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Beautiful Mess Called Life

Individuals often overestimate how harshly others judge a messy, chaotic life

WITH COVERAGE FROM
nature

Liz Tormes

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Embracing the Mess

The pandemic has been a hard time for most people, even if not everyone is struggling in the same way. Families, for example—mothers in particular—had to shift their routines drastically to accommodate remote schooling schedules for kids, which disrupted daily life in big ways. Several of my mom friends lamented to me repeatedly that they felt shame about giving their children the iPad to occupy them or letting them watch inordinate amounts of TV so the adults could get their own tasks done (or just have a break!). Pandemic aside, parenting seems to be one area where people are worried that others must think they're a "bad mom" or "bad dad" for not adhering to some idea of perfection. But as social psychologist Anna Bruk writes in the cover story, our so-called messy lives aren't really noticed by outsiders. And giving yourself a high dose of self-compassion is a tried-and-true way to relax about an imperfect—and sometimes chaotic—existence (see "Other People Don't Think You're a Mess").

Elsewhere in this issue, check out the surprising ways that the sound of our voice affects how we perceive ourselves (see "A Change to the Sound of the Voice Can Change Your Very Self-Identity") and a report from senior editor Gary Stix on whether we'll ever want to get close to people again (see "COVID Expanded the Boundaries of Personal Space—Maybe for Good"). Yes, life has been exceptionally unsettling lately, but it's the only one we've got.

Andrea Gawrylewski
Senior Editor, Collections
editors@sciam.com

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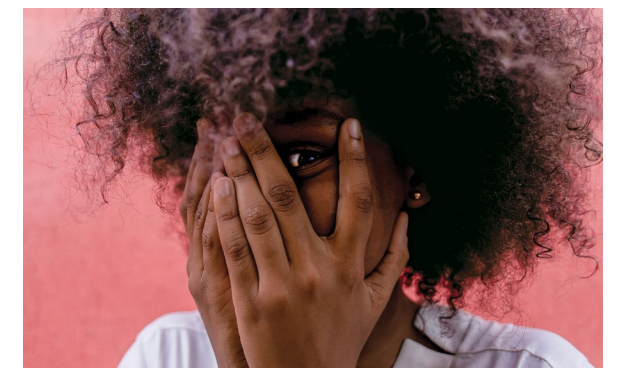
On the Cover

Individuals often overestimate how harshly others judge a messy, chaotic life

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NEWS

Suicide Rates Rise in a Generation of Black Youth

Multiple causes underlie a disturbing trend. The increase for girls is more than double that for boys

Suicide is a devastating problem among Black youth, and researchers and mental health professionals are desperate to understand why and how best to address it. A 2018 study found, for instance, that Black children between the ages of five and 12 are about twice as likely to die by suicide as white children of the same age. The urgency to deal with the issue has only grown more acute. A new study found that suicide rates among Black children and adolescents have recently been worsening: between 2003 and 2017, suicides rose in this group, especially among Black girls, whose rate of increase was more than twice as high as that of Black boys.

In the new paper, published on September 8 in the *Journal of the American Academy of Child & Adolescent Psychiatry*, researchers extracted information from Centers of Disease Control and Prevention databases about the 1,810 Black people aged five to 17 who had died by suicide between 2003 and 2017. They found that suicides rose over time during that period among Black youth of all ages and that the biggest increases occurred among teens aged 15 to 17. More than 2.5 times as many Black boys died by suicide as Black girls, but the annual increase among girls—6.6 percent—was more than twice what it was for boys.

The findings are "deeply concerning," says Janelle Goodwill, a psychologist and social worker at the University of Chicago Crown Family School of Social Work, Policy, and Practice, who was not involved in the research. They also challenge the long-held assumption that suicide rates among young white individuals are higher than those among young Black people. The September 8 paper only analyzed data through 2017, so it lacks figures for the COVID-19 pandemic. A CDC study published in August 2020 reported that, in late June of that year, more than one

quarter of young adults had contemplated suicide within the past 30 days.

Suicides among Black youth may have increased for a variety of reasons. For one thing, adverse childhood experiences are extremely high in this group, says Michael A. Lindsey, a co-author of the new study and executive director of the McSilver Institute for Poverty Policy and Research at New York University, and such experiences could be increasing. Black youth may also be experiencing more racial discrimination, which has been linked to an increased risk of suicide. And they may be traumatized by headlines about the deaths of Trayvon Martin, Michael Brown and other young Black individuals.

Psychological barriers to accessing mental health care may provide another explanation for these findings. "There's a lot of stigma related to mental health treatment that seems to persist in Black communities and families," Lindsey says, "including the propensity to want to share concerns related to one's emotional and psychological well-being with family members only—and not share it with professionals."

It is unclear why rates of suicide are increasing most among Black girls, but Lindsey notes that the discrimination and sexual violence they experience may increase the risk that they will take their own life. According to the CDC, one in eight high school girls of all races experiences sexual dating violence, compared with one in 26 high school boys. Black teen girls also appear to be at a higher risk of sexual violence than girls of other races—and such violence is a known suicide risk factor. Other research has pointed to the compounding effects of sexism and racism on Black girls and how together they might increase this group's risk of depression and anxiety, compared with that of Black boys.

Black girls also follow different trajectories when contemplating suicide than Black boys do, according to another new study published in September in *Prevention Science*. Based on results from nationally representative surveys, researchers found that high schoolers who attempted suicide impulsively, without prior suicidal ideation, were disproportionately Black and male and less likely to report feelings of sadness and hopelessness. Female high schoolers, on the other hand, were more apt to feel sad and hopeless and go through mental planning steps before their attempts.

According to Meghan Romanelli, a licensed clinical social worker at the University of Washington School of Social Work and a co-author of the *Prevention Science* paper, Black boys who attempt suicide may be less likely than others to suffer from the feelings of sadness and hopelessness that characterize depression and might fit the criteria for other diagnoses, such as post-traumatic stress disorder. If so, "it's likely that these youth are experiencing symptoms or warning signs that we aren't recognizing or picking up on," she says. They may also be less likely to tell others that they are struggling.

Another condition linked to suicide in Black youth is attention deficit hyperactivity disorder, or ADHD. In the *Journal of the American Academy of Child & Adolescent Psychiatry* study, five- to 11-year-old Black children with a diagnosis of ADHD were at a heightened risk of suicide. ADHD itself might not increase suicide risk, Lindsey says. But rather symptoms of ADHD and depression—which can include irritability and interpersonal problems—can overlap and make it hard for professionals to recognize that kids with the disorder are also depressed. "The underlying reasons for why they're irritable or angry might be missed," he notes.

The new studies have important implications for suicide prevention in Black communities. Teachers, parents and mental health professionals who engage regularly with Black youth need to be educated as to "nuanced, subtle behaviors that

> **"There's a lot of stigma related to mental health treatment that seems to persist in Black communities and families, including the propensity to want to share concerns related to one's emotional and psychological well-being with family members only—and not share it with professionals."**
> —*Michael A. Lindsey*

actually might be indicating that a child is at risk," Lindsey says. They need to learn that at-risk youth may express irritability rather than sadness as a warning sign. Physical symptoms could be important, too: Lindsey's research has shown that depressed Black youth who live in low-income housing sometimes complain of physical pain. Interventions that aim to reduce the stigma associated with mental health treatment in Black communities are now becoming available. Lindsey and his colleagues developed a program called the Making Connections Intervention to provide depressed young people with mental health care and reduce the stigma associated with receiving it.

Another goal of such interventions should be to convey the message to Black children and teenagers that they are valued members of society. Right now there is a "lack of compassion and care for young Black lives," Goodwill says, which may be fueling feelings of worthlessness. We must counteract this pernicious message, she says, so that young Black people in America understand that "their lives are full of meaning and purpose."

—Melinda Wenner Moyer

The Brain Guesses What Word Comes Ne-

Like some AI systems, the organ of thought appears to predict what word follows another to coax meaning from language

In the midst of a conversation with an acquaintance, your brain might skip ahead, anticipating the words that the other person will say. Perhaps then you will blurt out whatever comes to mind. Or maybe you will nurse your guess quietly, waiting to see if—out of all the hundreds of thousands of possibilities—your conversational partner will arrive at the same word you have been thinking of. Amazingly, your companion will often do so.

How does the brain do this? Figuring out how we process language has long been a focus for neuroscientists. Massachusetts Institute of Technology researchers brought a new take to the question using a technique called integrative modeling. They compared dozens of machine-learning algorithms called

neural networks with brain scans and other data showing how neural circuits function when a person reads or listens to language. The researchers had a two-part goal: they wanted to figure out how the brain processes language and in doing so push the boundaries of what machine-learning algorithms can teach us about the brain.

The modeling technique reveals that a key role may be played by next-word prediction, which is central to algorithms such as those that suggest words as you compose your texts and e-mails. The researchers discovered that models that excel at next-word prediction are also best at anticipating brain-activity patterns and reading times. So it seems like

these models are not just useful for proposing the word "want" after you have typed "do you"—or for allowing computers to complete any number of tasks from behind the scenes. They may also offer a window into how your brain makes sense of the flood of words coming out of your friend's mouth.

The researchers contend that this study marks the first time that a machine-learning algorithm has been matched to brain data to explain the workings of a high-level cognitive task. (Neural networks have been used in visual and auditory research for years.) The finding suggests that predictive processing is central to how we comprehend language and demonstrates how artificial neural networks can offer key insights into cognition.

"I did not think this would happen in my lifetime," says Evelina Fedorenko, a cognitive neuroscientist at M.I.T. and co-senior author of the paper. "These models fare much better than I would have predicted, relative to human neural data. That just opens up all sorts of doors."

The researchers examined models based on 43 artificial neural networks—a technology that consists of

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thousands or millions of interconnected nodes, similar to neurons in the brain. Each node processes data and feeds them to other nodes. Some of the models the M.I.T. team looked at were optimized for next-word prediction, including the well-known Generative Pre-trained Transformer (GPT-2), which has made an impression because of its ability to create humanlike text.

The researchers found that the activity of the neural network nodes was similar to brain activity in humans reading text or listening to stories. They also translated the neural networks' performance into predictions of how brains would perform—such as how long it would take them to read a certain word.

The work lays a foundation for studying higher-level brain tasks. "We view this as a sort of a template or a guideline of how one can take this entire approach of relating models to data," says Martin Schrimpf,

a Ph.D. student in brain and cognitive sciences at M.I.T. and lead author of the paper.

The researchers found that the models that were best at guessing the next word were also best at predicting how a human brain would respond to the same tasks. This was especially true for processing single sentences and short paragraphs. The models were significantly worse at predicting words or human responses when it came to longer blocks of text. None of the other tasks reflected what was going on in the brain. The authors argue this is strong evidence that next-word prediction, or something like it, plays a key role in understanding language. "It tells you that, basically, something like optimizing for predictive representation may be the shared objective for both biological systems and these in silico models," Fedorenko says.

To this point, Dan Yamins, a computational neuroscientist at

Stanford University, who was not involved with the research, remarks, "A sort of convergent evolution has happened between the engineering and the real biological evolution." Computer science has independently come up with a solution for a sophisticated cognitive task that the brain had devised over many millennia.

"I'm superimpressed by what [the M.I.T. team] achieved," says Noah Goodman, a psychologist at Stanford, who was also not involved with the research. But he adds that he suspects that the data are not sufficient to explain how people derive meaning from language. Despite these reservations, Goodman says the method is "still vastly better than anything we've had in the past."

While neural networks and computational science more generally are only rough analogies for the brain, their role in helping us understand our own mind may be substantial. Integrative modeling used by Fedorenko and her colleagues demonstrates that neural networks and computational science might, in fact, be critical tools in providing insight into the great mystery of how the brain processes information of all kinds.

—*Anna Blaustein*

Experimental Brain Implant Could Personalize Depression Therapy

Symptoms subsided for one woman after a carefully targeted neural circuit was stimulated

Sarah remembers what it was like both before and after the treatment. The 36-year-old vividly recalls how, after her depression lifted, she had to readapt to performing the tasks other people do routinely each day. Even the simple act of looking at a menu took readjustment.

"I also had to learn, relearn," she said at a press briefing, "how to actually have opinions about things and actually pick something on a menu and order it and not just go along with what everyone else wanted. Because I was so used to the fact that I couldn't make decisions, that [ability], over the last five years...., just atrophied and disappeared."

Sarah's intractable depression, which had not responded even to electroconvulsive therapy, yielded after an experimental treatment

Sarah, who received a brain implant for her depression, is attended by researcher Katherine Scangos of the University of California, San Francisco.

conducted at the University of California, San Francisco. The treatment detects depression-related brain activity and then applies electrical stimulation at a targeted location to relieve symptoms. The device used

for the procedure has already been approved for treating epilepsy by providing brain stimulation after it registers electrical patterns that predict an oncoming seizure.

In the October 4, 2021, study in

Nature Medicine, the researchers describe how they set about to find a stimulation site using electrodes to probe emotion circuitry in Sarah's brain. As they looked, they found that one site might lower anxiety and that

another might increase energy levels.

When the team activated a site deep in Sarah's brain in a reward-related area called the ventral striatum, she had an immediate reaction. Sarah was doing needle-work during one session to distract herself from negative thoughts when a stimulus was applied to that spot. Her mood changed quickly. In a U.C.S.F. article about the treatment, she recounted her surprise at feeling that she was enjoying what she was doing—experiencing, in fact, a sense of "glee and happiness."

The researchers also wanted to know when to provide a stimulus. Previous research on activating neural circuits to relieve depression using other deep-brain stimulation (DBS) techniques have met with mixed results. Earlier attempts did not map the brain to take into account the fact that depression may vary among individuals.

These efforts also applied continuous stimulation. The U.C.S.F. researchers suspect that the effectiveness of this type of treatment depends on knowing when an electrode should be activated in anticipation of symptoms growing more severe, similar to the approach

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> —*Katherine Scangos*

that is taken with epilepsy.

They looked for what they call a "biomarker" that could supply such an alert. They found it in the amygdala, which mediates emotional processes and is also connected to the striatum. High-frequency neural activity—"gamma oscillations"—in the amygdala indicated when symptoms were about to get worse.

In 2020 the team implanted the about $30,000 epilepsy device, Neuropace RNS, in the right hemisphere of Sarah's brain. An electrical wire goes to the amygdala to detect gamma activity. When present, a warning flashes back to a thin metal disk placed in the skull. The disk, a neurostimulator, then transmits a signal along a separate wire to the striatum to tamp down feelings of sadness and depression.

Stimulation is applied in a short six-second burst and then turns off until another gamma warning is received. This intermittent switching

on adds up to no more than 30 minutes a day. But for Sarah, it has made a difference. "The device has kept my depression at bay," she said at the press briefing, "allowing me to return to my best self and rebuild a life worth living."

When tried with new patients, the therapy will again be personalized. Others will also undergo the process of electrical probing to look for brain stimulation areas most suited to their depression. But the challenges accompanying Sarah's case make the U.C.S.F. researchers optimistic. "We didn't know if we were going to be able to treat her depression at all because it was so severe," said Katherine Scangos, a U.C.S.F. physician and lead author of the *Nature Medicine* paper, at the press briefing.

Longtime DBS researchers also took notice. "This is an interesting and important proof of principle case," says Helen Mayberg, a neurologist at the Icahn School of Medicine at Mount Sinai, who has been a pioneer in earlier DBS studies for depression and was not involved in the new study. "Time will tell if this approach substantively improves on simpler open-loop

strategies [without biomarkers]."

Andres Lozano, a professor of neurosurgery at the University of Toronto and a collaborator of Mayberg's, who was also not involved in the *Nature Medicine* paper, says that the work is an "exciting finding that leads to a more personalized and 'just in time' approach to delivering brain stimulation in depression when and where it is needed." He adds that "several questions remain, including the generalizability of these biomarkers across patients and whether the application of stimulation produces more than merely acute changes but indeed an enduring benefit."

Sarah is just one patient. The study she enrolled in was a "proof of concept"—what researchers call an "n of one." "We're still learning; we're at the very, very beginning of trying to understand how this works," says U.C.S.F. neurosurgeon Edward Chang, who is co-senior author of the study. U.C.S.F. is in the process of lining up 11 additional patients. The new research could ultimately provide a better idea of whether targeting just the right brain circuit can lift the penumbra that hangs over a severely depressed person.

—Gary Stix

An Inventory of All the Brain Cells That Let You Run, Jump and Roll

A project to map the motor cortex used the widest range of tools for probing brain cells ever deployed in a single, coordinated effort

Pioneering neuroscientist Santiago Ramón y Cajal jump-started the search for a "components catalog" of the human brain toward the end of the 19th century. His intricate drawings of brain cells, complete with their weblike connections, still appear in many textbooks. Looking for brain parts is driven by more than curiosity. Before the generations-long endeavor of deciphering the brain can proceed, neuroscientists need to first identify its multitude of component parts and then figure out what each one does.

The task is complicated by the many ways cells can differ. Ramón y Cajal provided glimpses of the shapes that distinguish some cell types but also left a virtually infinite amount of work for future genera-

tions of neuroanatomists. Cells can differ by location, biochemistry and other properties. These different descriptors often do not correspond to one another in any simple way, a fact that has fueled debates about how to define cell types. As tools to record the signals that neurons use to communicate became available, researchers have tried to categorize

cells by comparing their different firing patterns, the specialty of the discipline known as electrophysiology. This effort comes closer to classifying what cells do, but is still descriptive in that it describes behavior rather than morphology.

The journey toward a definition that describes cells according to their function comes to an end at

the genome, the blueprint that underlies all other biological properties. That these efforts are now bearing fruit is demonstrated by a large, international consortium, funded by the National Institute of Health's BRAIN Initiative. It has produced a genomics-based census of the cell types in one region, the primary motor cortex, which is

responsible for controlling complex movement.

This atlas applies equally to mice, monkeys and humans. The motor cortex became the region of focus as a first step toward more comprehensive brain inventories because it is both well studied and similar across species. Called the Brain Initiative Cell Census Network (BICCN), the group comprises the efforts of many labs, spearheaded by the Allen Institute for Brain Science in Seattle. The findings, described in 17 papers in *Nature,* represent a resource that will accelerate efforts to understand brain function and provide insight into brain diseases and disorders.

The project used the widest range of tools for probing brain cells ever brought to bear in a single, coordinated effort. Studies document how these tools measure different cellular properties, and a flagship paper describes the integration of data from 11 companion papers, to produce a cross-species atlas of cell types. A few studies push beyond the motor cortex in the mouse to detail other regions and brain networks. Still other studies ask questions about how human brains are shaped by evolution and during early development.

The research relied heavily on "genomic" technologies, such as "transcriptomics," which measures gene activity by sequencing RNA molecules in different cell

Sunburst plot of the taxonomy of different cells from the mouse motor cortex. Cell classes, subclasses and types are displayed from inner to outer rings.

types. Researchers also employed "epigenomic" techniques that look at how gene activity is influenced without altering the underlying genetic code. The scientists used two such techniques that observe how genes are switched on and off by the addition of a chemical group to DNA or how genes can be read more easily by rearranging the structure DNA is wrapped up in.

The researchers used genomic data to produce a "ground truth" set of classifications for different cell types. They also measured other properties, like shape and electrophysiology, to add extra dimensions to the genetic categories and begin inspecting how well they align. "There's a link between genes and properties, so it's more than just a means to classify; it's the explanatory basis for what cells do," says neuroscientist Ed Lein of the Allen Institute, who helped to coordinate the project and led two of the studies. Some studies also used new or recently developed techniques that measure multiple properties simultaneously. "Patch-seq" recorded the electrophysiology and gene activity of individual cells where they are situated before reconstructing

their 3-D shape. "Spatial transcriptomics" tools that measure gene activity of cells by combining genomics and brain imaging allowed the mapping of cells' locations, providing information about the distribution and proportions of cell types.

Methods for tracing neural connections also enabled the generation of an input/output wiring diagram of the mouse motor cortex. "This concerted effort allowed us to look at the cell types from all different angles," says neuroscientist Aparna Bhaduri of the University of California, Los Angeles, who led one of the human brain-development studies. "Being part of this package means many of these new techniques will have wider applicability, sooner, because they're so rigorously tested against all the others."

The data sets, curated by a part of the consortium called the BRAIN Cell Data Center (BCDC), are publicly available. "This is helping to standardize the field. It's going to be a foundational cell-type classification reference, much like the human genome for genetics," Lein says. He hopes this will allow researchers to move past a very basic task in brain science, the debating of definitions.

"Understanding the components lets the field move to the next set of questions," he says. "Like what do these cells do?"

The extensive catalog would not have been possible without a series of technological developments that allows individual brain cells to be poked and probed. "Single-cell genomics is transforming this field and many other fields of biology," Lein says. "It has provided a common language for describing cellular diversity." Bulk tissue analysis has been possible for more than a decade, but techniques capable of examining individual cells have become standardized only over the past five years. Measuring gene activity and regulation is important because all cells contain the same DNA, but different cell types implement it differently. "There's maybe 100 different cell types in a small patch of your cortex, and we need to understand how each type deploys its genome differently," says neuroscientist Fenna Krienen of Harvard Medical School, who worked on the cross-species study. "That's what single-cell resolution enables, and that enables us to do all sorts of things we couldn't

imagine doing five years ago."

Combined analyses during the project produced a taxonomy tree, much like "tree of life" illustrations. Major branches reflect important groupings, with shared developmental origins. A first branch separates neural and nonneural cells, splitting off, say, blood cells. The second division, between neuronal and nonneuronal types, separates neurons from "support" cell types, collectively termed glial cells. Neurons then split into excitatory types, which increase the chances of other cells firing, and inhibitory types, which put brakes on the activity of other cells. These two broad categories divide into 24 major "subclasses" (including nonneural and glial cell types), which are mostly conserved between species.

These can be further divided to arrive at the final branches—the "leaves" of the tree, designated as t types, the "t" being a shortening of "transcriptional," the genomic means of classifying cell types. The numbers of these categories differ among species: 116 in mice, 127 in humans, 94 in marmosets. The researchers then integrate transcriptomic data from all three species to find 45

t types that are common, including 24 excitatory, 13 inhibitory and eight nonneuronal cell types, such as astrocytes and oligodendrocytes.

Similarity among species suggests these cell types play important roles in brain function. "Evolutionary conservation is pretty strong evidence of things being under tight genetic control," Lein says. "And that those elements must therefore be important for the function of the nervous system." The vast majority of cell types were much closer between humans and marmosets than between marmosets and mice. "That was very satisfying to see," Krienen says.

The cross-species study profiled the well-studied type, called Betz cells in humans. The team found an analogous cell in mice, reflecting common evolutionary origins, but electrical and some other properties differed markedly among species. "The mouse has some general similarities to a human in terms of its body plan, but the details are different. The same is true at the level of cell types," Lein says. "You have all the same types, with a few exceptions, but their properties change a bit; that's the nature of our species differences." In contrast, "chandelier" cells, named for their beautifully elaborate connection structures, are very similar across species.

The data will allow researchers to target specific cell types, using either long-established genetic engineering "transgenic" tools in mice or, in other animals, DNA sequences delivered by harmless viruses. "The transgenic approach is effective for the well-established generation of mouse models," Krienen says. "Viral-based tools, which can of course also be used in mice, really reach their potential as ways of delivering genes, regulatory elements or mutations in animals, for which we lack that genetic toolbox, like nonhuman primates."

Being able to target cell types like this will enable a wealth of new tools for everything from studying brain development to dissecting neural circuits. "Now we know which genes might be deployed differently from one cell type to another, we can build tools with the cell-type precision we've longed to," Krienen says.

Understanding which genes and genetic sequences that regulate their activity are specific to different cell types will also advance researchers' understanding of disease. "This is going to have a big impact on disease because now we can pinpoint it to anatomy," Lein says. "Where are the cells being impacted by a genetic mutation?" Knowing how similar disease-relevant features are in different species could also inform choices about animal models. That's a major question that overhangs biological research; for example, is a study in mice relevant to humans? "If the relevant regulatory elements aren't conserved, is a mouse model of schizophrenia ever going to yield the insights we hope to get?" Krienen says.

The varied reports represent a bumper crop of data, but important details are lacking. "What's really missing here, that will be crucial, is proteins," says neuroscientist Botond Roska of the University of Basel, who was not involved in the project (but who advises the Allen Institute). "The only reason we have genes is because they code for proteins; this is the final machinery of cells."

Proteomics technologies exist but not yet at single-cell resolution. It is also not clear what influence different conditions might have on these data. "There's a massive influence of activity on gene expression," Roska says. "You'd have to probe these brains in different states to show these cell types remain the same under different conditions." These contributions, he says, are just a beginning. "It's a very important first step, but it's a long road to really standardize cell types in the brain," Roska says. "This is the first draft; it's a reasonable hypothesis, but now it's ready to be scrutinized by the whole community, questioned, tested and refined."

In the immediate term, the project is working on embedding data in 3-D space. "An atlas isn't just a bunch of GPS coordinates; it's having them located on a map," Bhaduri says. "That will be transformative because where cells are located in the brain is really important, and there's a lot we don't understand about how space and function interact."

Looking to the future, the project's next stage, a huge effort called BICAN (BRAIN Initiative Cell Atlas Network), which aspires to move into nonhuman primates and humans, has already been funded. "We've been able to really tackle the complexity of this one part of the brain," Lein says. "Now the stage is set to extend this, both across the rest of the mouse brain but also moving to nonhuman primates and the whole human brain."

—*Simon Makin*

Pandemic Year One Saw a Dramatic Global Rise in Anxiety and Depression

In hindsight, 2020 witnessed a disproportionate mental health burden on women and young people

....

COVID has posed a threat to body—and mind—for all people on the planet—the essence of the Greek-rooted coupling of πᾶν (*pan*) plus δεμος (*demos*) to form the now too familiar noun.

Yet there has been no incisive examination to date of the pandemic's psychological toll on a global basis. It is difficult to determine increases in cases of depression and anxiety because of a lack of data. No good numbers exist for many countries and even whole continents (Africa and South America).

Despite gaps in the data, a team largely based at the University of Queensland in Australia has made an estimate for 2020. "This study is

the first to quantify the prevalence and burden of depressive and anxiety disorders by age, sex, and location globally," the [researchers wrote in the *Lancet*](#).

The numbers themselves are devastating. Cases for depressive and anxiety disorders in 2020 are estimated to have increased by more than a quarter—an unusually large surge.

If the pandemic had not happened, the model used by the researchers estimated there would have been 193 million cases of major depressive disorder worldwide, whereas an estimated 246 million cases actually occurred, a 28 percent increase, or an added 53 million cases. For anxiety disorders, the number of cases was anticipated at 298 million,

but there may have been an actual 374 million cases—a 26 percent jump, representing an added 76 million cases.

The figures for both depression and anxiety usually remain stable from year to year. Such sharp upturns cannot be counted as routine fluctuations; "This is definitely like a shock to the system from what

we are typically used to seeing when it comes to the prevalence of these disorders," says Damian Santomauro, the lead author, from the Queensland Center for Mental Health Research, School of Public Health at University of Queensland.
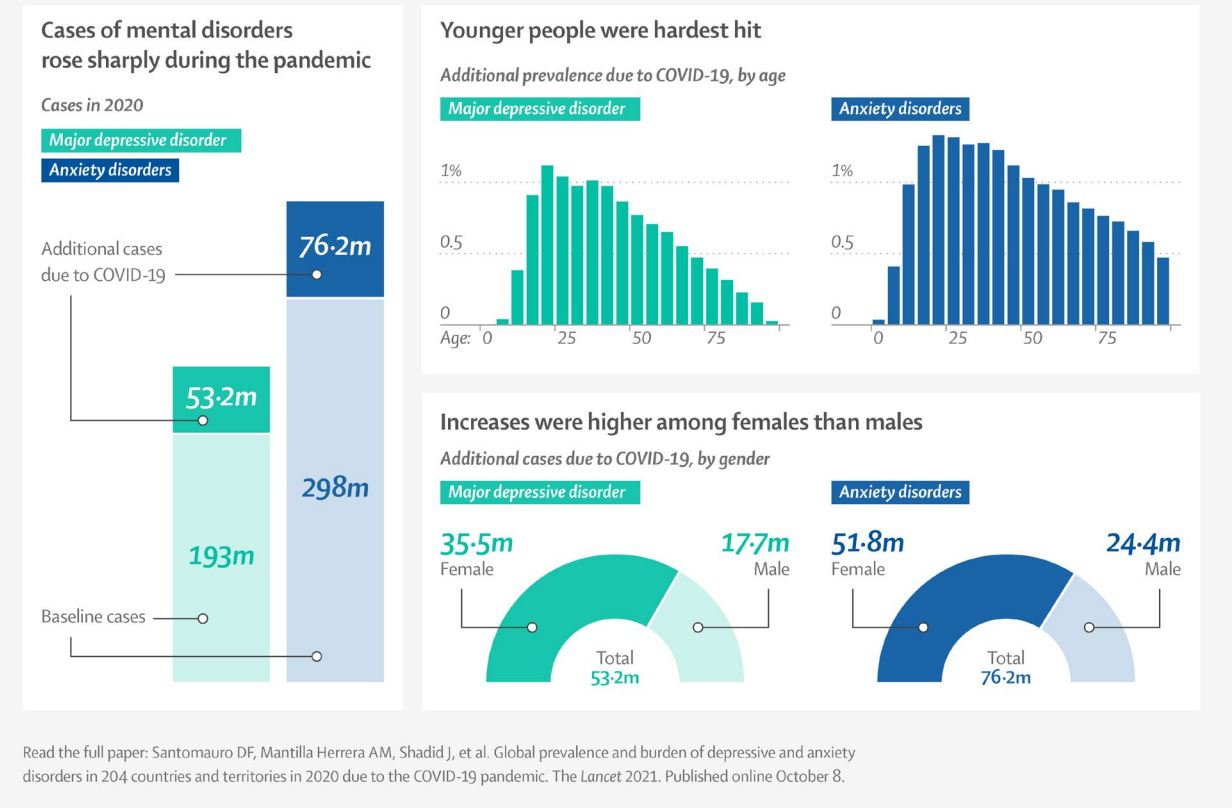
Women and young people were hit particularly hard. Almost 52 million of the added cases for anxiety during the first COVID year were accounted for among women, contrasted with 24 million for men. Although COVID caused more death and serious illness among older people, it was younger people who faced the greatest burdens of depression and anxiety. The category with the highest burden—the 20- to 24-year age bracket—had an estimated 1,118 added depression cases per 100,000 people and 1,331 more per 100,000 for anxiety. "We are hoping that these findings encourage more dialogue by policy makers, governments, researchers and people considering resource allocation and planning for mental health responses," says Alize Ferrari, one of the University of Queensland researchers.

The university team succeeded in making an estimate for global levels of depressive and anxiety disorders by compensating for the data that were lacking. They did so by relying on other data put together from 48 studies conducted in western Europe, parts of North America, Australasia and other regions that actually had mental health figures. They were able to statistically link depression and anxiety data to "COVID-19 impact indicators," infection rates by country and indicators tracking diminished population movements for 204 countries. That statistical relation between impact indicators and mental health data, analyzed for North America and other regions, could then be used to extrapolate the missing estimates for depressive and anxiety disorders for the many countries that lacked those data. All that was needed to make the calculations was the impact indicators, which exist for almost every nation.

Maxime Taquet, an academic clinical fellow in the department of psychiatry at the University of Oxford, who was not involved with the study, praised the effort as providing the first insight into the global impact of the pandemic on mental health. The study, he says, also points to the urgent need for depression and anxiety statistics from the countries

The COVID-19 pandemic has had a large and uneven impact on global mental health

Cases of mental disorders rose sharply during the pandemic

Cases in 2020
- Major depressive disorder
- Anxiety disorders

Additional cases due to COVID-19

76·2m
53·2m
298m
193m

Baseline cases

Younger people were hardest hit

Additional prevalence due to COVID-19, by age

Major depressive disorder
Anxiety disorders

Increases were higher among females than males

Additional cases due to COVID-19, by gender

Major depressive disorder
35·5m Female | 17·7m Male
Total 53·2m

Anxiety disorders
51·8m Female | 24·4m Male
Total 76·2m

Read the full paper: Santomauro DF, Mantilla Herrera AM, Shadid J, et al. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. The Lancet 2021. Published online October 8.

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for which estimates could only be made with statistical extrapolations. "We need to be quite cautious when we interpret the findings of this study because in large areas of the world we simply don't have any data," he says. Taquet wrote a commentary for the *Lancet* about the study.

The study will continue until the pandemic ends. The data are being incorporated in the larger Global Burden of Disease study, led by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington. Those numbers will surely be useful. COVID's mental health consequences are sure to linger long after any unofficial declaration that the pandemic has come to a close. —*Gary Stix*
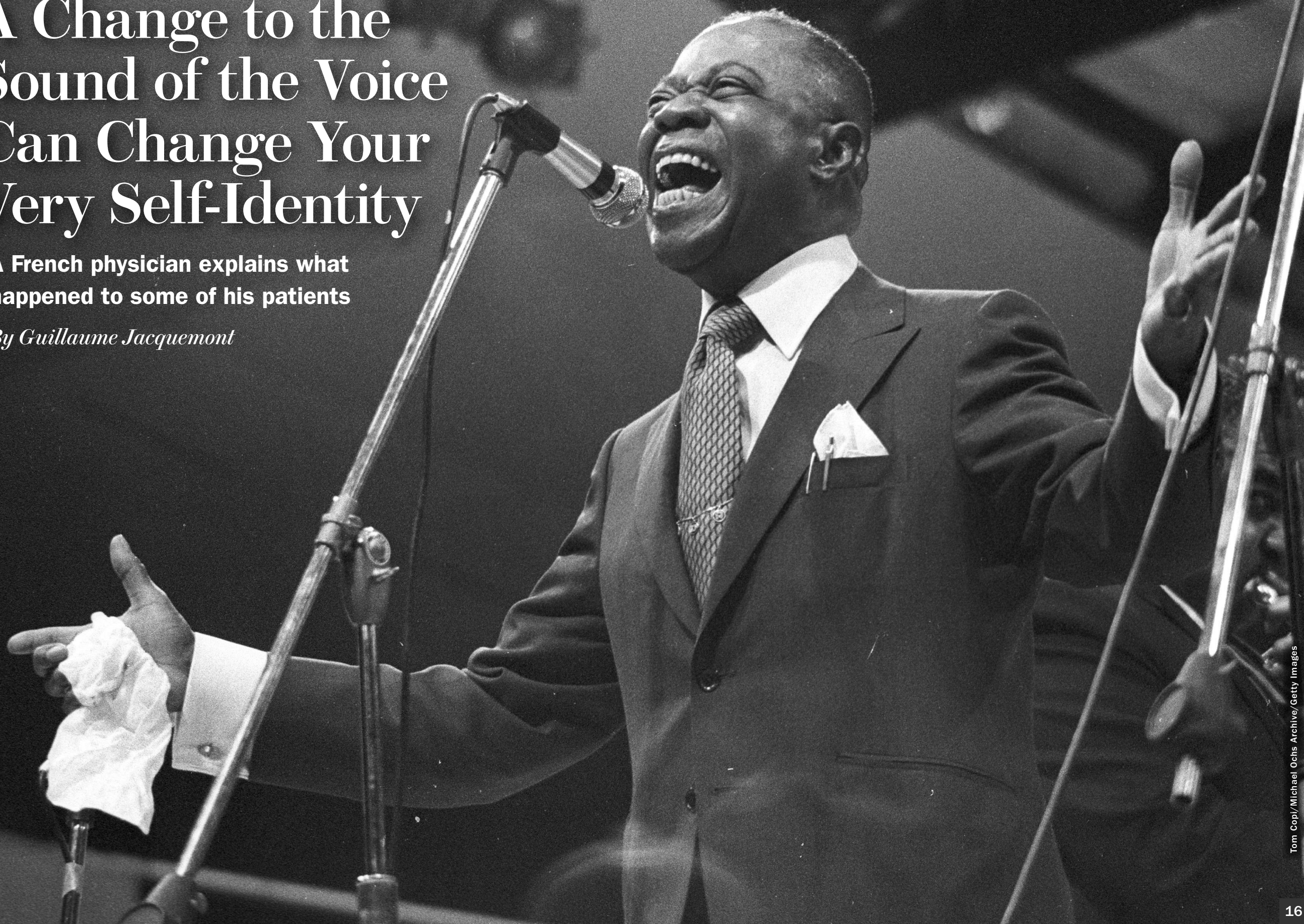
A Change to the Sound of the Voice Can Change Your Very Self-Identity

A French physician explains what happened to some of his patients

By Guillaume Jacquemont

Guillaume Jacquemont is an editor at *Cerveau & Psycho* and author of *La Science des Reves* (*The Science of Dreams*) (Flammarion, 2020).

T he voice is the human musical instrument. It consists of a vibrating element, resonating chambers and energy that produces the vibrations. The energy comes from the breath originating in the lungs. Vibrations occur in the two vocal cords at the lower part of the voice box, or larynx, that are arranged in a "V" shape, perpendicular to the trachea. Finally, the resonating chambers consist of multiple structures located above the vocal cords: the upper part of the larynx, the pharynx, the nasal cavity, the mouth.

Our voice is the only musical instrument that is both a string and a wind instrument—as the breath causes the vocal cords to vibrate. It is almost an orchestra unto itself. All this gives each of us a particular, unique vocal imprint; there are seven billion humans, seven billion different voices. *Scientific American*'s French-language sister publication *Cerveau & Psycho* talked about the wonders of the voice with Paris-based Jean Abitbol, an ear, nose and throat physician, phoniatrician and craniofacial surgeon.

[*An edited transcript of the interview follows.*]

How important is the voice to a person's self-identity?

It is indeed an essential component. We see this very clearly when we operate on patients to change their voice; their self-identity is strongly disrupted. For example, I met a lawyer who had a very deep, masculine voice because of an edema on her vocal cords caused by her smoking. (She smoked two packs of cigarettes a day.) She had a great charm and authority in her profession, where she interacted with criminals on a daily basis. ("My world is the prisons; I defend all the thugs," she told me.) But she wanted to change her voice, which her fiancé didn't like, and asked me to operate on her. I advised her to change her fiancé instead! She burst out laughing and had the operation done by a colleague.

When I saw her again, she had a very high-pitched voice and told me something terrible: "I am schizophrenic about my voice." She no longer recognized herself when she spoke and was seized by the impression that "it wasn't her," that it was someone else speaking. The consequences were terrible: her fiancé had left her, she could no longer work, she lost all her court cases, she had no authority, she no longer dared to open her mouth in prison.... Not because her voice had become higher-pitched, but because there was a sort of rupture of harmony with who she was, a conflict with herself, a feeling of loss of identity that destabilized her. She started smoking again, recovered her voice in two or three years, and gradually regained influence in her professional life.

I imagine that a change in your voice is also disturbing to people around you.

That's well put. Imagine that from one day to the next, your spouse or your children no longer sound the same. This is what happened to one of my patients, a 36-year-old woman. She had suffered from vocal cord paralysis since the age of nine or 10 following a viral infection of the vagus nerve, which controls the vocal cords. This gave her a voice like a whisper, with no power. She had to use a bell to call her husband or children!

I injected her with a substance that allows the vocal cords to become flexible again, and she recovered in two weeks. But she no longer recognized herself: "Doctor, I have a woman's voice!" She had never known this voice before because her paralysis dated back to before puberty. The experience was still very positive for her. She no longer felt like a strange beast. But her family felt unsettled. After the operation, her husband asked me a question with some irritation in his voice: "What have you done to her? She's not my wife anymore." The same goes for her children: "She's not Mom anymore!" Two months later, having gotten used to the change, they came to apologize and tell me that they thought it was great. But their first reaction had been to feel usurped, as if something had been stolen from them.

All of this illustrates the extreme caution that must be exercised before making changes to the voice apparatus. It's emotional surgery. When you have appendicitis, you operate on it, but if you detect a growth on the vocal

"In most cases, the desire to change one's voice in a profound way betrays an underlying psychological problem."
—Jean Abitbol

cords, if it is not cancerous and does not bother the patient, why touch it? I knew the ENT specialist who treated Louis Armstrong. Armstrong had vocal cords with two enormous masses that probably gave him that hoarse voice with inimitable evocative power. Imagine if they had been removed.

You mentioned "emotional surgery." Could you tell us more about the relationship between voice and emotion?

Our emotions are like the conductor of our voice. If you smile, if you're not feeling well, if you're anxious, all of this can be heard, because of very concrete consequences to your vocal apparatus. The lubrication of the vocal cords is very good when you feel good, but it is much less so when you're anxious, stressed or have stage fright. The blood supply also deteriorates in the latter case, notably because of a contraction of the blood vessels. The vocal cords then whiten and lose their flexibility, which translates into a dryness in the voice. In addition, frequent and intense stress causes gastric reflux in the vocal cords, which dry out because of the acidity and become covered with bumps (keratosis). As a result, the voice breaks and becomes hoarse. Emotional expressions also modify the configuration of the vocal resonance chambers, notably by mobilizing the mouth and cheeks.

Because of these things, we can't accurately re-create a voice synthetically. Even if projects to do this at the National Conservatory of Arts and Crafts (Conservatoire National des Arts et Métiers) achieve remarkable technical performances, the emotional side is missing. Con-

versely, the great opera singers, such as Luciano Pavarotti or Maria Callas, had an exceptional talent for conveying emotions.

What other facets of our identity are expressed in the voice?

Our social identity, for example. A lawyer or a doctor doesn't speak like a politician. This is expressed through language, of course, but also through components of the voice, such as the rhythm of speech. Perhaps the man who illustrated this most vividly was Charlie Chaplin in his film *The Great Dictator:* when the character who parodies Hitler addresses the crowd from his balcony, even though he doesn't actually speak a word of German, his speech immediately evokes a political harangue and an authoritarian leader. The voice also betrays our gender because it clearly differs between men and women. It is no coincidence that many transgender people want to change their voice.

Why do men and women have such different voices?

Mainly because of the hormonal influx at puberty, testosterone causing a lengthening and thickening of the vocal cords (which are about 24 millimeters long and four to five millimeters wide in men and 18 millimeters long and three to four millimeters thick in women), as well as an enlargement of the resonance box of the larynx. This is why castrati, who were for a long time made to sing in operas, had to be operated on before puberty. This did not give them a woman's voice but a child's voice, even

higher than that of a woman. If their voice was so out of the ordinary and had such power, it is because the growth hormones and the thyroid hormone, which are produced by glands other than the testicles and which are under the influence of the Y chromosome, gave them the morphological size and the respiratory strength of a man.

Apart from this particular case, a man's voice generally has predominantly low pitches and a woman's high pitches. The low and high notes always coexist in both sexes and enhance each other, like a diamond and its case. Because the beauty of a voice is its depth.

Are there many people who are not comfortable with their voice and want to change it?

No, not really. It's rare that someone comes to me with such a request. And in 95 percent of cases, I send them to a psychologist because it's a sign that they have a problem with themselves. For example, a 40-year-old woman with a thin, broken voice recently asked me to operate on her. But when I examined her, I discovered a magnificent vocal apparatus. She then revealed to me that her problem dated back to the day after she lost her mother, who she said had an exceptional voice. There was nothing I could do. It was up to a psychologist to intervene.

In most cases, the desire to change one's voice in a profound way betrays an underlying psychological problem. Without wanting to change it completely, many people want their voice to be more persuasive, to have a certain power. The importance of the voice in communication has long been known, but the desire to control its power has increased 10-fold with COVID-19 and the advent of telecommuting, with virtual meetings. A voice coach can help. In the end, what these people want to change is not their voice itself but the way they use it. **M**

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Discrimination Persists in Society—But Who Discriminates?

Is discriminatory behavior widely dispersed or highly concentrated in a small number of people?

By David Z. Hambrick

David Z. Hambrick is a professor in the department of psychology at Michigan State University. His research focuses on individual differences in cognition and the development of expertise.

Americans are becoming more tolerant of people of different races, ethnicities and sexual orientations, recent research indicates. Yet discrimination toward people in marginalized groups persists at disturbingly high levels. Scientists have proposed two hypotheses to explain this apparent paradox. The dispersed discrimination account holds that, because of implicit biases, most people—even those who hold strong egalitarian beliefs—regularly engage in subtle but still harmful acts of discrimination, albeit with little or no awareness. The concentrated discrimination account counters that a numerical minority of "bad actors"—highly and explicitly biased people—are responsible for most discriminatory acts.

These competing hypotheses lead to different recommendations about how to effectively combat discrimination in businesses, universities, the military and other organizations. If the dispersed discrimination account is correct, then arguably everyone in a given organization should undergo training to reduce implicit bias. If the concentrated discrimination account is true, then this type of training is unlikely to reduce discrimination in the organization, and policies should target explicit bias in a relatively small number of bad actors. A new study published by social psychologists Mitchell Campbell and Markus Brauer, both then at the University of Wisconsin–Madison, tested these hypotheses through a series of survey studies and field experiments involving 16,600 students at the university. The results overwhelmingly supported the concentrated discrimination account, challenging the view that the main problem is implicit bias.

In the survey studies, the students answered questions to measure their views on campus culture and their perception of peers' engagement in discriminatory conduct. The field experiments took place on campus. In each, the researchers observed students in a staged situation interacting with a confederate (an actor following a script) who was easily identifiable as belonging or not belonging to a marginalized group. The question was whether the students, who were unaware they were being observed, spontaneously behaved in a positive manner toward the confederate. For example, in the "door holding" experiment, a white or Black confederate followed students as they entered a campus building. The "focal" behavior, which both the confederate and an onlooking researcher recorded, was holding the door. Other focal behaviors examined were providing directions, helping to pick up dropped note cards and choosing a seat on a bus. In an additional set of field experiments, researchers responded to job ads, sending the contact person for each job two résumés and cover letters: one with a prototypically white name (for example, Cody Miller) and the other with a name more typical for a particular marginalized group (for example, DeShawn Washington for a Black candidate). The focal behaviors were the contact person responding at all, requesting more information or inviting the applicant for an interview.

Campbell and Brauer reasoned that if the dispersed discrimination account was correct, marginalized students would report having generally negative attitudes about campus and peers, and much smaller percentages of students would exhibit the positive focal behaviors (holding the door, providing directions, and so on) when interacting with a marginalized confederate. In contrast, they reasoned that if the concentrated discrimination account was correct, the results would be the opposite: marginalized students would report generally positive attitudes about campus climate and peers in the surveys, and there would be small differences in the percentages of students exhibiting the focal behaviors toward the two types of confederates.

The survey results supported the concentrated discrimination account. In one survey, white students were more positive about campus climate than students of color were. Students of color were still generally positive in

their ratings, however. For example, 64 percent of students of color indicated they felt respected on campus "very often" or "extremely often," compared with 83 percent of white students. As another example, 75 percent of students of color felt "very respected" or "extremely respected" by faculty and instructors in class, compared with 78 percent of white students. In another survey, at least 95 percent of students in each of three marginalized groups (students of color, LGBTQ students and students belonging to a minority religious group) indicated that a small percentage of their peers were responsible for discrimination observed on campus. Overall, the survey results indicated that discrimination is a problem on campus but that its likely cause is a numerical minority of highly prejudiced people.

The field experiments told the same story. Differences in students' treatment of marginalized and nonmarginalized confederates were small even when they were statistically significant. For example, in the "door holding" experiment, 87 percent of students held the door for a white confederate versus 82 percent who did so for a Black confederate. (The student population is majority white, but the studies observed the behavior of any students who encountered the confederates.) Similarly, in the "asking directions" experiment, 92 percent of students were willing to provide directions to a "lost" confederate who was white, versus 83 percent who did so for a confederate who was Asian and 86 percent who did so for one who was Muslim (a white woman wearing a hijab).

In one of the résumé studies, "Cody Miller" received a reply 63 percent of the time, and "DeShawn Washington" received one 54 percent of the time. The implication of these findings is that, in the types of situations examined, a small percentage of people on campus would act positively toward a white person but negatively toward a marginalized person. Overall, the results were roughly in line

Understanding the causes of discrimination in all of its repugnant forms is an urgent goal for psychological science. In recent years the view that most people engage in discriminatory acts because of implicit biases has gained widespread public acceptance.

with the Pareto principle, which states that for many events, such as crimes or traffic accidents, around 80 percent of the effects come from 20 percent of the causes.

Campbell and Brauer emphasize that their findings in no way imply that discrimination is not a serious problem or that claims of discrimination are exaggerated. They further argue that prodiversity interventions can work but only if they take into account "the reality of discrimination in a particular setting: how many individuals engage in discrimination and what forms this discrimination takes." If, for example, a small number of explicitly prejudiced people are responsible for most or all of the discrimination occurring in a company, an intervention that requires all employees to undergo implicit bias training will probably fail to address the problem. Research suggests that interventions that convey the message that nearly everyone engages in discriminatory behavior may even make the

workplace atmosphere *worse* for marginalized employees because after the training, nonmarginalized employees may avoid interacting with them out of fear of unwittingly discriminating.

The study has a number of limitations. Marginalized students with highly negative opinions of campus may have chosen not to complete the surveys. The field experiments examined behaviors in which little effort was required on the part of students to help the confederates. It could be that the dispersed discrimination account would be supported when examining behaviors that require greater effort. The studies were conducted on a university campus where many students express egalitarian beliefs and there are strong norms against prejudice and discrimination. It is possible that the dispersed discrimination account would be supported in other settings. The research also did not examine all the behaviors that can undermine members of marginalized groups in different situations, such as use of offensive language. As a final caveat, this work examined individual acts of discrimination that students might encounter and did not address structural bias in health care, education, policing, housing, or other areas.

Understanding the causes of discrimination in all of its repugnant forms is an urgent goal for psychological science. In recent years the view that most people engage in discriminatory acts because of implicit biases has gained widespread public acceptance. In a 2016 presidential debate, Hillary Clinton commented that "implicit bias is a problem for everyone." Campbell and Brauer's findings suggest it's still not clear the extent to which implicit biases explain discriminatory conduct. (Other work has called into question the validity of implicit bias measures for predicting real-world discrimination.) Research aimed at answering this fundamental question will inform the design of interventions that may one day meaningfully reduce levels of discrimination. **M**

COVID Expanded the Boundaries of Personal Space— Maybe for Good

Our physical safety perimeters have widened, a study suggests

By Gary Stix

Gary Stix is a senior editor at *Scientific American.*
Follow him on Twitter @gstix1

THE STOP DISTANCE PROCEDURE IS SIMPLE: A researcher moves toward a study participant. When the approaching person gets too close, the volunteer says, "Stop." The task is straightforward. But it is also quite effective at probing the dimensions of a person's physical comfort zone, or "personal space."

This procedure was integral to a preprint study that was conducted at Massachusetts General Hospital to test changing perceptions of personal safety zones before and during the COVID-19 pandemic. The researchers took advantage of baseline statistics they had gathered from 19 people prior to the pandemic. The team compared them with data collected from a dozen of those subjects after the outbreak began and found personal boundaries had expanded by 50 percent or more by one measure. This marked the broadening of a safety zone—a natural, instinctual one that differs from the six-foot distancing guideline from public health officials.

The study is small, but it is part of a growing body of social science work trying to gauge long-term mental health effects of the pandemic. Researchers are curious about whether changes to our comfort zone of personal space will persist and whether this zone might vary from place to place. Does its observed size hold in rural Mississippi as well as the Boston area, where the study was conducted?

Scientific American talked with the study's lead researcher Daphne Holt, an associate professor of psychiatry at Harvard Medical School and Massachusetts General Hospital, who has extensive experience in trying to understand how people establish a surrounding space that they can claim as their own. She talked about her recent study as a preliminary step toward new research her group plans to undertake to assess COVID's ongoing psychological impact.

[*An edited transcript of the interview follows.*]

How did you got involved with this research?

I've been interested in personal space for quite a while. My group studies some of the automatic behaviors that represent the building blocks of social interactions, the very basic things that we do instinctually and automatically. One of these instinctual behaviors is the way we define personal space.

I am a psychiatrist. And the illness that I've been studying for most of my career is schizophrenia. And it turns out that people who have schizophrenia sometimes display abnormal personal spacing. They often stand far away from other people. And we've found that this enlargement of personal space in schizophrenia is related to some impairments in social functioning. It sounds circular in a way: you are less interested in being around other people, and so you stand farther away from them.

For everyone, there are tiny variations in personal space depending on how well you know someone. We all have this comfort zone where, if somebody intrudes, we begin to feel uncomfortable. Culture definitely influences personal space. Social hierarchy has an influence, but it turns out that if you control for all those factors—and we can do that in the laboratory—people have a fairly consistent personal space preference. It's surprisingly stable; it doesn't really change over time. We're very interested in understanding the brain mechanisms that govern that behavior. And we've done studies of it using very high-resolution functional magnetic resonance imaging [fMRI].

What have you found?

We've discovered that the responses to personal space intrusions show an interesting pattern in terms of how they are physically arranged in the brain. We found that there are "columns" of activation, which are essentially thin stacks of simultaneously activated cortex extending from the middle to the outer surface of the brain, within one part of the parietal cortex. These columns respond to stimuli that are located within, but not beyond, the boundaries of personal space. That's been really exciting because it gives us clues as to how basic sensory information is used to calculate the distance that we prefer to stand from other people.

Have you used other methods?

We also use conventional methods, including the stop distance procedure, in which a study staff member approaches a participant in the study until that person says to stop. We're trying to understand the pattern of responses to personal space intrusions—what we call the

"shape" of the responses. This is something that is not really fully understood.

We have also used virtual reality [VR]. An avatar will approach the subject, or the subject will approach the avatar in a virtual-reality environment. And it turns out that people have a very similar personal space response to an avatar as to a real person. The responses are essentially identical, even though the avatars don't look much like real people. Avatars can look generally similar to real people in the way a three-dimensional animated character can, but they are rudimentary enough so that they can be immediately distinguished from actual humans.

What initially interested you in using virtual reality?

The reason we decided to use virtual reality was, in part, because our work could then be easily moved into the [fMRI] scanner. But the main reason is that personal space measurements are affected by the physical characteristics of the people involved with the research. For example, if you're interacting with a taller person, you're going to stand farther away from them. So if you're using real people in these measurements, you're going to have some extra noise in the results that's related to these different physical characteristics. But virtual reality allows you to perfectly control for all these variables and to study their contributions. For example, varying the position or the length of an avatar's arm or engaging in eye contact with an avatar can tell you how those things affect personal space.

You were studying a group of people to understand how they deal with personal space. And then COVID came along, which led you to test whether their notion of personal space had changed.

It did seem like an obvious question. We were all suddenly being asked to practice this behavior—social distancing—that's fairly unnatural. We had to stand at least six feet away from other people. A typical personal space size ranges from 60 to 100 centimeters (about two to [3.3] feet), depending on the circumstance.

Social distancing as a public health measure is very deliberate, but the normal way that we distance ourselves from another person is mostly unconscious. So the question was: How were the public health norms affecting our instinctual personal space boundaries? With virtual reality, we had this opportunity to actually study questions related to personal space in a virus-free, safe context.

What did you discover?

We discovered that personal space was dramatically increased in all the ways that we measured it. We measured it by having a person approach another person or avatar or having an avatar or person approach the study participant.

In all the measurements we did, we found a significant increase in personal space during the pandemic, compared with the same measurements in the same people collected before the pandemic. We saw this even in response to avatars. So it was clearly not because of an immediate risk or danger of infection.

How much did personal space perimeters increase?

Out of a total of 19 participants, 12 people completed all of the assessments, including virtual-reality sessions, before and during the pandemic. For those who were assessed both times, there was a 40 to 50 percent increase or more in the size of personal space, compared with before the pandemic, when it was 80 to 90 centimeters [about 2.6 to three feet] for one of the measurements we took. It's now about 125 centimeters [4.1 feet] on average.

So are you going to do larger trials related to personal spacing?

We have a National Institutes of Health grant to support a collaboration with some engineers at the University of Massachusetts Amherst who have developed a wearable sensor that can measure distances from other people using sound waves. The way that the sound bounces off of the other objects in the room can tell us whether the person is standing next to a living thing versus an inanimate object. We can actually measure personal space in real time with the sensor.

This study was planned before COVID to measure personal space in people with schizophrenia, but we're talking about using the technology to also study people's recovery from the pandemic and whether some of the

> "I think it's likely that some people will have more trouble readjusting to whatever the new normal is.
> We may be able to use objective markers of social behavior, such as measurements of personal space, to identify people who needs additional support."
> —Daphne Holt

persistent effects of it on people's social behaviors can be measured using this method. Ultimately we want to be able to identify the people who need help during this phase of the crisis.

As a psychiatrist, are you worried that these effects could, in fact, be long-lasting?

Yes, I think we're already seeing post-traumatic stress symptoms in some people and that some are more vulnerable than others to the psychological effects of this society-wide trauma. I think it's likely that some people will have more trouble readjusting to whatever the new normal is. We may be able to use objective markers of social behavior, such as measurements of personal space, to identify people who need additional support.

We've also developed a VR-based intervention, essentially a course or workshop, that is designed to help people recover from the pandemic. It helps to build resilience by teaching techniques that may help people handle stress and challenging experiences or social interactions in their daily lives. But it also targets the changes that have occurred in personal space.

Are we entering a new phase that approximates the much trumpeted "new normal"?

We made this very dramatic change during the pandemic in the way that we interact with other people. That raises a fundamental question about the regulation of personal space. Is what has happened during the pandemic going to have an ongoing effect on the way our brain calculates the distance we maintain from other people?

It may be that we never revert back to our previous ways of being in the world. In the case of personal space, it may affect things like how we design office spaces, our homes, restaurants or elevators. Those things may have to change if people are persistently needing a little bit more distance from others. **M**

Anna Bruk is a social psychologist and postdoctoral researcher at the University of Mannheim in Germany.
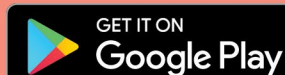
BEHAVIOR

Other People Don't Think You're a Mess

Individuals often overestimate how harshly others judge them. But self-compassion can help build a more balanced, healthy perspective

W e all have weaknesses, and all know hardship. But it's difficult, even on a good day, to admit we are struggling, to ask for help or to apologize when we are out of line.

After a year and a half of overwhelming stress caused by a global pandemic, many of us have become even more familiar with feeling vulnerable and have grown adept at avoiding difficult conversations. We may blow up to let off steam, for instance, and not take responsibility for the harm our actions cause. Or we may sulk when people close to us fail at guessing our needs. When setting clear boundaries is in order, many of us may say "yes" to everything only to end up resenting everyone—including ourselves—for having too much on our plates.

Often the best way to break these cycles is to

admit our difficulties to others. That step can be excruciating and frightening, but keeping problems to ourselves can create even more long-term complications. After all, unacknowledged feelings and frustrations rarely stay under the rug. That is why it is important to figure out how to openly articulate one's feelings or thoughts even when that form of expression leaves us feeling exposed or uncomfortable.

Two of my University of Mannheim colleagues—Sabine Scholl and Herbert Bless—and I refer to this form of genuine, intentional emotional exposure, done in spite of one's fears, as "showing vulnerability." Unlike other forms of self-expression or self-disclosure, this act always carries risk, such as the possibility that others may perceive someone as weak or even incompetent in consequence. Confessing romantic feelings, for example, could provoke a painful response if these sentiments are not shared, whereas declaring one's love for pizza is simply an authentic, low-stakes statement.

The good news is that, according to research, our worries about the negative evaluations of others may not be entirely reflected in the way people actually see us in difficult moments. Building on prior pioneering studies of vulnerability by researcher Brené Brown of the University of Houston, my colleagues and I conducted six experiments that revealed consistent results: Across a variety of situations, such as asking for help or admitting to a mistake, people perceived their own displays of vulnerability more negatively than others did. We refer to this pattern of con-

flicting perceptions as the "beautiful mess effect."

It's important to be aware of this mismatch because it can prevent people from sharing their true feelings and needs. In a safe environment and with a responsive conversation partner, a vulnerable stance in close relationships may have tremendous benefits. For example, studies show that revealing personal information about oneself may increase relationship closeness and trust. An authentic apology, meanwhile, could repair a fractured relationship.

Given these advantages, we next wanted to know how people could overcome the beautiful mess effect, with its differences in perception. Our new experiments suggest that the concept of self-compassion can be of great help when it comes to finding beauty in the mess of one's own shortcomings.

Self-compassion originated from ancient Buddhist teachings. Today's scientists, however, have researcher Kristin Neff of the University of Texas at Austin, to thank for defining the concept in detailed psychological terms. According to Neff, self-compassion consists of three components. First, self-kindness entails a caring and understanding response towards one's own suffering. For instance, when someone is struggling with feelings of failure, Neff encourages people to imagine how they might speak supportively to a friend in that position and then apply similar thoughts to themselves. The second component—common humanity—refers to recognizing pain and failures as an unavoidable part of life. Finally, mindfulness entails clear awareness of

the present moment—neither ignoring one's difficulties nor overexaggerating their magnitude.

My colleagues and I thought that self-compassion could influence how people perceive their own display of vulnerability. After all, vulnerable situations can trigger a lot of shame and fear, and these moments are precisely when self-compassion is most helpful. For instance, consider admitting a mistake. People who treat themselves as they would treat a good friend wouldn't shame themselves for being imperfect. Instead they would remind themselves that imperfection comes with the territory for all mortal creatures. In addition, a mindful approach to the mistake would lessen the need to either overexaggerate or deny its significance.

Such a compassionate reaction to one's own vulnerability, in turn, could make it easier to be vulnerable with others. As a result, we expected self-compassionate people to see their own show of vulnerability in a more positive light—closer to the way they perceive the same behavior in others. So we predicted that the beautiful mess effect would be less of an issue for highly self-compassionate people.

To test this prediction, we invited 340 university students to participate in four experiments that revolved around different vulnerable situations. In one of the experiments, participants read a text that asked them to imagine either themselves or another person of the same gender admitting to their boss that they'd made a substantial mistake while working on a project. After reading the text, participants were asked to evaluate this confes-

sion: Did they see it as an act of courage or a sign of weakness? Does showing vulnerability equal revealing one's strength or inadequacy? At the end of the study, we measured how self-compassionate the participants were using a seven-point scale designed by Neff. (You can fill out a version of this questionnaire for yourself on Neff's Web site.)

As predicted, people who don't have a lot of compassion for themselves evaluated an admission of their own mistake more negatively than when they imagined others who took the same step. Highly self-compassionate study participants, on the other hand, did not fall prey to this beautiful mess effect. In their evaluations, the difference in how they viewed displays of vulnerability in themselves versus others was significantly smaller than in people lacking self-compassion.

We conducted similar experiments with different situations, such as revealing one's imperfections or confessing love to another person first. We observed the same pattern of results: with higher levels of self-compassion, participants became less likely to judge their own displays of vulnerability harshly. In other words, self-compassionate people may be less likely to fall afoul of the beautiful mess misperception across a spectrum of situations.

Notwithstanding the numerous benefits of showing vulnerability, it is, by definition, a risky business—especially for members of marginalized communities who often bear the extra burden of less psychologically safe environments. People should always be thoughtful about when

and where they choose to disclose information about themselves. But without self-compassion, making oneself vulnerable—even in a safe space—can feel like self-destruction, which makes it all the more difficult to take this step. Conversely, being kinder to ourselves may give us a safe place to land, no matter where showing our vulnerability leads us. Then we don't need to have as much faith in the notion that everything will go smoothly if we share our struggles with others. Instead we can have more trust in ourselves to handle the outcome either way.

Luckily, our level of self-compassion is not set in stone, and it can be intentionally cultivated. For example, journaling exercises can help people change the way they think about their own strengths and weaknesses by writing about one's feelings with awareness and acceptance, offering oneself words of support, and reflecting on how others share difficult experiences. By developing a kind, mindful attitude toward ourselves, we can become more comfortable with showing our vulnerabilities. This practice, in turn, can strengthen our close relationships.

Brandy Schillace is editor in chief of *BMJ's Medical Humanities* journal and author of the recently released book *Mr. Humble and Doctor Butcher*, a biography of Robert White, who aimed to transplant the human soul.

AUTISM

Coming Out Autistic

Transgender or gender-fluid people are more likely to be neurodivergent, and vice versa. Here's what that's like

I was late for lunch. At the time, I was juggling a teaching position with my work as public engagement fellow and running a journal; I'd made an appointment to meet a new graduate student assistant—but time got away from me. I was out of breath by the time I arrived, head still spinning with the effort of code-switching from one role to the next. It would take a few minutes to pull myself together, but the student was already there. I sat down, attempted some small talk (badly), rearranged my jacket on the chair four or five times. When I got myself in order, we commenced our discussion of the journal as we waited on sandwiches.

"I want to ask you something," she said. "How do you keep all your perso-

"Fledging," original artwork, acrylic on canvas.

Brandy Schillace

nas straight? I mean, how do you keep from losing yourself, being autistic and all?"

"I am not autistic," I corrected. She put down her lunch.

"But you are. Just like me."

She meant no offense. But I felt outed, vulnerable. I'd worked most of my life to present as "normal" and even believed it myself on good days. I couldn't accept her casual diagnosis. It would take a coming-out journey (my second) to help me arrive at a place of acceptance.

I do not (yet) have an official diagnosis for autism. This is by design. I was born in the late 1970s in the midst of a family crisis. My mother rescued us both from my biological father and keep me hidden away at my grandparents' house for fear he might violate her restraining order. I developed unusual behaviors. I could walk and talk in full sentences by the age of eight months. As a toddler, I put thought bubbles above my crayon drawings with pictographs for meaning. I loved words. I memorized stories, poems, songs. My grandmother considered me "gifted." But in addition to these traits, I could scarcely be handled or touched. I could not be taken into enclosed or noisy spaces; I bit and scratched other toddlers. I understand now that I suffer easily from sensory overload—I can get physically ill simply walking into a junk shop. Back then, I was just "being weird," and it was thought best if we kept it to ourselves.

In school, I had to adapt. It was hard going. I excelled in every subject and failed miserably (and embarrassingly) at social cues. But to my young mind, that was just part of growing up, and I wasn't as good at it as other people. Don't be weird, I told myself. Don't be weird.

I'm weird. I memorize lists of normative behaviors (introduce yourself, make eye contact, ask about the family, don't make those weird noises, don't tic in front of people, wear the right face for the job), but I never quite get it all right. Even so, I still did not think I was autistic. Being told I must be, by someone who was also autistic, distressed and shocked me. All of my associations for neurodivergence came with baggage.

I may never forgive *Rain Man*. Dustin Hoffman's portrayal of Raymond, the autistic elder brother of Charlie Babbitt (Tom Cruise) shows him unable to communicate effectively, prone to public meltdowns, and—because the doctor deems him "unable to make his own decisions" or function in society—ultimately in need of institutionalization. The film never provides Raymond's point of view—only the perspectives of those around him, who are entrusted to make his decisions for him. I was horrified by the movie. It frightened me. I understood very clearly that there were accepted norms and that you could be locked away for violating them.

I knew I wasn't like other people. But I had also internalized the idea that this was "fixable," that I was curable. Adaptive behavior is recommended to parents of autistic kids today: <u>help your child fit in socially</u>, they say, as though autism were something to be schooled out of you by proper training. <u>Masking</u> may be a means of hiding who you are to prevent being outed (or harassed), but it comes with consequences, including anxiety, exhaustion—and <u>loss of identity</u>. And that, at least in part, was

the question put to me by the graduate student when I arrived late to lunch: How do I present all these faces without losing my authenticity? It frightened me that I didn't have an answer.

In my early attempts to adapt, I used other human beings as look-books. I copied expressions, ways of being in the world, how to perform emotion so I could be better understood. I learned to see social interactions as a play; I can handle any genre—so long as I have the script and know the dress code. Trouble happens when there is no script or someone changes it halfway through. I spent harrowing lunch hours driving home in traffic because I'd worn the wrong self for the day's activities. I can feel physically sick if I misread the type of attire expected for an occasion. It has been mistaken in me for vanity, but I'm not dressing to impress others so much as putting on the part required. It came naturally to me to play both male and female parts; I excelled in almost any costume. I didn't know who I was without them.

I left my job in 2018. It should have been liberating; I'd just embarked on a freelance career and had a book contract. Working from home meant nothing to dress for, and without a specific role, I felt anxious and adrift. Similar experiences played out for people around the world in 2020 with pandemic lockdowns; I was an early adopter. I flipped from my work wardrobe of power suit-skirts and heels to men's jeans and T-shirts—but I felt between selves. Maybe there was a reason for that, my therapist suggested. Did I feel like a different gender from the one I was assigned? It wasn't a solution, but it was

at least the right kind of question.

My body has always been a vehicle for the transportation and translation of ideas, and all the scattered performances were what I collectively called "myself." The specific bits of my body didn't really enter into the equation all that much. Many trans people experience terrible dysphoria over aspects of their bodies and seek to change them; some experience none, and some fall between. For me, my gender felt wholly outside of, rather than a reflection of, myself. Extrinsic. I had mainly constructed it from other external cues.

I am married to a cisgender and heterosexual (cis/het) man, and so most people assume I am a cis/het woman. I had neither expressed nor denied it; I just hadn't considered the question. I have always had traits largely considered "masculine," and my sexuality is pretty fluid, too. Mark intrigued and interested me; I fell in love with him for that, not because he was a man. So, I had to ask myself: was I just performing as cis/het?

For me, gender was something to be worn and used, a means of interacting with the world; I didn't know how to see it as an identity in and of itself. Jude Ellison S. Doyle wrote recently in an article entitled "Divergent: The Emerging Research on the Connection between Trans Identities and Neurodivergence": "It wasn't possible to transition as long as I thought of myself as defective…. It was all so exhausting I could barely leave the house." I identified with that sentiment. I had been trying to choose a single new gender (and to do it right) but was still only expressing a part of who I am. In my search to understand

Brandy at age two, finger painting.

what my identity meant to me rather than how I packaged it for other people, I realized I am gender-fluid: nonbinary but containing multitudes. In that new freedom, I found myself returning to that other possibility. I had come out as gender-fluid; could I also come out as autistic?

In August 2020 the authors of the largest study to date on the overlap of autism and gender diversity announced their findings: about 25 percent of gender-diverse people have autism (compared with about 5 percent of cisgender people), leading them to suggest transgender and gender-diverse adults were between three and six times more likely to be diagnosed as autistic.* As Doyle puts it, " 'Autistic' is one of the most trans things you can be." So why isn't this connection more well known?

One point, remarked on by Doyle and also by Eric Garcia in his new book *We're Not Broken: Changing the Autism Conversation,* is that autism is underdiagnosed along gendered lines. Cisgender men are identified as autistic more frequently, and at a much younger age, than either cisgender women or gender-diverse people. Even the autistic stereotypes are masculinized; an "extreme male brain" theory posits that autistic people process the world through a "male" lens. In truth, there are no significant differences between male and female brains—but as Garcia points out, some autistic behaviors are seen as "female behaviors." It is more likely, then, that a boy who behaves neuroatypically will be recognized and diagnosed. If parents, teachers and therapists are seeing symptoms along a binary of gender, they're going to miss people, and among gender nonconformists, it's a significant percentage.

For many an acceptance of an autism diagnosis leads to a questioning of gender normative rules

Marilyn D. Watts

and an embrace of gender diversity. Garcia quotes Charlie Garcia-Spiegel, a presenter at Autspace, a conference on, for and by neurodivergent people: "We [autistic people] can see a lot of the social rules around gender are bullshit, basically." It suggests that the 25 percent of autistics identifying as trans have been freed to do so by their autism. For me this occurred in reverse. Questioning how I felt about my gender(s) gave me license to look at the other performed behaviors I'd learned to cultivate. It's also made me realize how much I have been impacted by social expectations and how hard I had worked to meet them over the years.

As Eryn Star, an autistic and transmasculine writer and advocate emphasizes, trans people encounter prejudice, violence and denial of access to health care and other services. Some people claim they are illegitimate and want to prohibit them from living authentic lives. At the same time, people with autism are frequently rendered as incapable of making decisions for themselves about their sexuality. This increasingly public disdain and discrimination against trans and autistic people has surprising champions, including author J. K. Rowling, who suggested that autistic trans people assigned female at birth (AFAB) were being pressured to transition. (The autistic community responded with the hashtag #WeAreNotConfused.)

"I have faced," Star says, "the denial of my queerness because I am disabled." Living authentically as both trans and neuroatypical means confronting what I had always feared: if you cannot ape nor-mativity, you may be denied your autonomy.

For years I feared acknowledging my autism because I had absorbed the prejudice surrounding disability. Autistic people (as Garcia's book title emphasizes) are not broken. Autism is disabling because we live in a world built for and by neurotypical people. Acknowledging my autism is not an admission of weakness; it's a statement about myself as a self.

For Star, rediscovering their body as an autistic person no longer repressed by social pressure led to discoveries about their gender as trans-masculine nonbinary. For comedian Hannah Gadsby, the late diagnosis of autism led her to "be kinder to myself" and "not always to take the responsibility." Both early and late diagnosis with autism offers a window into understanding our own identities. I've learned that I have a right to ask for and expect accommodation. Neurotypicals think they are meeting us halfway because they don't realize we've already come miles and miles just to get here. I am neurodivergent. I can be forgiven for missing cues and instead be honored for how much work goes into social interactions, all the time.

So much of this—perhaps all of this—comes down to acceptance, accommodation and justice. After a lifetime of trying to perfect myself, I'm finally living in my own authenticity: autistic, gender-luid, unique. I'm still in the play. But if I don't have a script, I can write my own, or I can cut the scene and draw the curtain. No matter how we identify, trans, neurodivergent, neuroqueer, we have a right to be—just as we are.

Gleb Tsipursky is a behavioral scientist, CEO of the future-proofing consultancy Disaster Avoidance Experts, and author of *Returning to the Office and Leading Hybrid and Remote Teams: A Manual on Benchmarking to Best Practices for Competitive Advantage.*

CREATIVITY

Remote Work Can Be Better for Innovation Than In-Person Meetings

Seven steps for more inclusive and productive virtual brainstorming

F ear of losing their innovative edge pushes many leaders to reject hybrid and virtual work arrangements. Yet extensive research shows that hybrid and remote teams can gain an innovation advantage and outcompete in-person teams by adopting best practices for innovation, such as virtual brainstorming. What explains this discrepancy between leadership beliefs and scientific evidence?

After interviewing 61 leaders on a strategic return back to the office, I discovered the root of the problem: The vast majority of leaders tried to pursue innovation during the lockdowns by adapting their office-based approach of synchronous brainstorming to videoconference meetings. They found that videoconferences aren't well suited for

traditional brainstorming and thus feel they need to go back to the office.

Unfortunately, these leaders are stuck with their existing methods for innovation and haven't investigated and adapted modalities better suited to virtual innovation. This failure to adapt strategically to their new circumstances threatened their capacity for innovation and their ability to retain employees. Multiple surveys of remote workers during the COVID pandemic show that 25 to 35 percent wanted remote work only, and 50 to 65 percent wanted to return to the office with a hybrid schedule of a day or two on-site. Forty to 55 percent said they were ready to quit if they didn't get their preferred schedules, and many have already resigned when employers tried to force them to return. To put it mildly, it's hard to do innovation with such a large part of your workforce quitting and the rest demoralized as a result of such high rates of turnover.

Leaders often fail to adopt innovative best practices because of dangerous judgment errors called cognitive biases. For instance, the rejection of better practices in favor of preestablished ways is called functional fixedness, and it very much applies to innovation.

Another cognitive bias related to functional fixedness is called the not-invented-here syndrome. It refers to leaders feeling antipathy toward practices from outside their organization, such as novel innovation methods.

Defeating cognitive biases to return to the office successfully and thrive in the future of work requires the use of research-based best practices.

These practices can be used in a hybrid model of one to two days in-office while permitting a substantial minority of employees to work remotely full-time.

In-person synchronous brainstorming represents the traditional approach to intentional innovation. It typically involves groups of four to eight people getting together in a room to come up with innovative ideas about a preselected topic.

Research in behavioral science reveals that the benefit in idea generation from such brainstorming comes from two areas identified by scientists. One involves idea synergy, or when ideas shared by one participant help to trigger ideas in other participants. The other is social facilitation, or when participants feel motivated when they know they're collaborating with their peers on the same goal.

These benefits come with counterproductive effects, however. An example is production blocking. That's when someone has an innovative idea during a group discussion, but other people are talking about a different topic, and the innovative idea gets lost in the mix.

If you never had that happen personally, you're likely extroverted and optimistic. Introverts have a lot of difficulty with production blocking. It's harder for them to formulate ideas in a crowded and noisy environment of team brainstorming. They generally think better in a quiet environment, by themselves or with one other person at most. And they have difficulty interrupting a stream of conversation, making it more likely for their idea to remain unstated or ignored.

Those with a more pessimistic than optimistic approach in the workplace also struggle with brainstorming. Optimists tend to process verbally, spitballing half-baked ideas on the fly. That's perfect for traditional brainstorming. In contrast, pessimists generally process internally. They feel the need to think through their ideas to make sure those ideas don't have flaws. Although brainstorming explicitly permits flawed ideas, it's hard for some people to overcome this reluctance.

Many people are also powerfully impacted by a second major problem for traditional brainstorming: evaluation apprehension. Many lower-status, junior group members feel worried about sharing their ideas openly because of previous discrimination or anxiety about what their peers will think. Moreover, despite instructions to share off-the-wall ideas, many people don't want to be perceived as weird or out of line.

As a result of these problems, numerous studies show that traditional brainstorming is substantially worse for producing innovative ideas than alternative best practices. It can help build team alignment and collaboration and help group members feel good about their participation. But leaders shouldn't fool themselves that using this technique will result in maximizing innovation. To leverage innovation to gain or keep a competitive edge, traditional brainstorming is not the way to go.

Trying to do traditional brainstorming via videoconference is a poor substitute for the energizing presence of colleagues in a conference room, thus weakening the benefits of social facilitation. It's also subject to the same problems of evaluation apprehension as traditional brainstorming. Instead

of the losing proposition of videoconference brainstorming, leaders need to adopt the best practice of asynchronous virtual brainstorming. Here's how it's done:

Step 1: Initial idea generation. Team members generate ideas and add them to a shared online collaboration tool. To tap social facilitation, the group can input ideas during a digital co-working meeting. Focus on quality over quantity and consider contradictions between ideas. Science has found that this focus on opposing goals facilitates innovation.

The submissions should be anonymized to avoid evaluation apprehension. But the team leader should be able to later track each person's submissions for accountability.

Step 2: Idea cleanup. The facilitator categorizes ideas and sends them out to all team members.

Step 3: Idea evaluation. All team members anonymously comment on each idea.

Step 4: Revised idea generation. Team members can do another idea-sharing session, reevaluating old ideas or generating new ones.

Step 5: Cleanup of revised ideas. Clean up and categorize the revised ideas using step two.

Step 6: Evaluation of revised ideas. Comment on revised ideas.

Step 7: Meet to discuss ideas. Finalize which ideas should be moved toward implementation. This kind of practical planning meeting is easy to have virtually for full-time virtual workers. It also works well to have steps one through six done virtually by hybrid teams and to do step seven in-office. But it's critical to avoid doing steps one to six in the office to avoid production blocking and evaluation apprehension.

Behavioral economics and psychology research has established the superiority of digital brainstorming over in-person brainstorming. For example, a study comparing virtual and in-person groups found in-person groups felt better about their collaboration. The feeling proved deceptive, however: virtual brainstorming resulted in more ideas generated.

In fact, research finds that the larger the in-person group, the fewer novel ideas each person has—but the opposite is the case for electronic brainstorming. That means with more people, you get a larger number of novel ideas per person. This effect is likely because of the removal of evaluation apprehension and production blocking, which tend to increase with the addition of more people.

Virtual brainstorming creates the maximum number of novel ideas, gaining an innovation advantage. It also provides the optimal experience for the largest number of group members, balancing the preferences of introverts and extroverts, optimists and pessimists, and lower-status and higher-status members. Team leaders who wisely prioritize focusing on integrating introverts, pessimists and lower-status team members into the team—which is more difficult than with extroverts, pessimists and higher-status members—find virtual brainstorming especially beneficial.

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

Mirage in the desert, near Aswan and Abu Simbel, Egypt.

The Allure of Mirages

Our centuries-long fascination with optical phenomena

In June 1827, after a full day of travel, journalist Richard Madden arrived to Adjerond, Egypt, near Suez. He looked at the horizon across the vast desert and was struck by a vision that would stay with him long after his voyage. "At one moment, the rippled surface of a lake was before my eyes … the mosques and minarets were distinct, and several times I asked my Bedouins if that were not Suez before us; but they laughed at me and said it was all sand," he later wrote.

A 2020 paper by science historian Fiona Amery of the University of Cambridge posits that mirages first became the object of popular captivation in Britain in the 1820s and 1830s, a period that exploded with vivid descriptions in novels, scientific journals and travel literature. It was also during this time that the public grew enthralled with the unreliability of sight, as demonstrated by magic-lantern shows and instruments such as the stereoscope or the zoetrope.

In contrast with perceptual experiences such as pareidolia and afterimages, mirages are proper optical illusions. This means that their fundamental explanation lies in optics: the science of the behavior and properties of light. Meanwhile many so-

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called optical illusions have little to do with the physics of light, but they take shape in the mind of the observer. Such illusions are more appropriately called visual (or in other senses, auditory, tactile, etcetera) or cognitive, depending on whether they arise from sensory or cognitive brain regions. One example of a visual (rather than an optical) illusion is our perception of movement in certain stationary images, which occurs when our visual brain circuits respond to local brightness changes in an image as they would do to actual motion.

As for mirages themselves, they result from the quantum-electrodynamics phenomenon that photons always take the path of minimum time. Thus, when air temperature is constant, light travels in a straight line. But in the presence of a steady temperature gradient, light follows a curved path from hotter to cooler air. In the specific case of a vertical temperature gradient, light curves from the sky to the observer's eye. One familiar example of such a situation is seeing the sky reflected on the road ahead, which we may interpret as water on the ground. This kind of "mirage effect" reflection was central to the development of underwater cloaking technology in the past decade.

"Although I was aware of the existence of the Mirage, I could not prevail on myself to believe that the images ... were only reflected," wrote Madden, and so it remains today. As mesmerizing now as 200 years ago, mirages still puzzle our senses and remind us that there is much more to vision than meets the eye.

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