Technology Networks

The Scientific Observer

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Privacy in the Brain:

The Ethics of Neurotechnology

Scientific Storytelling: It's All About Context

Leftover Lockdown Ways

COVID-19 Vaccine Safety in Pregnancy

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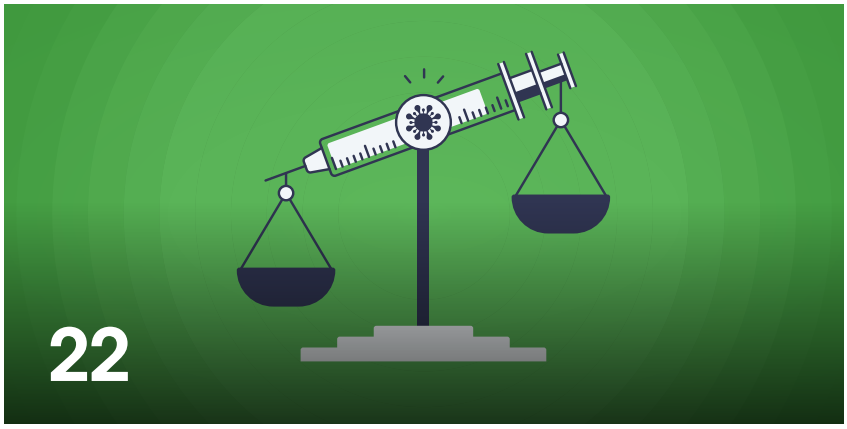

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EDITORS' NOTE

Welcome to issue four of *The Scientific Observer*, the new editorial venture brought to you by *Technology Networks*. Each month, we explore key themes and topical issues by combining a selection of our favorite scientific stories from the *Technology Networks* communities with new and exclusive content.

The global pandemic has highlighted the integral role that science communication plays in informing the general public. For good science communication, the narrative must refer to the philosophy of science as a "process of self-correction", explains Professor Yotam Ophir in this exclusive interview for *The Scientific Observer*.

This issue's feature focuses on the rapidly advancing field of neurotechnology. In the near future, devices that modify and augment our cognition, externally and invasively, will become commonplace. A recent meeting of the Organization for Economic Co-operation and Development (OECD) resulted in a concerted effort to develop an ethical framework for neurotechnology. With academics, ethicists and billionaires all involved, can we realize that ethical future?

Our COVID-19 vaccine coverage includes an exploration into the relationship between the currently authorized vaccines and pregnancy by Amber Schmidtke. What data do we have, and what data do we still need?

And finally, in our last installment of *The Stay-at-Home Scientist*, one researcher reflects on the ability of humans to adapt and grow in the face of difficulty, and expresses excitement to see what the "new normal" holds for scientists across the globe.

If you have an idea for a story, or you would like to contribute to *The Scientific Observer*, please feel free to email us at any time – editors@technologynetworks.com.





MOLLY CAMPBELL **TIFFANY QUINN** **BECCY CORKILL** **LUCY LAWRENCE** **ANNA MACDONALD**

From the Newsroom

UNRAVELING THE ROMANESCO CAULIFLOWER'S SPIRALING STRUCTURE

LAURA ELIZABETH LANSDOWNE

A team of researchers has identified the genes responsible for the spiraling conical structures that comprise the Romanesco cauliflower, and have replicated these patterns in a small flowering plant called *Arabidopsis thaliana*.

JOURNAL: *Science*

FIRST GENOME-EDITING EXPERIMENT CONDUCTED IN SPACE

MOLLY CAMPBELL

For the first time, scientists have used a CRISPR-Cas9 mutagenesis strategy on eukaryotes in an unlikely laboratory – the International Space Station (ISS). The original inspiration for the study came from four high school students that won the 2018 *Genes in Space* science contest.

JOURNAL: *PLoS ONE*

SINGLE DOSE OF PSYCHEDELIC COMPOUND PSILOCYBIN CAN REMODEL CONNECTIONS IN THE BRAIN

RUAIRI MACKENZIE

Psilocybin, a psychedelic compound that can be derived from over 200 species of mushroom, can remodel connections in the mouse brain. That is the conclusion of a new study that examined structural changes in the brain that might explain psilocybin's enduring antidepressant effects.

JOURNAL: *Neuron*

Photo by Didssph on Unsplash/https://unsplash.com/@didsss

Scientific Storytelling: It's All About Context

MOLLY CAMPBELL

Scientists are human, and humans make mistakes. To perceive scientists as infallible and omniscient is to undermine the very foundation on which science is built: self-correction.

Science is a process, says Dr. Yotam Ophir from the Department of Communication, University at Buffalo. This process is not finite. It involves a community of individuals coming together to continuously critique each other's research to further enhance, develop and update knowledge.

After years spent studying the effects of misinformation, both in science and more broadly, Ophir developed an interest in how people perceive science as a field. Scientific research is largely communicated to the public via media outlets. How does the narrative used in this communication impact beliefs and support for science?

This was the question posed in Ophir's latest research study, conducted in collaboration with Professor Kathleen Hall Jamieson, published in *Public Understanding of Science*. In this interview, we ask Ophir to explain the different types of narratives that exist around science, their impact and why retractions should be interpreted as a positive step in scientific progress. Ophir also provides useful advice on navigating the world of scientific research and science communications.

Q: Please can you tell me a bit about how you started this specific research study?

A: For the last 10 years or so I have been studying misinformation, how it spreads, how it influences society and what can be done against it to ameliorate some of the damages. Some of this work was dedicated to scientific misinformation specifically, such as issues relating to tobacco misinformation, vaccine misinformation and so on. At some point, I started thinking more broadly about people's misperceptions about science itself.

There is a lot of research that suggests that teaching people facts, for example

that the world is warming up, or that vaccines do not increase the chance of developing autism, does not seem to do much in the face of misinformation. People are not being persuaded to trust – or mistrust – science based on scientific facts. What does influence people's view on science is their understanding of what science is, how science works, the logic behind science and the values of science.

Over recent years, scientists have been raising an alarm about an inability to replicate important research findings. My collaborator in this project [Professor Kathleen Hall Jamieson] wrote a piece in the *Proceedings of the National Academy of Sciences* in 2018 about the problem she saw surrounding the narrative of this inability to replicate. She concluded that the fact that a study does not manage to replicate other research is being interpreted by scientists and journalists alike as a scientific "crisis" [the replication crisis], and that this is a problem.

Q: You randomly assigned research subjects to read stories that represented several different media narratives. Can you summarize these narratives?

A: We built our experiment based on the work that Professor Jamieson had done previously. She had identified multiple narratives that the media use when describing science. The first, which is a popular narrative, focuses on an individual's achievements, so it is referred to as the "quest discovery" narrative. This narrative centers on individual achievements, which by itself is misleading because it creates the impression that science is progressing through individuals, alone in their labs, continuously having "eureka" moments. That is not how science works. This narrative is misleading, but it wasn't our main concern as it typically does not reduce trust in science.

The second type of narrative often employed by journalists is the "counterfeit quest". This is the story about a researcher that rose to fame with a high impact study, before it was eventually discovered that the research was fake, wrong or unethical in some way. The paper is retracted, and the scientist is now being punished in one way or another. An easy example here is Andrew Wakefield's work on vaccines and autism, and his infamous 1998 paper in *The Lancet* that got retracted – eventually, leading to Wakefield losing his license to practice medicine in the UK.

Mistakes will be made, and papers will be retracted, but I do not think that it [retraction] should be considered controversial.

In recent years, we have seen a third narrative emerge, that I think came from scientists, not journalists. As there was a move towards open science and increased transparency – which are great in my opinion – there was a realization that certain studies, including influential ones in the hard, and later social, sciences, could not be replicated which led to retractions, and it was described in the media as a "crisis", meaning that science was "broken" and "should not be trusted".

What was missing in the media coverage is a contextualization that will frame scientific errors in light of the values of science. We proposed in our study a new narrative that acknowledges that, yes, studies are being retracted and some findings cannot be replicated, but the fact that we can identify and correct errors in published work should be interpreted as a sign that science is doing what it should be doing.

We decided to run an experiment and see if the stories that we kept seeing in the news media had a detrimental effect on people's trust in science and if our new narrative could fix it. We asked people to read news articles that were based on real coverage that represented these different narratives.

Q: What did you find?

A: What we found in general was that the "science is broken" narrative indeed led to distrust in science and scientists. Also, our suggested new narrative – one that is transparent about errors in science but contextualizes them as part of a healthy scientific process – ameliorated some of the detrimental effects of the crisis stories. These effects were stronger for people who trusted science to begin with, indicating that some will be more open to the idea of our new narrative that science is doing what it should be doing than others. In other words, the introduction of the new narrative could be more effective if we keep working in other ways to increase trust in science.

Q: Presenting hard facts does not help to ameliorate the damage caused by misinformation but contextualizing failures and providing an understanding of the scientific process does. What if the public does not understand the scientific process, for example, if they have not studied science, or are perhaps not working in a science-related career?

A: That is why, in our study, we chose not to look at scientific publications, but focused instead on news articles; this is how people generally learn about science. Most of us do not read scientific papers, and most of us cannot understand 99% of the work that is out there. Even scientists are experts in only one field, and thus learn about most scientific topics from the media. We need the media to mediate science to us. That is why we targeted journalistic practices in this research, not scientific practices.

Q: Can you talk more about the philosophy and values of science?

A: Science is always skeptical, always questioning. It is never turning knowledge into dogma or faith. We continue to ask questions even after our work is getting published. In our view, the fact that high impact research managed to pass peer review, to get published and then is found to be wrong, isn't a sign of crisis. We see it as science doing what science should be doing. These are the values of science; it is what makes it so epistemologically strong. Science is a reliable way of knowing, because even when something is considered a finding, you can still question it, you can still retest it.

Q: What about "controversial" retractions?

A: I do not think retractions should be seen as controversial. I think they're part of the game for a couple of reasons, both of which result from our limitations as humans. First, we all make mistakes. Just like any other person working in any other profession might make mistakes, scientists will inevitably make mistakes at some point. Some research that we publish might not be accurate, that is a fact of life. Second, some of us will play the system and we lie. There is only so much that anonymous peer review can do to catch blatant lies. If someone fabricates data, it may be increasingly harder to identify errors. Mistakes will be made, and papers will be retracted, but I do not think that it [retraction] should be considered controversial. Perhaps the background story is controversial, if a scientist was lying to get a grant, that is controversial. But the mere fact that that we found a mistake, and we can pinpoint it and correct it is again, in my view, a scientific achievement. It is a natural process that shows us that science is doing what it is set to do. We need to get better at communicating that, because there is a thin line between healthy skepticism – whereby you question what you hear, look for evidence, corroborate data and the sources of data – and toxic cynicism.

A cynical person might see a retracted paper and assume that means all of the research connected to the paper is incorrect. "We knew all along that we shouldn't trust science", might be their narrative. Skepticism and cynicism are two very different things.

Q: If you could provide a key piece of advice to a scientist that is in the early stage of their career, what would you say?

A: Firstly, be as transparent as possible. Do not think about transparency as a weakness. This connects to the previous point, that retractions are not controversial because they are part of transparency. Secondly, remember that a person's view of your work is less dependent on their understanding of the actual facts – the theories or evidence that you found – and more dependent on their trust in the scientific process. It is better to communicate why your work is reliable, than to flood people with statistics, or graphs. My third piece of advice is to be modest and remember to practice healthy skepticism yourself. When I first published this research study, I told a journalist to trust the science, not scientists. My eight-year-old daughter heard and questioned me on this. "But dad, you're a scientist? So, are you telling me not to trust you?" I told her that was absolutely right. Do not trust me because I am smart, because I have a degree from a prestigious institution, or because a scientific journal published my work. Do not trust me, because I am just a person and people make mistakes. Some of my thoughts might be brilliant, some of them might be completely wrong. Trust the scientific process instead. If you publish something, a year or two from now it might be found to be wrong. Do not get defensive about it, accept it and say "Okay, that is how science works. I found something and I put it out there so other scientists can look at it and make sense of it. Whether it will be challenged or not, I contributed to the scientific endeavor". ●

Yotam Ophir was speaking to Molly Campbell, science writer for Technology Networks.

PROTEOMICS

Scientists have been studying

the proteome –

THE ENTIRE COLLECTION OF PROTEINS EXPRESSED IN A CELL, TISSUE, OR WHOLE ORGANISM –

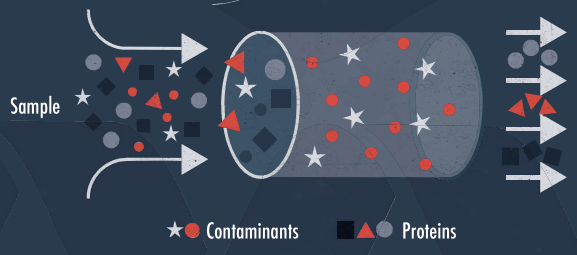
for many decades.

It was the development of electrospray ionization (ESI) for mass spectrometry (MS) in the late 1980's that prompted a shift in proteomics research from antibody-based methods to MS-based methods; a shift that would advance and transform the field dramatically. As time has progressed, MS technologies and data analysis pipelines have been continually refined and improved, resulting in a multitude of MS-based approaches to proteomics research being at the disposal of scientists in the field.

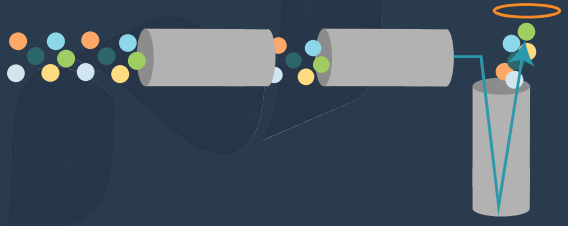
WHEN STUDYING PROTEINS, THERE ARE MANY QUESTIONS THAT SCIENTISTS COULD ASK...

TO ANSWER THESE QUESTIONS, PROTEOMICS RELIES ON THREE TECHNOLOGICAL CORNERSTONES...

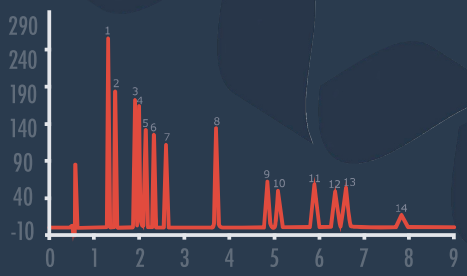
1 Sample preparation



2 Mass spectrometry



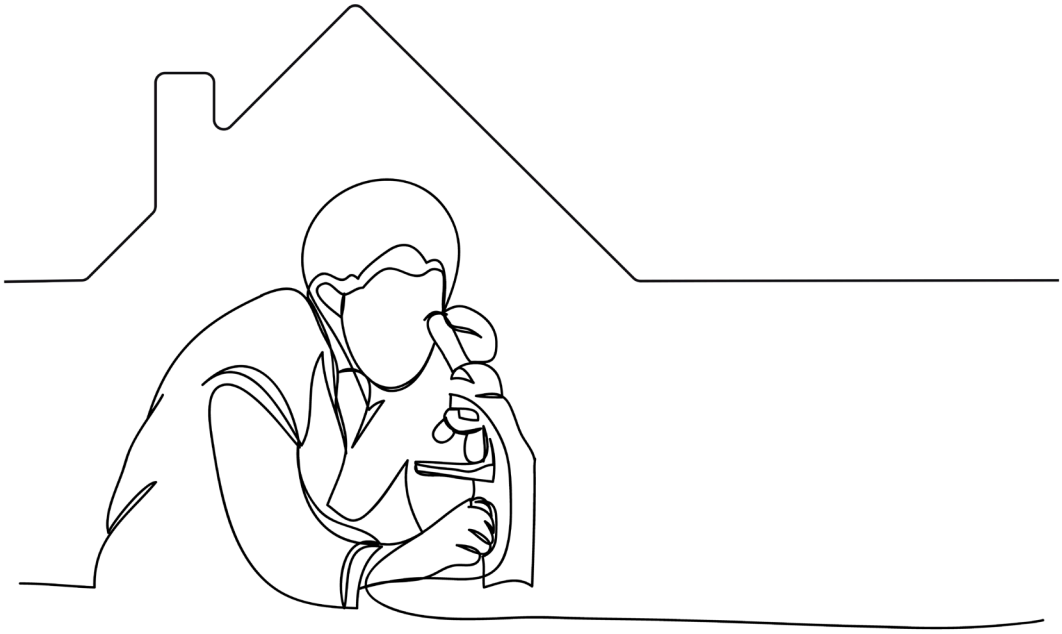
3 Bioinformatic tools to analyze and assemble acquired data



FOR ACCESS TO THE FULL INFOGRAPHIC, PLEASE CLICK HERE!

Leftover Lockdown Ways

ANONYMOUS



I often wonder if the people from the good old days felt towards bra-wearing like I feel towards mask-wearing: it really is uncomfortable but needs to be done. I always carried my phone and keys around, now it is phone, keys and a mask. I guess it is becoming second nature and us humans are quick to learn new habits.

If I think back to March last year, we have really adapted, and systems have evolved to accommodate the lockdown. I remember the shock when we heard the news that a pandemic has hit this earth. No one knew how it would turn out. I felt surges of anxiety when I thought about what was going on around us. I mean, not even having the freedom to go for a run in the street – it was scary.

And now, we have adapted. Where I live, we are still encouraged to work from home as much as possible. Online meetings have become second nature and we all mastered various different platforms and their nuances. This is definitely something that I will continue with after we have all our freedom back. I'll choose wisely which meetings will go online and which warrant in person interaction.

Working from home is not so easy. But let me explain, compare and contrast, before I complain. I have three boys and my study is inside their home – the place where there is lots of laughter, games and the common sibling rivalry.

I am in awe of our human race and our ability to adapt. I am also excited to see what the new "normal" will be like.

Even though I can close my study door, I hear these sounds of happiness and distress. I have become a master of shutting out sound, but the odd shout of elation/distress does creep through the keyhole and leads to bits and pieces of distractions throughout the day.

Yet, when I compare my office environment to my home environment, there are also the odd distractions daily – colleagues or students popping in to say hello, or to ask for advice. The 68 km required to travel to my university office and home has now been replaced by a few meters, which is a huge benefit in terms of travel cost (what will I do with all that money?). However, I used the travel time as a mental transition from work to home, and I had to find different ways to shift my mind between virtual work and home now that I am working inside my home. This was not impossible. I now have a ritual of closing my laptop and plugging it out, and that signals the end of the day. I also implemented very specific working hours – lovely, but also hard to have as a boss. I do miss my colleagues, but ad hoc phone calls have become a natural phenomenon and seem to be a good replacement.

Working from home has been a huge adaptation for me, but it's working. I am in awe of our human race and our ability to adapt. I am also excited to see what the new "normal" will be like, but one thing I do know, we will never be able to go back to pre-COVID without some leftover lockdown ways. ●

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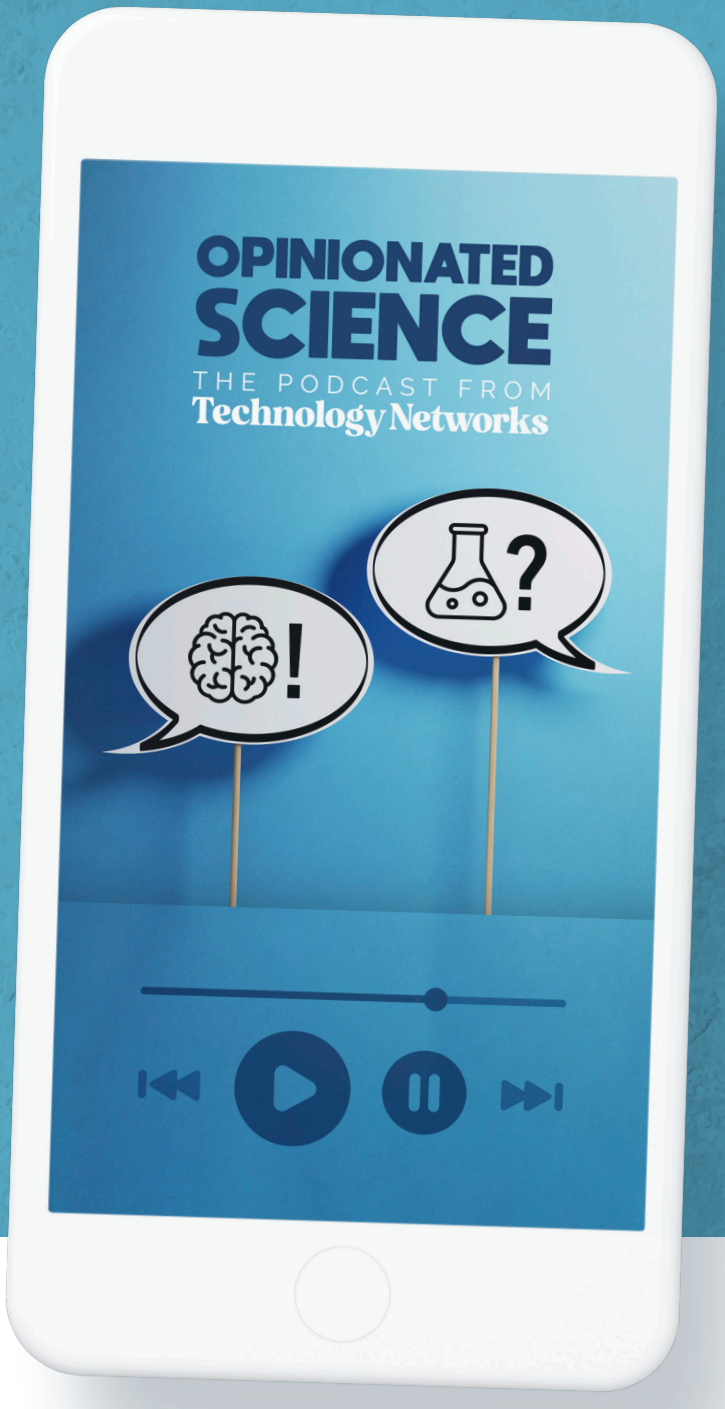


Don't Keep Your Opinions to Yourself

Opinionated Science is *Technology Networks*' homemade podcast, where our team of scientists-turned-journalists serve up slices of the weirdest and most fascinating stories from the world of science.

Find Opinionated Science on all major podcast platforms, including Apple Podcasts and Spotify.

How Good Conversation Benefits From Data Compression

ROBERT HOLLAND

WHAT IS DIMENSIONALITY REDUCTION?

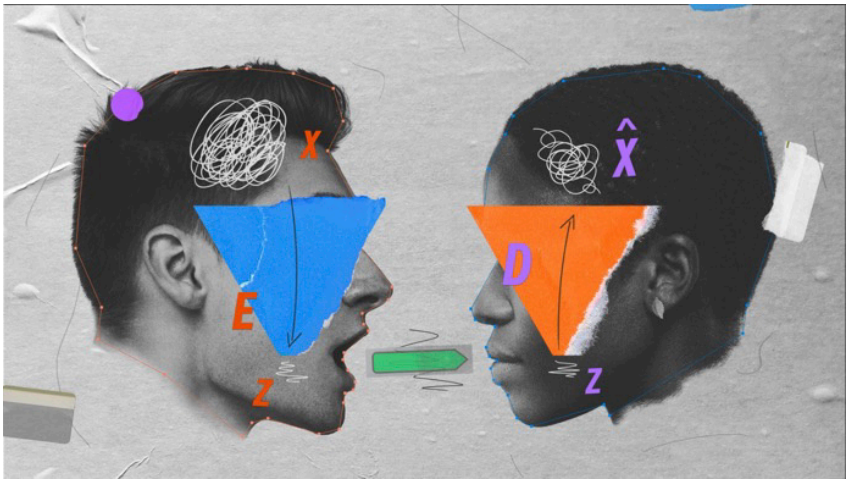
What does "big data" mean to you? To most it refers to huge datasets comprising millions of data points. It has become a fundamental part of our tech-reliant culture. So far a staggering 50 billion photos have been uploaded to Instagram and 250 billion to Facebook. We're used to hearing how machine learning leverages these increasingly large datasets to analyze trends and generate novel insights. However, the "big" in "big data" can also refer to the data points themselves.

Smartphones are now sporting 4k cameras. These have resolutions of 3840 x 2160, resulting in a whopping 8 million pixels per image, or file sizes of 24MB at 24-bit precision. A single medical image can be even larger. A typical 3D MRI scan might have a resolution of 512 x 512 x 128, resulting in 33 million voxels (3D pixels) stored using 128MB of memory (at 32-bit precision). Does a medical doctor really draw 33 million conclusions from a single scan?

Ultimately, this depends on what kind of conclusions we're interested in. For example, a doctor staging cancer from a medical scan needs to know how many tumors there are, their locations, sizes and other characteristics. This information can be written down without the need for 33 million variables. Images at higher resolutions are desirable for improved detection, yet the amount of relevant symbolic information they contain remains comparatively small.

HOW DOES CONVERSATION COME INTO THIS?

Imagine you're describing your dream house to a friend. "It's on a cliff by the sea, made with red brick, two floors, a chimney and huge windows."



CONVERSATION AS DIMENSIONALITY REDUCTION:

Autoencoders consist of an encoder, E mapping an input x to a lower dimensional version Z. This is then decoded by D to give x^. Typically E and D are neural networks trained so x^ matches x as closely as possible (under some predefined definition of "closeness").

Here, speech serves as a low bandwidth medium for information transfer. You're forced to compress or encode the house in your mind's eye into words, which are then decoded by the listener. The hope is that the image they create resembles the original you envisaged. That your words carried the essence of what you were trying to say.

In this instance of dimensionality reduction, we assume the world and all its complexities can be adequately captured in words. Clearly, and much to the frustration of writers, we can never completely describe the world this way. We are always losing some nuance in the process and can never guarantee our words are interpreted the same way each time they're read. No two people reading this article will have imagined the same house. A skill shared by good orators and writers is to maximize the amount of relevant information they convey in a given amount of words.

However, there is a trade-off between retaining the information we care about while minimizing the size of the compressed format. Any dimensionality reduction, reconstruction or denoising technique, be it linear regression, principle component analysis or autoencoders, walks this line. Lossy compression formats such as JPEG and MP3 operate on the same principle.

If we cannot organize and interpret our own thoughts and feelings, how can we expect to be understood by, or indeed understand, someone else.

SO WHY NOT BYPASS CONVERSATION ALTOGETHER? WHY COMPRESS CONCEPTS AT ALL?

The benefits of compression lie as much in the process itself as in the end result. Recall that autoencoders are trained to reconstruct data. This may seem like a pointless task; what's the use in reproducing what you already have? The key is in the presence of an information bottleneck, which for human communication is typically speech, gesticulation and body language.

Have you ever gained a better understanding of an idea through explaining it to somebody else? If we break it down, two things are happening here. Superfluous details are stripped away to reveal the concept in its simplest form, which is simultaneously reorganised to become more understandable. In machine learning the former is referred to as denoising, and the latter as disentanglement[1]. Both are found to be an inherent properties of autoencoders[2] and skilled conversationalists. Essentially, your points become more interpretable in your own mind through your attempt to make it more understandable for someone else.

It's no secret that not every engineer enjoys conversation. Some go as far as Elon Musk, seeking to solve the "data rate issue" of human communication. Musk's company Neuralink is developing ways to bypass speech altogether by linking mind to machine, thereby increasing the bandwidth of human communication.

This sounds great in theory, and we will never know all the benefits and consequences until we experience it for ourselves. Imagine knowing someone else's thoughts and feelings exactly as they do. Such intimate connections might help us to see past our surface differences. But might we lose the structuring of our thoughts that conversation entails?

And if we cannot organize and interpret our own thoughts and feelings, how can we expect to be understood by, or indeed understand, someone else. Should we instead accept that we can never truly know each other's minds?

If you know what I mean. ●

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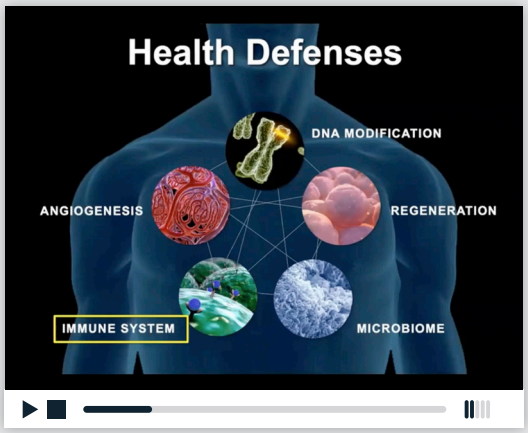

TEACH ME IN 10 by LabTube

Food as Medicine

WITH DR. WILLIAM W. LI

LAURA LANSDOWNE

We are making it easier than ever to access complex areas of science and to learn something new. *Teach Me in 10* challenges scientists to present and summarize their research, or a scientific concept, in less than 10 minutes. Our feature episode for the July Issue of *The Scientific Observer* is "Food as Medicine" with Dr. William W. Li.

Dr. Li is an internationally renowned physician, scientist and author of the *New York Times* bestseller *Eat to Beat Disease: The New Science of How Your Body Can Heal Itself.* His groundbreaking work has led to the development of more than 30 new medical treatments and impacts care for more than 70 diseases including cancer, diabetes, blindness, heart disease and obesity. With over 11 million views on his TED Talk, "Can We Eat to Starve Cancer?" it is no wonder that Dr. Li has also featured on Good Morning America, CNN, CNBC and the Dr. Oz Show, as well as featuring in USA Today, TIME Magazine, The Atlantic and O Magazine.

In this episode of *Teach Me in 10,* Dr. Li discusses the relationship between food, health and disease and shares several examples of foods that have been scientifically proven to support our immune system. If you're interested in the relationship between food and disease, and wondered how life might look if we tested food in a similar way to medicines, then this is the episode for you! ●

Privacy in the Brain:

The Ethics of Neurotechnology

RUAIRI MACKENZIE

A monkey playing ping pong is not your classic ethical "dilemma". But watching Pager, the nine-year-old macaque, bat a ball from side to side, is a view into a moral minefield.

Pager isn't physically moving the ball. Instead, as part of a trial by Elon Musk-run neurotechnology company Neuralink, he is playing the arcade game Pong on a screen, for which he is rewarded with a banana smoothie in return. He's also not using a joystick. Rather, a pair of Neuralink implants are translating signals from Pager's motor cortex into onscreen movements of a Pong paddle.

If you are a tech nerd, the kind that Musk is unashamedly targeting for recruitment into his growing company, you might marvel at the features of the device, a 1,024-channel electrode dubbed the "N1 Link" that even boasts Bluetooth control via mobile phone.

If you are an animal lover, you might feel unsettled, noting that Pager is conducting his tests on a fake tree in front of a projection of his natural forest home.

Most people probably feel a combination of these emotions, like how you might be both horrified and awestruck by a particularly engrossing episode of *Black Mirror.* This technology is not only surreal, but also likely to be coming to a hospital (or tech store) near you very soon.

WHAT IS NEUROTECHNOLOGY?

The Link is a type of neurotechnology, a broad term that refers to the field of science that marries electronic components to a nervous system. Musk's Neuralink represents one of the most well-funded and, perhaps unsurprisingly for a man who sent a car into space, eye-catching examples of neurotechnology.

But these devices have been quietly worked on for decades. Giles Brindley, a University of Cambridge physiologist, produced a brain implant that could wirelessly stimulate the visual cortex way back in 1965. This was developed as a visual prosthesis and the phosphenes that the implant generated (irregular flashes of light that appear in the visual field) enabled the user to identify a few letters of the alphabet. While being of little practical use at the time, Brindley's experiments established the moral basis for neurotechnology – these devices' worth would surely be undeniable if they could bring sight to the blind and voice to the voiceless. Fifty six years after Brindley's first publication, a new study by researchers at the University of California San Francisco (UCSF) took a leap towards that latter goal.

The BRAVO (Brain-Computer Interface Restoration of Arm and Voice) study saw UCSF neurosurgeon Edward Chang and colleagues develop a device that picked up neural signals intended for the vocal tract. Chang surgically implanted this device into a patient, dubbed BRAVO1, who had suffered a stroke more than a decade prior that had robbed him of most of his movement and his voice. The implant was fitted above BRAVO1's motor cortex and, after years of painstaking communication via a pointer device and a touchscreen, BRAVO1's implant was able to help him construct sentences using only the power of his mind.

Musk's Neuralink also wants to help restore senses to disabled people. He is also open about his vision for the end goal for the technology – to see these brain implants mass marketed to the general public, used to not only cure diseases, but to enhance the healthy human brain. Who'd want the job of weighing up the costs and benefits?

ENTER THE ETHICISTS

Ienca Marcello is a professor of bioethics at Swiss university ETH Zurich. Marcello's current grant, in partnership with German and Canadian researchers, is to investigate the interaction between human and artificial cognition via neural interfaces. Marcello recently spoke at a two-day neurotechnology workshop arranged by the Organization for Economic Co-operation and Development (OECD) that focused on how this nascent technology will interact with society.

"When I started working in this field at the beginning of the previous decade, there were only a handful of tech companies involved in this domain," says Marcello. Now, things have gotten a bit more complicated. Neurotechnology devices are broadly split into invasive and non-invasive categories.

Invasive technologies, like Neuralink, implant electrodes and other hardware directly onto, or into, the brain. From here they can record or input electrical signals from specific brain regions. The region targeted will vary depending on the aim of the device. Want to feed signals from a camera to bypass a non-functional retina? Aim for the visual cortex. Want to give relief to the gait-disrupting tremors experienced by people with Parkinson's disease? A deep brain stimulation electrode releasing signals onto the subthalamic nucleus (STN) or globus pallidus internus (GPi) could do the trick.

Non-invasive technologies bypass surgery altogether and make their recordings from the surface of the scalp. Aside from applying gel used to improve the signal connection, these techniques require very little of the user – a huge benefit compared to invasive technologies, but struggle to achieve the level of resolution or effectiveness of invasive tech, as the scalp and skull can muddy the picture.

Non-invasive technologies, which bypass the not-so-slight hurdle of brain surgery, have opened up neurotechnology to a consumer market. Devices such as the Flow Neuroscience tDCS brain stimulator and the Muse headband, aiming to reduce stress or improve meditation through brain stimulation, have tapped into the "wellness" market that is in overdrive.

NEUROTECHNOLOGY'S GLOW-UP

Anna Wexler, an assistant professor of medical ethics and health policy at the University of Pennsylvania, has focused on these direct-to-consumer devices, which not so long ago, were mainly the preserve of DIY brain hackers. "What

has changed in the last few years is that we've been seeing more investment, from venture capitalists and others, in these devices. So, these devices have really gone from things that people would create in their basements or home garages to sleeker products with well thought-out engineering and design components," Wexler tells *Technology Networks.*

The sudden glow-up that non-invasive neurotechnology has gone through has caught regulators by surprise. Wexler, who wrote in 2015 about the regulatory challenges that these devices would face, still believes that marketing brain stimulation devices as "wellness" products has allowed some companies to skip strict regulations. Is a device that makes only vague medical claims about mood boosting liable to the strict laws of the Food and Drug Administration (FDA) or should they be addressed by consumer product agencies? The FDA, Wexler notes, has not taken action against smaller neurotechnology companies that have made explicit medical claims about their devices.

and harder to assess, Wexler says: "The second part of the harm issues is unintended negative consequences outside of safety, so things like potential effects on cognition if someone uses the device very frequently." While the presence or absence of a charred chunk of hair after an excessive round of unregulated stimulation is easily quantifiable, assessing how someone's subjective experience of reality might be altered by devices – especially those that explicitly aim to help people by tweaking their mood – is hard to measure, and there have not yet been any conclusive studies on this, Wexler explains.

THE HUMAN RIGHT TO BRAIN PRIVACY

In the face of a rapidly changing field, this is an oversight that Marcello and the OECD, through their recent Recommendation on Responsible Innovation in Neurotechnology, have aimed to rectify. In Marcello's view, this is a goal that needs urgent attention. "It's possible to predict that in the decade that just

Variation in how we think isn't limited to whether we use words or images. Sometimes, the very nature of our thinking can become disrupted.

The key ethical issues facing currently available at-home devices are questions of harm, which can be viewed in two different ways. "The first way is as an immediate adverse reaction that is measurable, like a burn on the skin beneath where an electrode was placed," says Wexler. While users on online neurotechnology forums, like Reddit's r/tDCS, a community for users of transcranial direct current stimulation devices, have reported burns from self-designed devices, some leading neurotechnology devices hardcode in strict limitations to how much current can be put through their headbands. The second issue is more fundamental, began, we will see neurotechnology become a mainstream technology, something that is not used only by a handful of innovators, but by a large chunk of the world's population," he says.

The ethical issues that face Wexler's at-home devices today will likely be a walk in the park compared to those that will emerge in the near future. If Musk can meet his promise that the Neuralink device could one day help users replay memories or even achieve "superhuman cognition", ethical issues that are both unique and greater in magnitude than those raised by any other form of technology could appear.

"This is because the human brain is not just another organ, it is the fundamental biological substrate of mental faculties such as consciousness, memory, language, perception, emotions and so on," says Marcello.

"All those are things that make us human and therefore addressing the ethics of incorporating brains and machines requires fundamental ethical analysis of notions such as personal identity." To Marcello, this is a fundamental matter of human rights, about what it means to think for oneself.

Who are we protecting our rights from? The growing neurotechnology market has attracted a series of big tech companies. This includes not only Neuralink, but companies that made their fortune in social media, such as Facebook.

To Marcello, social media represents the "what not to do" of tech regulation: "I really think that ethics was not a priority among social media actors," he says. Marcello says that social media companies focused on innovation and return on investment and only considered ethics after numerous privacy scandals forced them to act. Social media companies, who make almost all of their revenue from selling access to their users' data to advertisers, exist in an uneasy moral gray area, explains Marcello. "What we see with social media is not that data are stolen from people explicitly, but that people are sharing their data under a weak consent regime and have a very limited awareness about the kind of inferences that can be made based on their data."

Marcello calls this tactic *implicit coercion.* "We have consent, but we do not have informed consent, and for some reason we have accepted that consent without informed consent is OK, socially acceptable and legally justifiable," says Marcello.

Would users of a brain computer interface be willing to pay less for their device in exchange for their neural and cognitive data being made available to advertisers? Marcello is skeptical of the idea that a similar approach will work for neurotechnology. Instead,

he believes privacy paradigms are required.

"We need to improve our models of consent. We need to make opt-in, affirmative consent mandatory for all consumer technology applications. You cannot just presume consent from your end users," says Marcello.

WHO REGULATES NEUROTECHNOLOGY?

What's encouraging to hear from the ethicist is that his worries are not just confined to the ivory tower of academia. International organizations are getting involved – Marcello recently completed a report for the Council of Europe, who have launched a five-year strategic action plan on the ethics of biomedicine that includes a chapter on neurotechnology, while governments in Chile and Spain have moved towards codifying the right to brain data privacy in their laws.

The OECD, rather than providing a set of hard, top-down rules, is attempting to help neurotechnology companies self-regulate. Can we really trust these companies to police themselves? Marcello is hopeful. "A lot of companies in these fields are quite committed to innovating responsibly and to incorporating ethics into their business model, and I think this is a big achievement because it's rather unusual in the history of technology that ethical considerations are incorporated early on in the design and development phase." He highlights what he sees as a commitment to neuroethics from industry players, even Facebook Reality Labs, who collaborated with Chang on his speech-restoring implant. This is a strong statement of support coming from Marcello, who is an extremely vocal critic of Facebook's data ethics on their social media platforms.

WHAT DOES A PRIVATE FUTURE FOR NEUROTECHNOLOGY LOOK LIKE?

This self-regulation might involve beefed up consent regimes and terms of use that can be understood by your average user – another innovation that would improve greatly on the standard set by social media companies. Finally, education and awareness among users is a priority. "For obvious reasons, people have very little knowledge about how valuable their data are, let alone about how valuable their brain data are. It's very important that we disseminate information to empower everyone to make free and competent decisions about their mental space," says Marcello.

This may all seem like an uncertain and tense future for neurotechnologies that could come to dominate our digital lives, but Marcello is keen to emphasize that these negative ethical concerns are only part of a wider picture. This includes technologies such as Chang's, and even non-invasive technologies targeting mood disorders – all innovations that aim to help people suffering from chronic conditions that have crushing impacts on their quality of life.

"We have to keep in mind that neuropsychiatric disorders are a major component of the global burden of disease, so we have a moral obligation to accelerate innovation in this domain, especially considering that our current therapeutic solutions through pharmacological therapy are relatively limited," says Marcello.

This is a dimension of Marcello's and Wexler's field that sometimes gets overlooked, but that is relevant to all ethics, not just those of buzzing devices for our brains. "I keep telling my students [that] ethics is not all about things that go wrong. It's also about how to maximize human wellbeing, and by connecting artificial intelligence to the human brain, we can develop better therapeutic, preventative and diagnostic solutions for people in need," concludes Marcello. ●

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COVID-19 Vaccine Safety in Pregnancy

AMBER SCHMIDTKE

For the general adult population, the risk of severe COVID-19 illness is lower than it is for elderly individuals, the exception being pregnant and recently pregnant women, who have an elevated risk. There is a desire to protect people at higher risk, but none of the COVID-19 vaccine clinical trials included pregnant persons. There is also disinformation circulating that speculates that COVID-19 vaccines are associated with infertility, without providing any evidence for the claim. What do the scientific data say? What are the benefits and risks for pregnant persons when it comes to COVID-19 and the vaccines, and does the benefit of the vaccine outweigh the risk of infection?

WHY WERE PREGNANT WOMEN EXCLUDED FROM COVID-19 VACCINE TRIALS?

The US Food and Drug Administration (FDA) placed an official ban on including women of "childbearing potential" in clinical research studies that lasted from 1977 until 1993.[1] This was shortly after the medical field recognized that certain medications could cause serious birth defects if taken during pregnancy, the most notable example being thalidomide.

Ever since, the inclusion of pregnant women in clinical trials has been an ethically complicated issue since no one wants to run the risk of causing birth defects. However, there are still medical conditions that pregnant people face that warrant controlled studies to ensure medications are safe and effective. With a lifesaving COVID-19 vaccine available against a life-threatening virus, in the context of pregnancy, those who are expecting are having to make a complex decision. Thankfully, we have data to assist with that decision.

WHAT DO WE KNOW FROM THE DATA WE DO HAVE?

The Pfizer–BioNTech, Moderna, Oxford–AstraZeneca and Janssen vaccines have been evaluated in

Developmental and Reproductive Toxicity (DART) studies.[2,3,4,5] These studies involve administering high doses of the vaccine (several times higher than the human equivalent) in rodents or rabbits to analyze what happens in the animals and their offspring. The advantage here is that the animals have much shorter gestation periods (weeks) than humans (months) and they produce lots of offspring, meaning scientists have access to a large sample size for data collection. If there is an issue relating to safety, it will be easier to detect. In all the DART studies conducted for the COVID-19 vaccines to date, there has been no impact on the animal's ability to get pregnant, stay pregnant or on pregnancy outcomes or birth defects either.

We have safety data in humans too, even though pregnant persons were not included in the original clinical trials. The US Centers for Disease Control and Prevention has been collecting data on people who self-identify as pregnant in their v-safe after vaccine health checker surveillance system and recently reported their findings for over 35,000 pregnant persons.[6] When considering post-vaccination side effects, pregnant persons experienced the same kind of symptoms as non-pregnant persons. Surprisingly, pregnant women experienced these symptoms less frequently than their non-pregnant counterparts; the exceptions being pain at the injection site and fatigue. However, fatigue may be considered a side effect of pregnancy overall.

The CDC also looked at pregnancy outcomes among those who have been vaccinated for COVID-19. The frequency of pregnancy loss, pre-term birth, low birth weight and congenital anomalies was similar to the general population of pregnant women, therefore the mRNA vaccines appear to be safe for both mother and baby.

The adenovirus vaccine platform (featured in the Oxford–AstraZeneca and Janssen vaccines) has previously been tested in pregnant persons during clinical trials for HIV and Ebola vaccines with no significant safety concerns. [7] However, we should not ignore the elevated risk, especially for women of childbearing age, for cerebral venous sinus thrombosis (CVST) + thrombocytopenia that has been detected in recipients of the Oxford–AstraZeneca and Janssen vaccines. This rare but serious complication has not been associated with the mRNA vaccines (Pfizer–BioNTech or Moderna), and so these vaccines could be an attractive alternative for women of childbearing age.

Evidence also shows that the antibodies produced by the vaccinated mother transfer to their baby both through the placenta and through breastmilk after delivery.[8,9] These antibodies confer temporary protection to their newborn. Of course, community efforts to keep case rates low through vaccination and non-pharmaceutical interventions (such as masking) will help to protect unvaccinated newborns also.

WHAT IS THE RISK OF COVID-19 FOR PREGNANT PERSONS?

Compared to uninfected pregnant women, those who are infected with SARS-CoV-2 while pregnant are five times more likely to be admitted to an ICU, six times more likely to be referred for high risk monitoring and 22 times more likely to experience maternal death. They are also more likely to require a cesarean delivery compared to a vaginal delivery.[10] Findings such as these are part of the reason why the American College of Obstetricians and Gynecologists (ACOG) shared their own recommendations that vaccines be permitted for pregnant persons shortly after they were authorized in December 2020.[11] Given the safety profile of the vaccines in pregnant persons to date, the benefits of vaccination appear to outweigh the risks, especially when compared to the risks associated with COVID-19 infection.

WHAT ABOUT THOSE WHO PLAN TO BECOME PREGNANT OR WHO ARE LACTATING?

There is disinformation circulating that claims that the COVID-19 vaccines cause infertility, but after millions of people have been vaccinated to date, there are no data to support that claim. In fact, there is more reason to suspect that the COVID-19 infection may contribute to infertility, rather than the COVID-19 vaccines. For example, high fevers in men can reduce their sperm production; in COVID-19 disease, it is not uncommon to have several days of high fever.

Compared to uninfected pregnant women, those who are infected with SARS-CoV-2 while pregnant are five times more likely to be admitted to an ICU.

According to the ACOG, "unfounded claims linking COVID-19 vaccines to infertility have been scientifically disproven." It goes on to strongly encourage vaccination for non-pregnant individuals, including those who are trying to conceive and those who are lactating.

WHAT ABOUT LONG-TERM EFFECTS OF THE VACCINE?

Paul Offit is the director of the Vaccine Education Center at Children's Hospital of Philadelphia. He recently said that the side effects associated with vaccines, if

they are going to happen, have always appeared in the first two months after administration. He goes on to add, "There are no long-term effects where you find that one year [or] two years later your child or you develop some problem that wasn't picked up initially. It has never happened." Since December 2020, over 300 million vaccine doses of COVID-19 vaccines have been administered in the US alone. We are well past the two-month window. If there was going to be an unexpected side effect, we would have seen it by now – but we have not. Perhaps the most important long-term effect of vaccination is avoiding hospitalization and death from the disease, and isn't that the goal, anyway?

Ultimately, the risks of COVID-19 infection are worse than any risk posed by COVID-19 vaccination for those who are pregnant, planning to become pregnant, or who are lactating. However, this can still be an anxious decision for many, and it is okay to have concerns. Your medical provider can be a valuable source of information and help you to weigh the risks and benefits if you are unsure. ●

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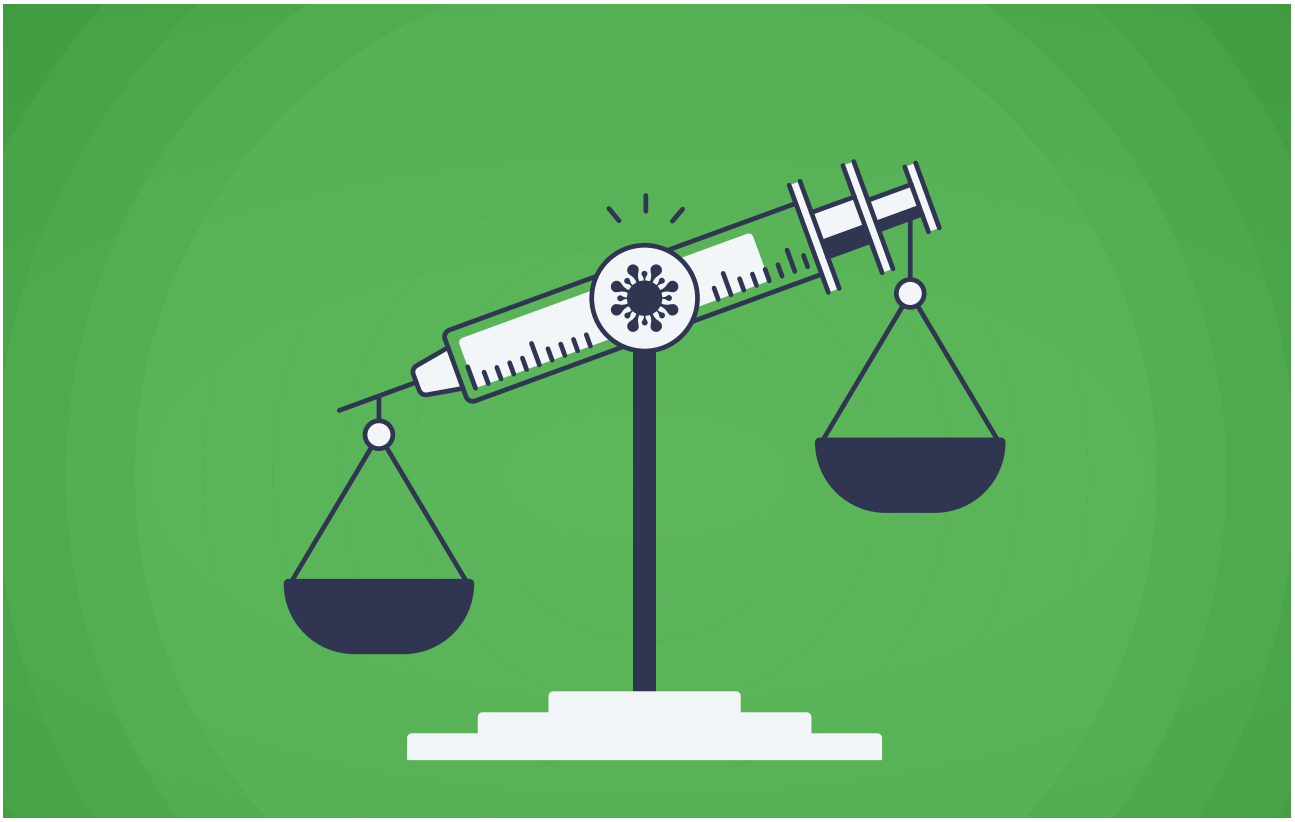

Examining Risk–Benefit Profiles for Vaccines

DAVID ELDER

The following article is an opinion piece written by David Elder. The views and opinions expressed in this article are those of the author and do not necessarily reflect the official position of Technology Networks.

During the early stages of the COVID-19 pandemic, researchers around the globe began a frantic race against time to develop an effective vaccine. By the middle of 2020 there were 17 candidates in clinical development[1] and by the start of 2021, three vaccines were approved: Pfizer–BioNTech (mRNA), Moderna (mRNA) and Oxford–AstraZeneca (DNA, modified chimpanzee adenovirus), now trademarked as Vaxzevria. As many of the severe symptoms of COVID-19; "including acute respiratory distress syndrome, pulmonary oedema, acute lung injury and pulmonary fibrosis"; are also related to the normal immune processes; the challenge was to protect the patient – without also inducing immune-mediated lung damage.[1]

Initially, most attention was focused on the mRNA vaccines and the potential for severe allergic reactions – this was subsequently linked with the use of PEG (polyethylene glycol) in the nano-particle formulation.[2] However, during the early part of 2021, researchers also became aware of a rare but concerning occurrence of unusual blood clots related with low blood platelets, in some patients taking the Oxford–AstraZeneca vaccine. One potential explanation was an exaggerated immune response, leading to a condition similar to heparin induced thrombocytopenia (HIT).[3]

Nonetheless, the European Medicines Agency (EMA) indicated that "COVID-19 is associated with a risk of hospitalization and death. The reported combination of blood clots and low blood platelets is very rare, and the overall benefits of the vaccine in preventing COVID-19 outweigh the risks of side effects".[3] The response to this balanced prognosis from the EMA, was markedly different in many European countries. Denmark totally banned the vaccine,[4] prompting many requests from other EU countries for their stocks of the vaccine. France having initially branded the vaccine as "quasi-ineffective" and restricting use to individuals under 65 years performed a complete *volte face* and restricted use to the over 55s.[5] The UK initially restricted use of this vaccine to those over 30 years[6] based on a 1 in 1,000,000 risk profile; which as the BBC explained is "roughly the same risk as being murdered in the next month or – if you get in a car and drive

for 250 miles – the risk of you dying in a road accident on that journey".[7]

Subsequently, based on additional data, the UK restricted the Oxford–AstraZeneca vaccine use for the over 40s.[8] The UK health agency reported that in the UK about 1 in a 1000 people are affected by venous thrombosis each year, many linked with the contraceptive pill.[9] This compares with 242 reported cases of thrombosis reports with low platelets (as of April 28, 2021), out of a total of 22.6 million first doses of Oxford–AstraZeneca vaccine,[8] i.e., *ca.* 1 in 100,000 risk. In addition, there is a 10-fold greater risk of blood clots from COVID-19 infection compared to the Oxford–AstraZeneca vaccine.[10] So, if all medicines regulatory agencies had access to the same clinical data, why did the "experts" not arrive at the same conclusions?

To answer that question, we need to better understand what risk is. Risk can be defined as, "The combination of the probability of harmful events and the severity of that harm".[11] However, much of what we think and do about risk makes little or no sense. Why do we fear relatively minor threats, whilst tolerating significantly greater threats?[12] One of the reasons why some countries were intolerant of this small risk is that they had access to alternative supplies of mRNA COVID-19 vaccines. Vaccine hesitancy and the need to reassure patients of the absolute safety of the vaccines may be another reason – not helped by politicians making wildly inaccurate claims about vaccine efficacy.[5] Although the various COVID-19 vaccines appear to have similar efficacy based on real-life data, cost may have been another factor. Psychologists have long been aware that people often equate cost with quality, even though there may be no difference in the efficacy of the products.[13] AstraZeneca was extremely philanthropic and provided their vaccine "at cost"; whereas, both Pfizer and Moderna will make significant profits from their products. This lower cost may have fueled vaccine hesitancy in the minds of many patients. Historical incidences of rare side effects from vaccines can also lead to poor public confidence in some vaccines. An extensive study of the background rates of narcolepsy in six European countries before and after 2009 H1N1 pandemic vaccine campaigns confirmed increases in Finland, Sweden and Denmark;[14] which probably resulted in Denmark's decision to ban the Oxford–AstraZeneca vaccine. As the old adage goes, risk is in the eye of the beholder! ●

Risk can be defined as, "The combination of the probability of harmful events and the severity of that harm". However, much of what we think and do about risk makes little or no sense.

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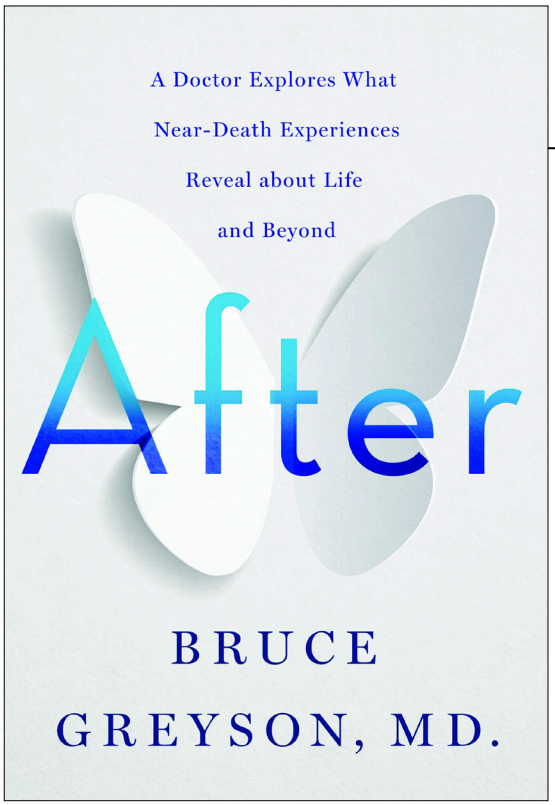
Science in the Media



AFTER

BOOK BY DR. BRUCE GREYSON

Near-death experiences have been described for many years in historical and literary records and seem to occur in 10-20% of people who come close to death. Some records describe people seeing relatives, experiencing out of body experiences to meeting an all-powerful being.

The author, Dr. Bruce Greyson, is the co-founder and president of the International Association for Near-Death Studies and editor of the *Journal of Near-Death Studies*. This book consists of four decades of research and thousands of interviews, and whether you are religious or not, this book is a fascinating read. The research is discussed in a very scientific approach and it does not argue for one specific interpretation, however, it provides the evidence and ultimately leaves it to the reader to form their own opinions.

Beccy Corkill

THE NAKED SCIENTISTS

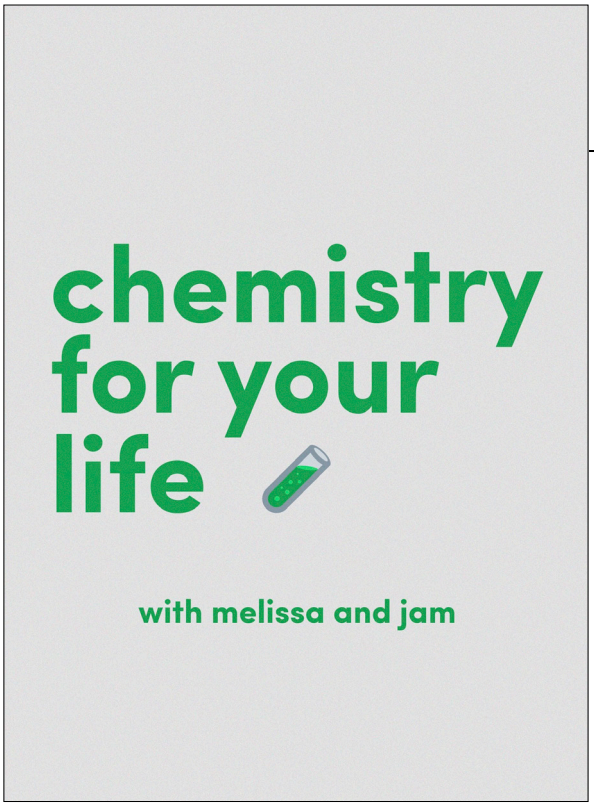
PODCAST, BBC RADIO 5 LIVE

Launched in 2001, *The Naked Scientists* was not only one of the first podcasts to exist but is now one of the world's most popular science shows. The team works with broadcasters internationally including the BBC, ABC and Radio New Zealand and has a global audience of over a million people worldwide each week. *The Naked Scientists* share approachable and relatable science topics and, as someone that shares their passion for communicating science, I am also an avid listener. Their episodes range from "The Secret Lives of Sharks" and "Human Space-flight" to "Unpacking ADHD" and figuring out answers to questions like "Will not having sex harm my health?" and "Why does Earth look flat for people on the surface when we know it's not actually flat?

The team have won multiple national and international awards for science communication and no matter the subject, I can guarantee you will gain something from each episode. Truly worth a listen!

Lucy Lawrence

THE NAKED SCIENTISTS



CHEMISTRY FOR YOUR LIFE

PODCAST, TRANSISTOR

Science informs so much of our daily life, from the materials we use, the foods we eat to the way we take care of our bodies and our health. So how much thought do you give to the science behind your life? Or specifically, the chemistry? I really enjoy thinking about the science of the mundane, and that's probably why the *Chemistry For Your Life* podcast has proven so entertaining. Hosted by Melissa Collini and Jam Robinson, this show seeks to answer some of the weird and wonderful questions about everyday life from a chemistry perspective. If the subject was not your forte in high school then fear not, in each episode Melissa and Jam breakdown complex scientific concepts into easily digestible and applicable chunks of knowledge that you can consider in your daily lives.

Molly Campbell

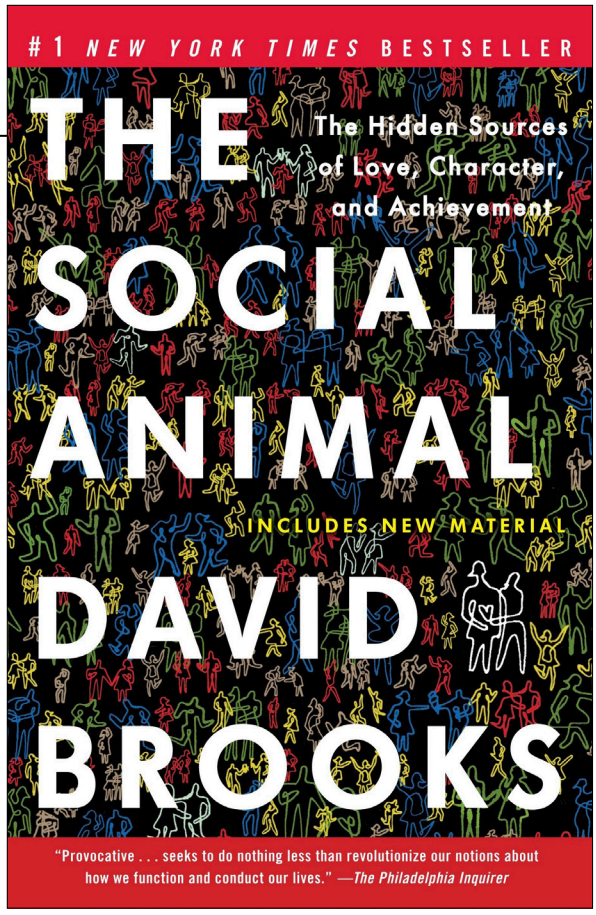
THE SOCIAL ANIMAL

BOOK BY BY DAVID BROOKS

In *The Social Animal,* David Brooks uses the everyday lives of two fictional characters, Harold and Erica, to explore the building blocks of humanity. As the reader follows their lives from birth to death, we experience the world through their eyes, witnessing the highs and the lows, their successes and failures. Brooks believes that – instead of relying on rationality – the majority of people make decisions based on their unconscious emotional state, which is in turn influenced by their social relationships. He argues that we are the result of our unconscious mind and that it is here where we make our most important life decisions.

Whether or not you agree with Brooks' viewpoint, his decision to use this book to examine a wealth of real-world research about the human mind and its impact on society, with reference to the events occurring in the lives of his fictional characters, is a clever way to explore his theory. And, if nothing else, it may give you pause for thought; it certainly made me question the way I see myself and others around me.

Tiffany Quinn




Technology Networks
Hi. How are you? Have you seen our Facebook groups?
No I haven't. Could you tell me more?
Our Facebook groups allow you to keep up to date with the latest news and research and share content with like-minded professionals. With three diverse groups there is something for everyone.
Sounds great! How do I join?
It's simple, just choose the groups and click the bubble. 👇
Come join the Neuroscience, News and Research Group here.
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Explore The Science Explorer Group here.
Thanks! I'll come join the conversation. 👍
Aa