everyone can become a better visual searcher.

The Eye of the Beholder

Although moving your eyes is easy and seemingly automatic, people do it in subtly different ways. Evan Risko, a psychologist at the University of Memphis, studies variations in how people view—literally—the world around them.

In a 2012 experiment Risko and his colleagues focused on an individual's desire to acquire new knowledge or sensory experiences. Participants completed two questionnaires that gauge curiosity levels. Then they looked at photographs of buildings, interiors and landscapes for 15 seconds apiece. The team used an eye tracker to precisely record each person's gaze. Those with greater curiosity visited more regions of the scenes, examining the details of each picture, rather than getting stuck looking in only a few places. The study was the first to suggest that personality type helps to determine one's method of examining things.

It turns out that people differ not only in *how much* they search but also in *how* they search. In a study published in 2010 psychologist Marcus Watson and his colleagues at the University of British Columbia recorded the eye movements subjects made while looking for a partial circle hidden among similar shapes on a computer screen. The investigators coached half the participants to use an active search approach and half to search passively. During active search, people move their eyes around more frequently. During passive search, they fixate for longer periods and move their eyes less. In Watson's experiment, the eye-tracking data showed that the passive searchers were more successful. When their eyes fell on the target, they were more likely to detect it, suggesting that they make better use of the information obtained from each fixation.

One can imagine how passive search might be advantageous in the real world. If you are shopping for specific salad ingredients, it might be most effective to wander around the produce aisle and let the desired vegetables "call" your attention as you broadly scan the displays. Passive search, however, is not always the most efficient strategy. If you are waiting for a friend at the mall, it might be helpful to use a "brute-force" approach, rapidly darting your attention around to a clothing store, a nearby coffee shop and the mall entrance.

In the study by Watson and his colleagues, participants tended to be either habitually active or passive seekers, but not both. When given specific instructions, however, everyone was capable of changing their eye movements. This finding implies that people could improve their search abilities by learning to flexibly implement an active or passive approach, depending on the circumstances.

Investigators in other areas, such as video gaming, are also finding that people can improve their search abilities. Avid gamers move their eyes more efficiently than others do in the service of a demanding task. Until recently, though, no one knew whether the games develop those skills or simply attract people who already have them. Neuroscientist Daphne Bavelier of the University of Rochester and the University of Geneva and C. Shawn Green of the University of Wisconsin–Madison set out to answer that question. What they found is evidence that playing video games improves perceptual abilities. Nongam-

Neuroscientists are finding that **playing video games** improves people's **perceptual abilities.**

ers who spent time with the action-filled *Unreal Tournament 2004* improved on a test of visual acuity at which gamers excel—picking out the orientation of a T shape among other T shapes [see "Brain-Changing Games," by Lydia Denworth; Scientific American Mind, January/February 2013]. And other research suggests that video games can train people to find targets more quickly.

Vision of the Future

Yet games are old news compared with a technology called stroboscopic vision training. Just as long-distance runners practice in the low-oxygen conditions at high altitude to improve their overall performance, vision scientists are obscuring human vision to make it stronger. Stephen R. Mitroff, L. Gregory Appelbaum and their colleagues at Duke University are experimenting with Nike-designed eyewear called Vapor Strobe—goggles that alternate between transparency and opacity, constantly interrupting the wearer's view.

In a 2012 study participants were asked to stare at a cross for just less than half a second (they were not wearing the goggles at this point). As they looked, eight letters, organized in a circle around the cross, appeared for a tenth of a second. This is not enough time for an eye movement, so people could not look at any of the letters directly. Next, after a variable period (ranging from one hundredth of a second to two and a half seconds), a line appeared, pointing to one of the previous letter locations. Individuals had to report which letter had been in that spot. This sounds difficult, but it is a classic test that has been used since the 1960s with great success. When the delay is brief, people are typically 90 percent accurate, revealing that we have a remarkable capacity to retain visual information for short periods.

The next step in this experiment was entirely new: the participants, some of them university athletes, engaged in a variety of physical activities—playing catch, passing a soccer ball or basketball, and practicing dribbling. Half the volunteers wore the stroboscopic eyewear, and half wore eyewear that looked identical but did not interrupt visual input. The first group's task was difficult because they got only momentary glimpses of the location, trajectory and speed of the ball. To move into the right positions to perform a catch, participants had to make efficient use of the visual information they did receive. In essence, this task encouraged their visual systems to work more effectively.

After the physical training sessions, both groups did the letter-identification task again. Both groups performed better on average, but the stroboscopic group showed far larger improvements, suggesting that the training helped them better capture and hold visual memories. Moreover, in a second experiment, participants underwent the same protocol but were not retested on the letter task until 24 hours after the physical training. Still, they showed improvement, demonstrating that the benefits of stroboscopic training are retained for at least a day. Mitroff and his colleagues have used the technology with professional athletes, including the Carolina Hurricanes, an NHL hockey team. That research has not yet been published. But if it reveals that the goggles aid top-notch athletes, whose visual systems are already finely tuned, that would be compelling evidence. Regular people would probably get an even bigger effect. And for athletes, even a tiny visual boost would confer the competitive edge that every team wants.

The take-home message from these various strands of research—on stroboscopic effects, video gamers, baggage screeners, and active versus passive looking—is that with training, people can become better searchers. That should be welcome news to anyone, whether you are a race-car driver or a Boggle-playing retiree. We are a species of seekers, constantly on the lookout for novelty, beauty, companionship, sustenance and meaning. Therefore, it seems perfectly fitting that science is seeking—and finding—ways to improve how we search. M

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Bad Mix for the Teen Brain

Heavy alcohol consumption may harm the developing brain, significantly impairing learning, memory and thinking in young people **By Janet Hopson**

Mike started drinking at age 14. At his very first party, he recalls, "I probably had 10 beers." He partied for seven years while playing high school and college football, and the consequences of his drinking resemble a "Just Say No" campaign: blackouts, arrests, academic problems, emergency room visits, driving suspensions and mandatory treatment programs.

About 10 percent of eighth graders, 18 percent of 10th graders and 24 percent of high school seniors binge on alcohol. That is, they consume four drinks or more at a sitting if they are female or five or more if they are male at least once every two weeks. (For the same alcohol dose, women tend to have higher blood alcohol levels than men because of their smaller size, lower body water content and lesser ability to metabolize alcohol.) In addition, 44 percent of college students drink this much or more at least twice a month.

As Mike's case illustrates, binge drinking can lead to serious health and behavioral problems. Periodic heavy drinking is more damaging to both body and brain than smaller amounts of alcohol consumed more often because extremely high blood alcohol levels are toxic to organs, severely impair sensory and cognitive functions, and encourage habit formation or addiction.

Scientists have also identified a subtler, longer-lasting effect of heavy alcohol consumption among teenagers and young adults: deficits in learning and memory. An emerging body of data indicates that alcohol damages specific regions of the maturing brain. In addition, a youthful brain has weaker controls that would stop a person from drinking too much. Scientists are finding clues in the brain that may help them identify the most vulnerable young people—in hopes of halting problem drinking before it starts. According to psychiatry researcher Reagan R. Wetherill of the University of Pennsylvania, the aim is to bolster brain development "just enough" so that young people can "inhibit their own drinking behaviors before they act."

FAST FACTS

Poisoning Thoughts

1» About 10 percent of eighth graders, 18 percent of 10th graders and 24 percent of high school seniors binge on alcohol; they consume a minimum of four or five drinks at a sitting at least once every two weeks.

2» High blood alcohol levels are toxic to organs, severely impair sensory and cognitive functions, and encourage habit formation or addiction.

3» Recent findings show that heavy alcohol consumption can also damage parts of the maturing brain, producing lasting deficits in learning and memory in young people.

Impulsive Minds

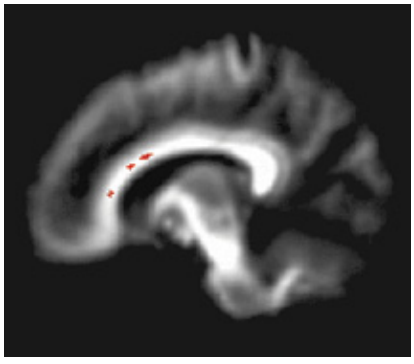
The teenage brain is a work in progress. In the past decade neuroscientists have revealed that the prefrontal cortex, which sits at the surface of the brain just behind the forehead, is relatively slow to reach maturity. This region is the seat of inhibitory control—the ability to stop oneself from acting impulsively—and of working memory, the mental scratchpad that enables a person to temporarily hold and manipulate information. Because the prefrontal cortex can mature years later than ar-

AIMEE BLUMSOM *Redux Pictures*

eas governing emotion and reward, teens explore and seek independence "before their inhibitory systems are in place," disposing them toward risky behaviors, says psychiatry researcher Susan F. Tapert of the University of California, San Diego.

Youths whose brain maturation is slower than usual may be in particular jeopardy. In a study published in 2011 a team led by Tapert and graduate student Andria L. Norman tested the inhibitory control skills of 38 12- to 14-year-olds while they were in an MRI machine. They then tracked the youths for four years to see who would start using alcohol. The 21 kids who had begun heavy drinking had, in their original scan, shown less activation in 12 brain regions—including parts of the prefrontal cortex and the adjacent parietal cortex, which helps to produce planned movements—than the 17 who abstained. In teens who went on to binge, Tapert says, "the circuitry responsible for inhibiting an action is not operating quite perfectly."

Wetherill has since tracked this diminished inhibitory capacity to a more specific brain location. In a study published in 2012 she and her colleagues used functional MRI to examine the brains of 20 12- to 14-year-olds who had never used alcohol but who came from families with alcohol problems. Teens from such families are more likely to start using and eventually abusing substances and in general tend to be more impulsive and defiant. Compared with 20 teens from families with no history of substance abuse, the brains of those in drinking families showed fewer and weaker connections between the frontal and parietal brain regions involved in planning, decision making and inhibitory control.



Heavy drinking can harm key regions of an adolescent's brain. In this image, the most prominent damage (*red spots*) appears in the bundle of nerve fibers called the corpus callosum that connects the brain's two hemispheres.

Thinking Too Hard

Not only are teenagers susceptible to the temptation of alcohol, but evidence suggests that drinking may harm their brains. The effects of drinking on the brain are not always straightforward. Yet clear differences in brain performance distinguish teetotalers from heavy imbibers. During the past decade pharmacology researcher Fulton Crews of the University of North Carolina at Chapel Hill School of Medicine and others have shown that a high blood alcohol level in rats, a model for human binge drinking, kills cells in the brain's frontal lobes and hippocampus, a hub for memory formation. Alcohol also suppresses the birth of new neurons, among other adverse effects. Adolescent rats are more sensitive than adult ones to each of these consequences—meaning the damage is greater at smaller doses. Indeed, the blackouts, and resulting amnesia, that occur in about half of all college students after binge drinking may result from hippocampal damage, says Aaron White, director of research on underage and college drinking prevention at the National Institute on Alcohol Abuse and Alcoholism.

In teens who went on to binge drink, "the circuitry responsible for inhibiting an action is not operating quite perfectly," says one researcher.

Some of the earliest insights into how drinking might affect an adolescent's learning and memory emerged in a study published in 2010 in Tapert's laboratory. Her then graduate student, Alecia Dager, now a psychiatry researcher at Yale University, tested verbal working memory—the ability to retain verbal information for short periods—in 24 nondrinking and heavy-drinking teens. Dager and her team gave the young people lists of words and word pairs to study while recording their brain activity. Later they tested the teens' recall of the words. The drinkers remembered 78 percent of the words, compared with 85 percent in the nondrinkers. Activity was significantly higher in parts of the prefrontal and parietal cortex of the drinkers during both learning and testing phases, probably reflecting increased effort, Dager says. In contrast, the hippocampus in the drinkers was underactive, which, in this case, the scientists interpret as echoing their poorer recall.

In 2011 a team led by U.C.S.D. postdoctoral fellow Lindsay M. Squeglia reported parallel findings on spatial working memory. This cognitive capacity allows you to create mental maps for, say, finding your way to a friend's house or redrawing a figure from memory. While in a brain scanner, 55 nondrinkers and 40 heavy drinkers aged 16 to 19 tried to recall shapes they had seen, among other spatial working memory tasks. The teens who had been drinking heavily for a year or two could do the exercises as well as the abstinent youths, although their parietal cortex was much more active. Teens who

FROM "ALTERED WHITE MATTER INTEGRITY IN ADOLESCENT BINGE DRINKERS," BY TIM MCQUEENY ET AL., IN *ALCOHOLISM: CLINICAL AND EXPERIMENTAL RESEARCH*, VOL. 33, NO. 7; JULY 2009

(The Author)

JANET HOPSON is a California-based science author, freelance writer and college lecturer. Her book *Magic Trees of the Mind* (Plume Penguin, 1999), co-authored with Marian Diamond, explored brain development from birth through early adulthood.

If drinking escapades such as this one at Miami Beach become a habit, young people risk damaging their still developing brains.

JOE RAEDLE Getty Images

had been imbibing heavily for three or four years, however, performed worse on the tasks; activity in other brain regions—those involved in vision and motor control—declined. When kids start drinking, the brain works harder to keep up, Squeglia suggests, but over time it can no longer compensate, and performance drops.

In a study published in 2012 Tapert and her colleagues similarly showed markedly higher brain activity in heavy-drinking 15- to 19-year-olds compared with nondrinkers on tasks involving visual working memory, the ability to focus on what is important in the environment. The longer a teen had been drinking, the harder the brain toiled, whereas in the nondrinkers the regions expended less energy as the teen matured.

Then Tapert's team documented in the same youths both the characteristic brain signature of low self-control and later, after they became drinkers, signs of less efficient information processing. In late 2012 the team reported scanning the brains of 40 youths twice, three years apart, starting when the kids were 15 years old, on average, while they did visual working memory tasks. In the 20 teens who became heavy drinkers between the scans, certain parts of the frontal and parietal cortex had been initially underactive, suggesting a lack of inhibitory control. Three years later, after starting to drink, other parts of these regions showed higher activity than they did in the 20 nondrinkers, a sign that the drinkers' brains had to exert unusual effort to perform the tasks.

Collectively, the Tapert group's work suggests that the 24 percent of high school seniors and 44 percent of college students who regularly binge on alcohol might be handicapping their cognitive abilities. They score an average of 7 to 10 percent lower on verbal, visual and spatial tests than their classmates who drink very little or not at all. These young people may have more trouble reading a map, following verbal directions to a place, assembling a bookshelf, planning a project, staying organized and learning new vocabulary, among other cognitive challenges. Still, the work is in its early days, and questions remain about the precise mechanisms of damage and how much restoration is possible.

Someday it might be possible to "immunize" kids against the propensity to drink by bolstering their system for restraint in childhood. Wetherill is developing computer-based games and exercises that could strengthen inhibitory pathways and eventually boost self-control in the types of situations that teenagers typically face. The earlier prevention programs begin, the better. "A kid who starts drinking at 14 is four times more likely to become dependent on alcohol than a kid who starts drinking at 21," White says.

No one yet knows whether the brain can fully recover from heavy drinking during its final years of development. In some of Tapert's subjects, cognitive deficits still remain after a decade. Mike eventually quit drinking, graduated from college and is now a successful account manager for a marketing company. He still experiences significant gaps, however, in his recollection of certain people and events in his past. He can only guess to what extent binge drinking and blackouts contributed because he also sustained numerous concussions playing football. The latest research, however, suggests that his partying could have contributed to a long-lasting erosion of his memory. M

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Can Herbs Ease Anxiety and Depression?

Some plant-based remedies may stand in for conventional ones, but most lack scientific support as treatments for psychological problems

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

HERBAL therapies are astoundingly popular among the American public. In 2008 statistician Patricia M. Barnes of the National Center for Health Statistics and her colleagues reported that almost 20 percent of children and adults in the U.S. had used an herbal medicine during the past year. In 1998 a team led by physician David M. Eisenberg of Harvard Medical School determined that use of herbs for physical and mental problems had risen 380 percent between 1990 and 1997.

Our enthusiasm for herbal medicine is undoubtedly fueled by the high cost of prescription drugs, the fact that these drugs do not work for everyone, and a burgeoning interest in natural remedies. Moreover, many people erroneously assume that natural substances are inherently safer than synthetic medications.

The use of plants as treatments dates to at least 3000 B.C. Today this practice is part of a broader movement known as complementary and alternative medicine. Many people turn to such treatments—which also include remedies such as acupuncture, aromatherapy and massage—for psychological problems. In a 2001 study sociologist Ronald C. Kessler of Harvard Medical School and his associates found that more than half of people with panic attacks or severe depression used some form of alternative therapy, including herbs, during the previous year, usually without medical supervision.

Nevertheless, most plants have not been studied for their therapeutic value or side effects. Studies of two herbal treatments—kava for anxiety and St. John's wort for depression—indicate that some plant-derived substances might help individuals with psychological problems, but the evidence is so far inconclusive.

Kick Back, Relax

Pacific Islanders have long used an extract of the root of the kava plant (*Piper methysticum*), which grows on those islands, for social, ceremonial and medicinal purposes, including relaxation and the reduction of anxiety. Introduced in the U.S. in the 1980s, kava extract is most often served as a drink, which Americans can now sample in any of various kava bars. The Purple Lotus Kava Bar in West Palm Beach, Fla., for example, offers "a popular alternative to the same old nightlife, a place to truly kick back and relax."

For the treatment of anxiety, people generally purchase kava in drug and health food stores. Some experimental results suggest the root has antianxiety properties. In a review article published in 2010, physician Max H. Pittler of the German Cochrane Center at the University of Freiburg and physician Edzard Ernst of the Peninsula Medical School in Exeter, England, analyzed 12 well-designed studies comparing kava with a placebo for the treatment of anxiety. They found that kava was more effective than the inert substance for ameliorating general anxiety, but the difference between the two was small. Un-

Kava extract, used to quell anxiety, is most often served as a drink, which Americans **can now sample in kava bars**.

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); THINKSTOCK (*herbs*)

fortunately, relatively few studies qualified for inclusion, and the investigations differed in the dosages used, strains of kava, duration of treatment and severity of the patients' anxiety.

In addition, although the herb is relatively safe, it should not be used with abandon. Its side effects may include stomach complaints, restlessness, headache and fatigue. Reports of the root causing liver damage led to a 2002 warning from the Food and Drug Administration, along with bans on kava in several countries. Further research has quieted this concern, and the bans have since been lifted. Even so, we cannot rule out the possibility that kava causes liver damage because alternative explanations for a few cases of liver problems remain unexplained by other factors.

Of more concern are interactions between kava and other medications. Kava can intensify sleepiness if taken with sedatives, sleeping pills, antipsychotics or alcohol, raising the risk of injury during activities such as driving and using heavy machinery. It may also enhance the sedating effects of anticonvulsants and worsen the side effects associated with antipsychotic medication.

Scientists have studied other herbal remedies for anxiety, too. A few studies hint, for example, that lemon balm and valerian may be calming. Still, the evidence supporting their efficacy is even more preliminary than that for kava. And their potential dangers are equally uncertain.

Weeding Out Despair

St. John's wort (*Hypericum perforatum*), a plant historically used to drive out evil spirits, is the most widely studied herbal medicine for depression. In a 2009 review physician Klaus Linde of the Munich Technical University and his colleagues evaluated 29 well-designed studies of St. John's wort, usually taken as a pill for major depression. Overall, the studies suggested that the herb was more effective than a placebo and just as effective as antidepressants such as Prozac yet came with fewer side effects.

Not all of the studies Linde's team analyzed, however, found an advantage for St. John's wort over a placebo. In addition, two large-scale U.S. investigations revealed scant support for the idea that St. John's wort could ease depression. One of these, a 2011 study led by psychiatrist Mark H. Rapaport, then at Cedars-Sinai Hospital in Los Angeles, indicated that the plant was no more effective than a placebo for mild to moderate depression. Thus, this herb may ease some cases of depression, but the evidence is far from overwhelming.

St. John's wort is not without some risks. It can cause stomach upset, skin rashes, fatigue, restlessness, headache and confusion. More serious is the possibility, though slight, that it can interfere with becoming pregnant, worsen dementia or trigger psychosis in vulnerable individuals. And as with traditional antidepressants, St. John's wort can trigger a manic episode in people with bipolar disorder. The herb also may interact dangerously with other drugs. If taken with certain antidepressants, it may cause potentially life-threatening increases in the neurotransmitter serotonin. It also can reduce the effectiveness of birth-control pills, heart medications and HIV treatments, among other drugs.

Approved drugs for anxiety and depression carry risks, too, but in those cases, the FDA is supposed to monitor and publicize them. In contrast, no government agency regulates herbal treatments. In addition, the fact that doctors do not prescribe herbs—and often do not even know their patients are using them—raises the risk of drug interactions. Further, relatively little is known about the purity or long-term effects of herbal remedies or what dose is optimal for a particular ailment.

> Because doctors do not prescribe herbs, they may not know a patient is using them, **raising the risk of drug interactions**.

Despite these concerns, advertisements for herbal remedies often make exaggerated and unsubstantiated claims. One online ad for an antianxiety pill called Seredyn containing a combination of largely untested herbs asserts that "over 93% of Seredyn users with occasional anxiety and 85% with chronic anxiety report positive results, and 80–83% of users with panic and anxiety attacks say that Seredyn helps prevent and stop their attacks." Such testimonials are essentially meaningless if not backed by verifiable data.

Nevertheless, more safe and effective herbal treatments for anxiety and depression may still be in our future. Perhaps one day scientists will discover in nature a large medicine cabinet offering new remedies for a broad spectrum of mental disorders. M

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

Send suggestions for column topics to editors@SciAmMind.com

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books

EVERYDAY PSYCHOPATHS

Confessions of a Sociopath: A Life Spent Hiding in Plain Sight

by M. E. Thomas. Crown, 2013 ($25)

Most of us don a poker face at one time or another to hide our emotional fragility. Sociopaths, a group that encompasses 1 to 4 percent of the population, may not require such a mask, because many of them do not experience intense emotions.

This character quirk does not make sociopaths dangerous criminals, despite their reputation. Sociopaths are sprinkled throughout our network of neighbors, co-workers and friends. In *Confessions of a Sociopath,* Thomas, a successful lawyer and clinically diagnosed sociopath, deepens our understanding of what it means to be a sociopath and provides a peek inside her own mind.

For instance, research shows that when faced with the threat of small electrical shocks or when shown disturbing images, sociopaths remain unfazed while their "normal" counterparts often wince with fear. Although the study implied that sociopaths' lack of empathy is a bad thing, Thomas saw this stone-cold, anxiety-proof demeanor as an asset, especially when tackling interviews or striving for a promotion.

She also assures us that sociopaths are not devoid of emotion as is commonly believed. Like children, sociopaths tend to put their own desires and well-being above those of others and often act on impulse without considering the repercussions. Thomas puts a positive spin on these attributes, noting that this self-confidence and drive are what allowed her to quickly climb the ranks at a prestigious law firm. Sociopaths also tend to have superior intelligence and creative skills as compared with their counterparts, she asserts.

Yet Thomas does admit that some of her sociopathic tendencies can be detrimental if left unchecked. In her early career, she bounced from job to job, unable to stay focused at one place for too long, and her tendency to try to manipulate co-workers got her into trouble.

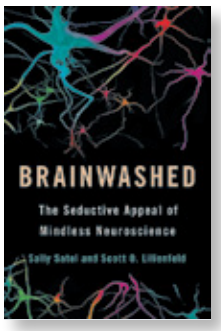
She eventually found her niche in academia, teaching law to perhaps the next generation of sociopaths. After all, sociopaths are great liars, she boasts, and hence have the skills to win cases, no matter the cost.

The goal of *Confessions* is to redefine sociopathy—or at least to shake off the stigma associated with it. And Thomas accomplishes both. Through her honest portrayal of herself as a highly capable yet deeply flawed individual, she demystifies her disorder. She becomes like any other person struggling through disappointment and striving for success. —*Brian Mossop*

ALL HYPED UP

Brainwashed: The Seductive Appeal of Mindless Neuroscience

by Sally Satel and Scott O. Lilienfeld. Basic Books, 2013 ($27.99)



Frito-Lay, the snack food giant, wanted to sell more potato chips to women. So it commissioned a neuroimaging study, which found that women looking at a shiny bag of potato chips had increased activity in the anterior cingulate cortex, associated with guilt. In the hopes of boosting sales, Frito-Lay switched to matte bags.

But how savvy was this swap? Not very, suggest psychologists Satel and Lilienfeld (the latter serves on the board of *Scientific American Mind*) in *Brainwashed,* which documents the rise of overhyped neuroscience. Activity in the anterior cingulate cortex also correlates with pain, decision making and motivation. The case is a classic example of reverse inference, the assumption that you can guess what someone is thinking by observing which brain region lights up on a scan.

Technologies have revolutionized the field of neuroscience. Yet scientists, lawyers and advertisers are increasingly using brain scans to make sweeping conclusions about our mental states and intentions, often leading to oversimplified or flawed explanations of the brain, Satel and Lilienfeld caution.

Reverse inference is just one of several common errors. A second pitfall is neuroredundancy, which uses neuroscience to reveal an obvious detail. Most of us can gather that a teenage defendant is immature, for example, without brain scans.

In other cases, neurohype has overstated how the brain influences behavior. Calling addiction a chronic brain disease was intended to reduce stigma—so addicts would not be accused of having a weak character—and to refocus research on brain-level explanations and treatments. Yet this approach downplays the complexity of addictive behavior and inadvertently created a new stigma, by associating addiction with mental illness.

These reasoning errors are founded on a mistaken assumption that the brain dictates every aspect of behavior. Such a claim, the authors argue, undermines the existence of free will and personal accountability.

Throughout *Brainwashed,* the authors give credit where credit is due, describing how imaging has illuminated the structure of the brain. They also explain that probing the brain is just one way to unravel how the mind works. It is this desire to understand the intricacies of what makes us *us* that keeps science endlessly exciting. —*Daisy Yuhas*

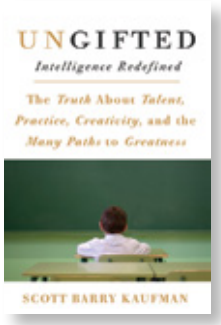
FORGET ME NOT

Permanent Present Tense: The Unforgettable Life of the Amnesic Patient, H.M.

by Suzanne Corkin. Basic Books, 2013 ($28.99)

H.M. could not remember what he had eaten for breakfast or recall a conversation from five minutes ago. He would not have recognized most of the events described in *Permanent Present Tense,* a new book about his life, nor its author, Corkin, the neuroscientist who studied him for nearly 50 years. H.M. did not know that in 1953 a devastating brain operation destroyed his ability to form long-term memories and that his amnesia revolutionized the science of memory.

Henry Gustav Molaison was 27, a shy, intelligent young man, when he underwent an experimental operation to relieve his severe epilepsy. The surgeon extracted two slivers of gray matter from either side of his brain, including his hippocampus, which, at the time, no one knew was the center of memory consolidation. Henry's amnesia was immediate and profound, and the "purity of his disorder"—he was otherwise cognitively normal—made him a much sought-after



SMART START

Ungifted: Intelligence Redefined

by Scott Barry Kaufman.
Basic Books, 2013 ($26.99)

In 2003 cognitive psychologist Kaufman applied for a Gates Cambridge Scholarship with an ambitious goal: he wanted to redefine intelligence. This mission was deeply personal. As a child labeled as learning disabled, low test scores relegated him to remedial classrooms. He later proved himself an able student, but Kaufman remained fascinated and disturbed by how a single test could dictate a person's destiny.

In *Ungifted,* Kaufman takes us on the intellectual journey that his research at Cambridge kicked off. He describes the fallibility of popular measures of brainpower, such as IQ tests, and proposes a new view of intellect.

In 1921 psychologist Lewis Terman began following an elite set of students with very high IQ scores. As adults, these subjects were generally healthier and more socially adjusted than the group of students with lower IQs and boasted productive, accomplished careers. Critics at the time, however, noted that these outcomes could have been predicted by socioeconomic status alone, and Terman's test missed some gifted individuals, including two future Nobel laureates.

Despite these flaws, students are still often ranked by such measures. Through early testing and teacher selection, certain children are singled out for an enriched lesson plan to push them to their limit, whereas others are labeled as low achievers, which often diminishes their expectations of themselves and hurts their performance in school.

Kaufman believes this system is problematic because a person's intelligence is much more nuanced than what can be captured in an SAT score. He makes a convincing case for incorporating valuable but less easily measured attributes into our view of intelligence, such as the persistence that can propel driven students to higher test scores than their less committed peers and the creativity demonstrated by individuals more in tune with intuition than intellect.

He also turns to neuroscience to help explain how different forms of intelligence might arise. The ability to infer underlying patterns, for example, is strongly linked to activity in the parietofrontal cortex. Creativity, meanwhile, appears to involve the brain's resting network, a chain of coordinated regions, including areas of the cortex and hippocampus, which is active while daydreaming or reflecting.

Most powerfully, Kaufman illustrates the importance of uncovering what gives each person his or her own brand of intelligence, taking into account individual goals, psychologies and brain chemistry. He details the distinct strengths of savants and prodigies and of those with autism and schizophrenia. By broadening our conception of intelligence, perhaps we can nurture more great minds. —*Daisy Yuhas*

ROUNDUP

Decisions, **Decisions**

Three books guide us to better choices

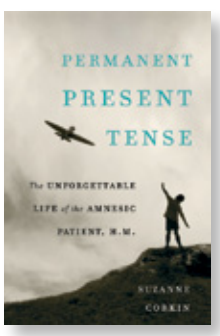
We make decisions all day long, from mundane choices about what to eat for breakfast to life-changing ones such as whom to marry. In **Decide: Better Ways of Making Better Decisions** (Kogan Page, 2013), David Wethey, a decision-making expert, lays out guidelines to help people cope with the stream of daily choices and understand which tactics work and which do not. For instance, Wethey advocates factoring in the personalities involved in a situation as well as listening to your gut.

In 2009 almost 62,000 people in the U.S. got their tattoos removed, according to psychologist Chip Heath and his businessman brother Dan. In **Decisive: How to Make Better Choices in Life and Work** (Crown Business, 2013), the brothers discuss how our brain is a flawed decision-making tool, swayed by emotions and biases. They offer strategies to conquer these shortcomings based on their analysis of decision-making research. The authors suggest consulting a mental checklist, which includes exploring alternative points of view and recognizing uncertainty.

But what goes on in our head when we choose a job or friend? In **The Mind within the Brain: How We Make Decisions and How Those Decisions Go Wrong** (Oxford University Press, 2013), neuroscientist A. David Redish looks at the complex processes in the brain that prompt us to make certain selections, as well as the defects in this neural system that can lead us astray. —*Victoria Stern*

GINES VALERA MARIN *iStockphoto*

study subject. His loss would be science's gain. In the reams of medical literature that cited him, he was known only as H.M.



In the name of science, Henry tried to learn new words, identify old photographs, and more. Researchers tested every facet of his memory, scanned his brain with increasingly sophisticated technology, and experiment by experiment teased out how memory works. Different types of memory engage different circuits in the brain. Henry's short-term memory (which lasted about 30 seconds) was intact, but without a hippocampus, his immediate experiences never converted to long-term memories. He could sometimes pick up new facts, such as celebrity names in the news, and learn motor skills, such as how to use a walker in old age—evidence of an unconscious memory still at work.

Corkin intends her book as both an exploration of the science of memory and a tribute to Henry, who died in 2008. She characterizes him as gentle and good-humored, a cooperative study subject, although the surgery dulled his emotions. Troublingly, she never explains how Henry was able to give consent for these studies.

The strange thing about reading *Permanent Present Tense* is that—despite an abundance of jargon and its gloss over the knottier questions—with every page you realize more how much of living is remembering. Without memory, you would never make a new friend, learn a new word or look forward to tomorrow. For 55 years, Henry never did.

—*Nina Bai*

askthe**Brains**

Why is it that I seem to think better when I walk or exercise?

—***Emily Lenneville,*** *Baltimore*

Justin Rhodes, *an associate professor of psychology at the University of Illinois at Urbana-Champaign, responds:*

AFTER BEING COOPED UP inside all day, your afternoon stroll may leave you feeling clearheaded. This sensation is not just in your mind. A growing body of evidence suggests we think and learn better when we walk or do another form of exercise. The reason for this phenomenon, however, is not completely understood.

Part of the reason exercise enhances cognition has to do with blood flow. Research shows that when we exercise, blood pressure and blood flow increase everywhere in the body, including the brain. More blood means more energy and oxygen, which makes our brain perform better.

More blood means more energy and oxygen, which makes our brain perform better.

Another explanation for why working up a sweat enhances our mental capacity is that the hippocampus, a part of the brain critical for learning and memory, is highly active during exercise. When the neurons in this structure rev up, research shows that our cognitive function improves. For instance, studies in mice have revealed that running enhances spatial learning. Other recent work indicates that aerobic exercise can actually reverse hippocampal shrinkage, which occurs naturally with age, and consequently boost memory in older adults. Yet another study found that students who exercise perform better on tests than their less athletic peers.

The big question of why we evolved to get a mental boost from a trip to the gym, however, remains unanswered. When our ancestors worked up a sweat, they were probably fleeing a predator or chasing their next meal. During such emergencies, extra blood flow to the brain could have helped them react quickly and cleverly to an impending threat or kill prey that was critical to their survival.

So if you are having a mental block, go for a jog or hike. The exercise might help pull you out of your funk.

How has the human brain evolved over the years?

—***Emma Schachner,*** *Salt Lake City*

John Hawks, *a professor of anthropology at the University of Wisconsin–Madison, answers:*

HUMANS ARE KNOWN FOR sporting big brains. On average, the size of primates' brains is nearly double what is expected for mammals of the same body size. Across nearly seven million years, the human brain has tripled in size, with most of this growth occurring in the past two million years.

Determining brain changes over time is tricky. We have no ancient brains to weigh on a scale. We can, however, measure the inside of ancient skulls, and a few rare fossils have preserved natural casts of the interior of skulls. Both approaches to looking at early skulls give us evidence about the volumes of ancient brains and some details about the relative sizes of major cerebral areas.

For the first two thirds of our history, the size of our ancestors' brains was within the range of those of other apes living today. The species of the famous Lucy fossil, *Australopithecus afarensis,* had skulls with internal volumes of between 400 and 550 milliliters, whereas chimpanzee skulls hold around 400 ml and gorillas between 500 and 700 ml. During this time, *Australopithecine* brains started to show subtle changes in structure and shape as compared with apes. For instance, the neocortex had begun to expand, reorganizing its functions away from visual processing toward other regions of the brain.

The final third of our evolution saw nearly all the action in brain size. *Homo habilis,* the first of our genus *Homo* who appeared 1.9 million years ago, saw a modest hop in brain size, including an expansion of a language-connected part of the frontal lobe called Broca's area. The first fossil skulls of *Homo erectus,* 1.8 million years ago, had brains averaging a bit larger than 600 ml.

From here the species embarked on a slow upward march, reaching more than 1,000 ml by 500,000 years ago. Early *Homo sapiens* had brains within the range of people today, averaging 1,200 ml or more. As our cultural and linguistic complexity, dietary needs and technological prowess took a significant leap forward at this stage, our brains grew to accommodate the changes. The shape changes we see accentuate the regions related to depth of planning, communication, problem solving and other more advanced cognitive functions.

With some evolutionary irony, the past 10,000 years of human existence actually shrank our brains. Limited nutrition in agricultural populations may have been an important driver of this trend. Industrial societies in the past 100 years, however, have seen brain size rebound, as childhood nutrition increased and disease declined. Although the past does not predict future evolution, a greater integration with technology and genetic engineering may catapult the human brain into the unknown. **M**

Have a question? Send it to editors@SciAmMind.com

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Head Games

Match wits with the Mensa puzzlers

1 MEET YOUR MATCH

This matchstick diagram shows an equation in Roman numerals: 3 – 5 = 2. Correct the arithmetic by moving only one matchstick. (You may not bend or break it or place it on any other matchstick.)

2 HALFSIES

Fill in the empty squares so that the vertical, horizontal and diagonal lines all add up to 15, using whole numbers or multiples of ½ only. No number may be duplicated, and the highest number you can use is 8. Two of the numbers are filled in to start you off in the right direction.

7½	2	

3 A SLOW HIKE

Mica and Jordan are trekking through the Grand Canyon. Mica can walk at a rate of only 1.5 miles per hour uphill and 2 mph downhill because she is recovering from a hamstring injury. During their first few days, they are climbing all uphill. Then they turn back, and it's all downhill. It takes them five hours longer to go up than it does to come down. How far was the summit from their starting point?

4 LONGER DIVISION

Divide 95 into two parts so that the greater part is the third smallest perfect square times double the smaller part.

5 ANAGRAM

Rearrange the same eight letters to make two English words and complete the following scene.

The mail carrier grumbled about the heavy load at one house: "This person must be on every mailing list in the country, judging by the number of catalogues addressed to the _ _ _ _ _ _ _ _." Nevertheless, he **_ _ _ _ _ _ _ _ all the mail through the slot in the front door.**

6 NO ACCOUNTING FOR TASTE

Hilda has some very peculiar likes and dislikes. She will buy paste, but not glue. She will eat at a table, but not at a counter. She will eat in a deli, but not in a café. Will she take a cab or a taxi?

7 WORD MORPH

Change FIST to HAND in six steps, by changing one letter at a time.

F I S T

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

H A N D

8 SENTENCE SNAKE

Find the sentence coiled below to reveal a moral. There is one null letter. Each letter is used only once.

O E U N I

G S P S H

D U N E D

E D O O A

E D O G N

9 MYSTERY MULTIPLICAND

The following multiplication puzzle uses all the numbers from 1 through 9 once each. Three numbers have been filled in to get you started.

1 × ×
× **9**
7 × × ×

Answers

1.

2. One possible solution:

4½	8	2½
3	5	7
7½	2	5½

3. 30 miles. (20 hours up and 15 hours down.)

4. 90 and 5.

5. RESIDENT, INSERTED.

6. Cab. She likes words that contain two letters in consecutive alphabetical order.

7. One possible answer: FIST, FAST, PAST, PANT, WANT, WAND, HAND.

8. NO GOOD DEED GOES UNPUNISHED.

9. 186 × 39 = 7,254

Marcia Cross
Stand Up To Cancer
Ambassador

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Photo by Randall Slavin

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ARE WE THERE YET?

MAPPING THE HUMAN BRAIN

BY DWAYNE GODWIN & JORGE CHAM

THERE'S A NEW INITIATIVE TO MAP THE HUMAN BRAIN CALLED "BRAIN RESEARCH THROUGH ADVANCING INNOVATIVE NEUROTECHNOLOGIES."

BUT WAIT, WHY DO WE NEED A MAP OF THE BRAIN? HAVEN'T WE DONE THAT ALREADY?

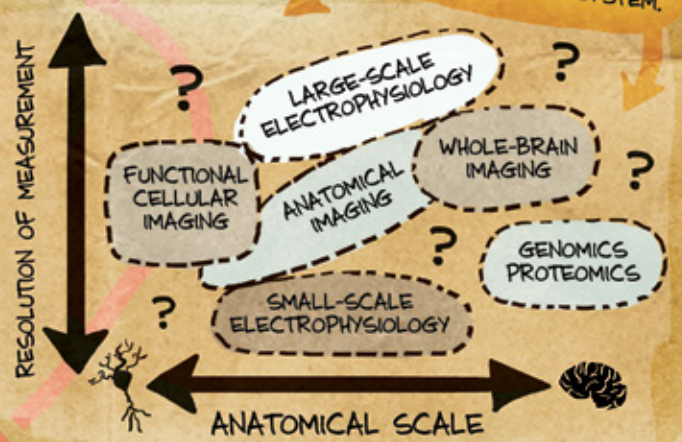
IN THE 1890S SANTIAGO RAMÓN Y CAJAL USED SPECIAL STAINS THAT REVEALED HOW NEURONS WITHIN BRAIN REGIONS ARE WIRED TO ONE ANOTHER.

AND IN 1909 KORBINIAN BRODMANN CLASSIFIED DIFFERENT REGIONS OF THE BRAIN BASED ON CELL STRUCTURE AND ORGANIZATION, CREATING A COMMON REFERENCE SYSTEM FOR SCIENTISTS ALL OVER THE WORLD.

think by the numbers

MANY CURRENT TECHNOLOGIES ALLOW US TO LINK NEURAL ACTIVITY TO BEHAVIOR.

BUT NONE CAN REALLY GIVE US A COMPLETE VIEW OF THE ENTIRE SYSTEM.



A TRUE FUNCTIONAL MAP OF THE BRAIN WOULD REVEAL HOW INFORMATION FLOWS FROM A SINGLE NEURON TO INCREASINGLY COMPLEX CIRCUITS, PRODUCING THOUGHTS AND ACTIONS ...

... AND HOW DIFFERENT DISEASES ALTER NORMAL PATTERNS OF BRAIN ACTIVITY, MAKING IT EASIER TO DESIGN CURES.

SOME SCIENTISTS ARE DEBATING WHETHER THIS IS FEASIBLE OR EVEN POSSIBLE.

BUT IF WE WORK TOGETHER, WHO KNOWS WHAT TREASURES MAY LIE AHEAD?

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

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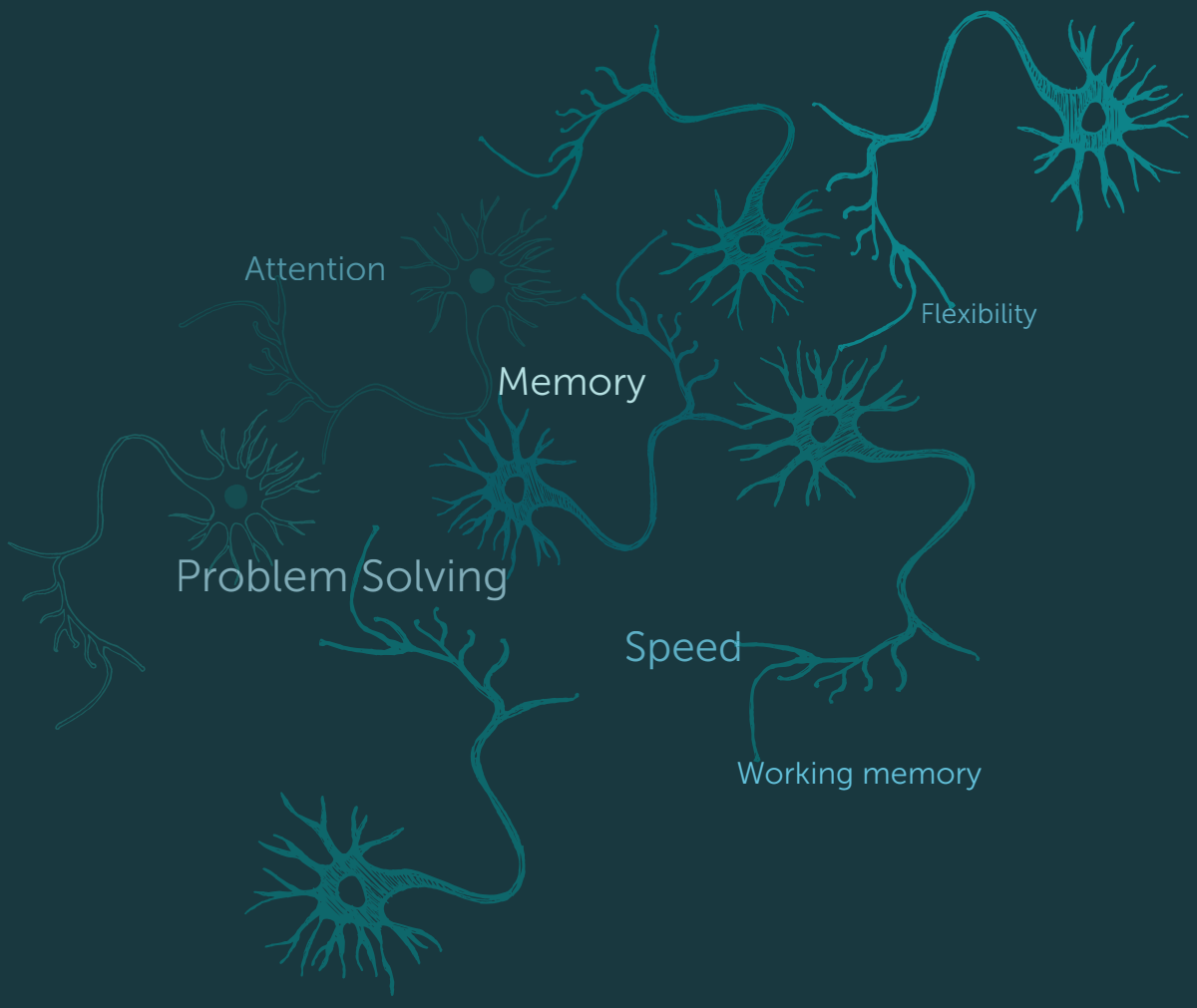

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