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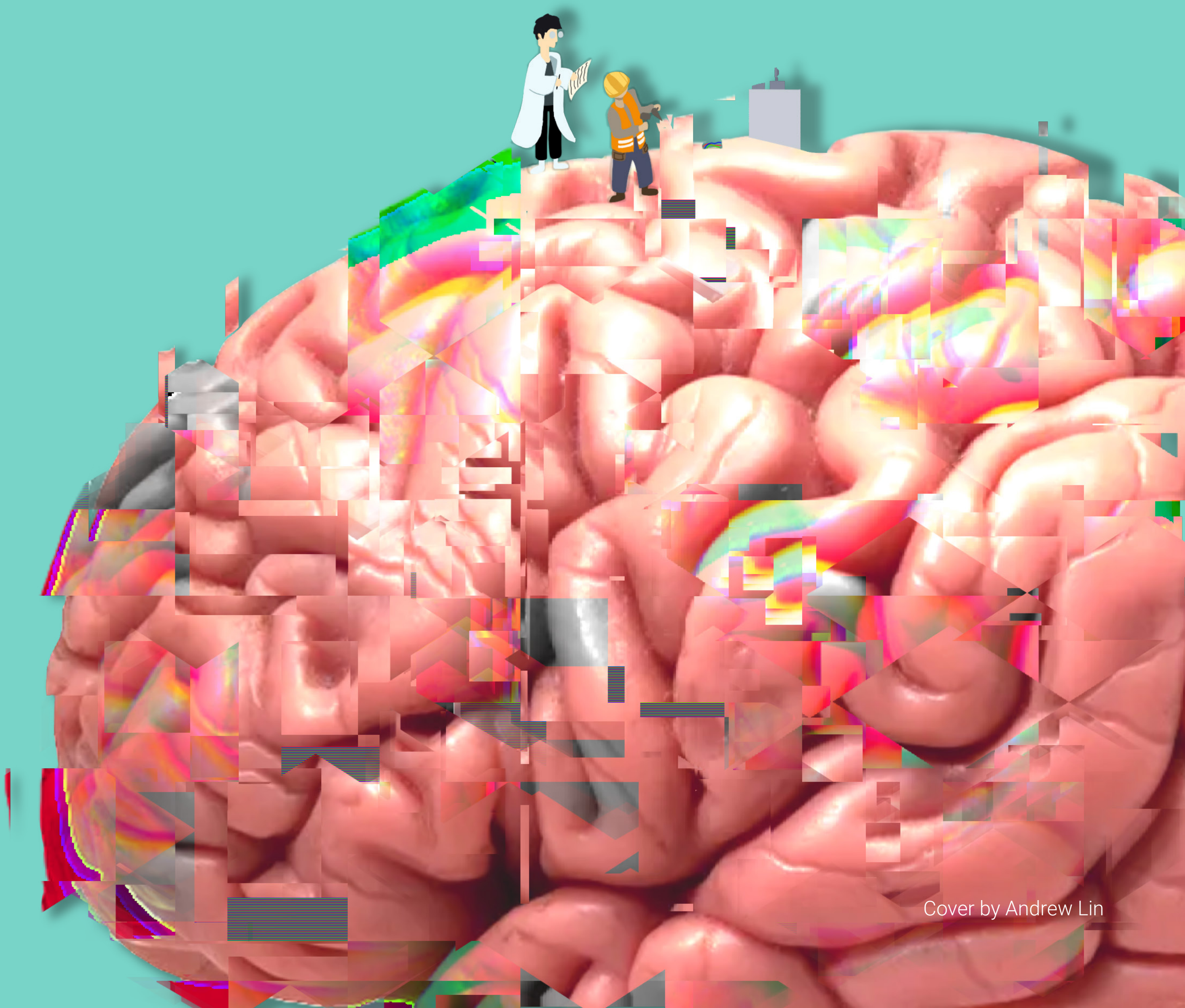
Issue 6: Change My Mind | Fall 2021



Cover by Andrew Lin

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Formatting by Amy Wang

Letter From the Editors

Dear reader,

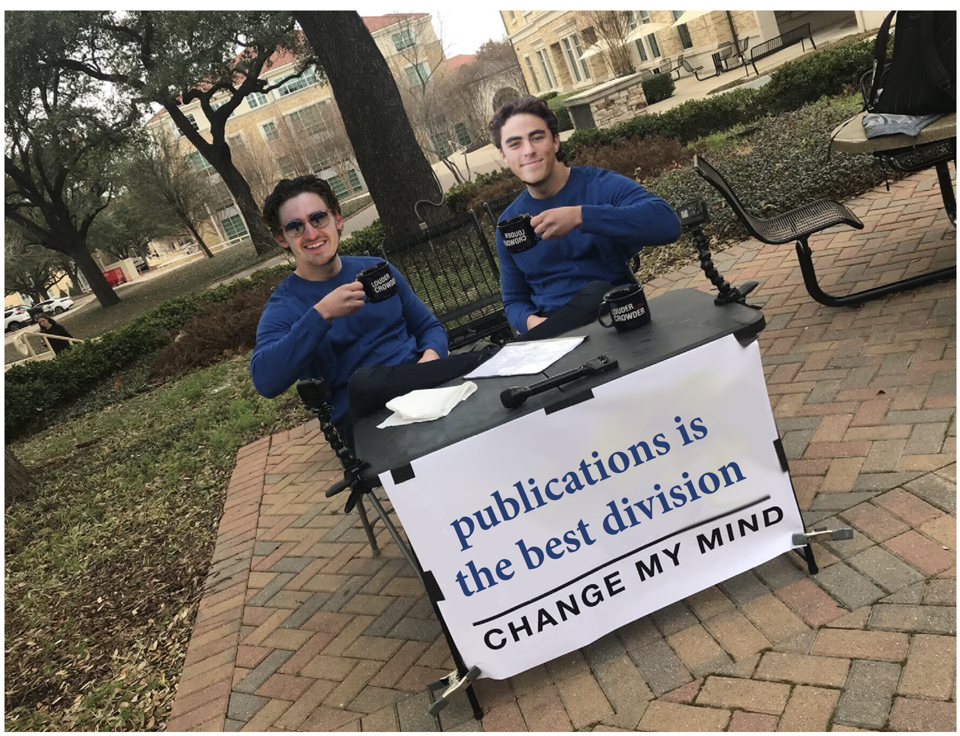
The fall of 2021 marked a turning point in many of our lives – developments in science and technology allowed the world to return to a sense of normalcy following the global pandemic. Though we are not in the clear yet, the past few months have seen dramatic changes in the world around us as well as within us. This semester has served as a bridge connecting our former online lives to a new and nostalgic in-person learning experience.

We chose the theme Change My Mind with the goal of enabling our writers to explore the idea of evolutions and transitions on particular topics within the fields of neuroscience and technology. We hope that these articles will expand your views and serve as a reminder that the only constant is change.

While serving as leads of Neurotech@Berkeley, we have been fortunate to spend time learning and working with an amazing group of people. We organized weekly meetings, held meditation circles, pizza parties, and group brainstorming discussions. The passion we collectively share for neurotechnology has been channeled into this magazine with the goal of inspiring the reader to develop new ideas, opinions, and perspectives.

We want to convey our deepest gratitude to you, the reader, for supporting our articles and helping to create a platform and community for exploring ideas within the fields of neuroscience and technology.

Sincerely,
Oliver & Luc

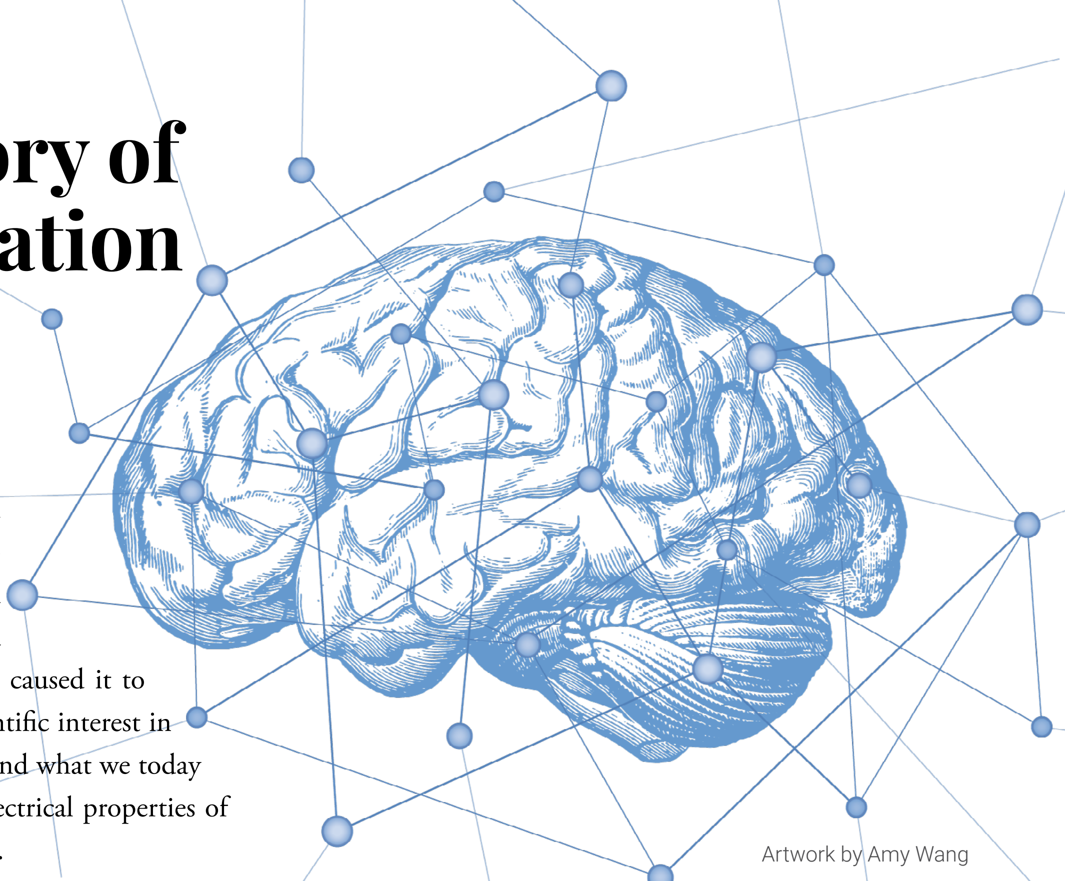


Change My MIND:

Via the Brain

A Little History of Neuromodulation

By Sameer Rajesh



Artwork by Amy Wang

Frog Legs and Frankenstein

The story I'm about to tell you starts in the late 1780s, when the 43-year-old Renaissance man Luigi Galvani, along with his wife, Lucia, serendipitously discovered that electrical stimulation of a frog's legs caused it to kick. His discovery led to a flurry of scientific interest in what was originally called bioelectricity, and what we today call *electrophysiology*—the study of the electrical properties of organisms from the cell to the organ level.

While I won't bore you with the details of their work, I will tell you that the Galvanis had made perhaps the biggest contribution to neuroscience up until that point, without even realizing it. They had discovered that there was some deep connection between electricity, this abstract phenomenon that we saw in lightning and that could be harnessed to generate power, and life. Decades of investigation would lead to the discovery that individual cells could propagate electrical signals down their length in the form of action potentials—these are the body's neurons. The famous biophysicists Hodgkin and Huxley would go on to win the Nobel Prize for their detailed mathematical analysis and modeling of the electrical properties of neurons, the so-called Hodgkin-Huxley model.

The connection between the nervous system and electricity even made its way into popular culture when, in 1816, inspired by reports of the Galvanis' work from 40 years prior, a young Mary Shelley imagined a story of a mad scientist using electricity to reanimate a corpse—the story eventually became a well-known tale: Frankenstein. Later this year, the 4th installment of the Matrix series will be released—a story that tells of a time when human minds will be harnessed for bioelectricity, a time when humans can be directly connected to computers and live in a virtual space.

But here, I aim not to bring you tales of sci-fi cyborgs and brainwashing computer chips—instead, I want to take us on a tour through the ways we can use electromagnetism to stimulate and heal damaged brains. We'll look at some examples of the ways we can use technology to change the brain in ways we don't even fully understand. I hope to impart to you, if nothing else, a deeper sense of appreciation for the technology that exists around us today, as well as the ingenuity of those physicians, scientists, and engineers, who work in these cutting-edge frontiers of medicine.

Welcome to the world of neurostimulation.

Neurological Disease

Whether or not the sentiment is justified, it is often said that what separates us from the rest of the animal kingdom is our capacity for conscious thought. If this is the case, it must be true that there is something uniquely human about our brains, some feature that makes us special. Agree or disagree, it is a fact that the human brain is one of the most complex biological machines we have encountered in the world—indeed, there is still so much we have to learn about it.

This, in my opinion, is what makes neurological disease so devastating. Patients with Alzheimer's, Parkinson's, Dementia—and even psychiatric disorders such as depression or anxiety—lose control and autonomy over that special aspect of our humanity. I mean not to say these conditions make someone any less human—on the contrary, they represent the human condition best by showing us how delicate the balance is between healthy and unhealthy brains.

Brain disorders can usually be traced to "faulty wiring". While the causes are deeper, most manifest in the way of neurobiological circuitry performing differently than is expected. One classic example is epilepsy, where random electrical disturbances send patients into life-threatening seizures. To predict the onset of epileptic seizures and treat them is among the holy grails of neurology, but the brain is hard to study.

How do we look into brains, then?

Back in the old days, they'd just cut your head open. Of course, we can't do that anymore, not that that provides the best information anyways. No, the best way to study the brain is when it's hard at work, and numerous medical tools have been developed to study the basic physiology of the brain.

Perhaps most commonly used are MRI, CT, and PET scans. These scans are used for a variety of imaging purposes, but they've made their way into staple positions in the world of neuroimaging.

The technical details of each of these techniques are interesting because of the quality and quantity of information that they now afford us, but perhaps beyond the scope of my aims in this piece. What I will say is that each provides different and unique perspectives on the structure and function of the brain. Techniques like fMRI can study changes in blood flow to regions of the brain during select activities, a feature that has allowed us to image which areas of the brain are associated with different cognitive processes and difficulties. The advent of computerized reconstructive methods has allowed us to hone into brain structure with far greater detail than previously allowed, making neuroimaging an incredibly rich field.

But new technology hasn't just given us an inside look at the brain. It's also given us a toolbox to therapeutically target areas of the brain. These neuromodulatory tools, though new to the game relatively speaking, are pushing the ways we treat disorders in totally new ways that exploit the key connection between electromagnetism and brain physiology. While there are so many new tools out there, the two I want to discuss here are Deep Brain Stimulation (DBS) and Transcranial Magnetic Stimulation (TMS).

Deep Brain Stimulation

DBS is very commonly used to alleviate symptoms of Parkinson's Disease in patients for whom medication is no longer sufficient. The principle is simple—carefully insert electrodes into specific areas of the brain and inject directed pulses of current. There is no consensus on how exactly this seemingly gruesome technique works, but plenty of research to suggest that it does.

DBS was "born" in the 50s when unethical studies were done on psychiatric patients to "cure them". Tantamount to invasive electroshock therapy, these patients were often not cured, and the results were fairly inconclusive. Though we would be remiss in ignoring this early past of DBS, most scholars note that its modern instance was first developed by Alim Benabid, a French-Algerian neurosurgeon who first used DBS to alleviate Parkinsonian symptoms.

When Parkinson's Disease Patients show signs that their current dose of medication does not seem to effectively manage their symptoms, they are often recommended for DBS surgery. Their physicians will decide upon ideal targets for DBS, generally in one of four areas of the brain (those in bold are most frequently used):

- **Globus Pallidus Internus**
- **Subthalamic Nucleus**
- Thalamus
- Pedunculopontine Nucleus

Upon inserting electrodes into some of these specific regions, small current pulses are delivered. This has the effect of somehow "resetting" the electrical activity in the region—the effects, diverse in nature, generally show relief of Parkinsonian symptoms.

DBS is now being studied as a possible intervention tool for other disorders. Most notably, some hypothesize it could be used to treat clinical depression, which could be a huge advance in our treatment of mental health disorders.

It's important to note, of course, that DBS is an invasive neurosurgical technique. And while surgical practice has become exponentially safer over the decades, a healthy degree of caution should be employed by both physician and patient before deciding to embark on a DBS treatment plan. Ultimately, we should work to render as much benefit as possible to patients while minimizing their suffering, and sometimes nonsurgical interventions might be safer.

This brings me to the next tool in our toolkit: transcranial magnetic stimulation.

Transcranial Magnetic Stimulation

Around 10 years after the Galvanis discovered a deep connection between biology and electricity, a young Michael Faraday was born in England. He had little formal education, but taught himself the sciences and would later go on to study Chemistry under the renowned Sir Humphrey Davy, perhaps the most famous chemist of his time and the discoverer of many common metals such as sodium and potassium.

Michael Faraday conducted experiments in electrochemistry and made use of batteries extensively [incidentally, the first battery was built by Alessandro Volta, Galvani's own student, possibly in the interest of discrediting Galvani's work]. His research led him to the strange discovery that magnetic fields could induce electric currents and vice versa—he termed this electromagnetic induction.

Induction is now employed in almost every electronic device you can find. Most electric motors and generators operate on this basic principle: a changing magnetic field can give rise to electric currents, and changing electric currents can give rise to magnetic fields.

Of course, scientists and physicians, upon discovering the electrical nature of the brain, wanted nothing more than to apply electrical stimulation to the brains of the ill and observe the results. So was born electroshock therapy, and its more humane child transcranial electric stimulation. These therapies rely on the basic idea that applying electric voltages and electric currents across the scalp can stimulate neural activity inside the brain. Patient outcomes have been positive, but there are risks and side effects, and generally, these techniques can cause pain in the patients.

In looking for gentler treatments, Dr. Anthony Barker, a physicist and engineer by training, imagined that the principle of induction could be used to generate small currents in specific regions of the brain. This idea became what is now known as transcranial magnetic stimulation—the use of magnetic fields to induce currents in the brain.

Today, TMS has found use as an FDA-approved treatment for clinical depression. Substantial research efforts are underway to determine its utility in treating other psychiatric disorders, as well as neurodegenerative diseases. There is already some evidence that it can benefit Parkinson's patients. In the interest of transparency, I should note that many studies performed to analyze the effectiveness of TMS do not use the most rigorous standards of blinding and placebos that might be expected of outstanding clinical research—but I think it is fair to say that TMS does show promise as an excellent therapeutic aid.

Most importantly, TMS is non-invasive. There is no head opening involved here. In other words, if we can develop TMS treatment protocols for more neurologic diseases, we can not only better patient symptoms but reduce the risk of negative surgical outcomes. I'm excited to see what the future of non-invasive neuromodulation holds because it's clear to me we'll be seeing some really special innovations in the coming years.

What if we could just do it ourselves?

Neuromodulatory tools are fantastic. To be able to use technology to directly manipulate specific areas of the brain such as inhibiting centers of addiction, or exciting the motor cortex, is an amazing advance in neuroscience and neurotechnology.

But some neurobiologists might tell you that you don't have the whole story. They hope that, maybe one day, we may be able to avoid using any of these tools at all.

Our brains are known to be somewhat plastic. At early development, different regions of the brain adopt different functions, and structure and function are fluid. This is why small children, when impacted by head trauma or brain surgery, generally come out more or less fine. Some children have even had entire halves of their brains removed, and they live a generally normal life.

The child's brain is a magnificent example of neuroplasticity—the idea that the brain can change, morph, and rewire itself to adopt as many functions as possible. Interestingly enough, as we grow older, we start to lose this ability—but it doesn't go away completely. Some suggest that it is the brain's neuroplasticity that allows for tools like TMS and DBS to have any utility at all. They argue that these tools directly stimulate some sort of neuroplastic rewiring to correct a faulty system.1

That's probably at least part of the story. This gives me hope that, perhaps one day, when we've figured out how the brain rewires itself, we can try to get it to heal itself. Psychiatrist Norman Doidge writes extensively on the topic in his aptly named book The Brain that Changes Itself and its sequel, The Brains Way of Healing. The subject matter and the extents to which Doidge takes his conclusions are generally controversial, so I will refrain from discussing them in detail—but if nothing more, they provide an excellent set of stories for all of us to get our gears turning about the wonderful capacity our brains may have to change and heal after injury.

Where to from here?

In 1798, Luigi Galvani died quietly in his home, having lost most of his money and status in the wake of a regime change in Northern Italy following the French Revolution. We stand today, over 200 years later, on the shoulders of giants who built upon his work in electrophysiology. From those early experiments on frog legs to neuromodulatory devices, our road has taken us far and I believe will take us farther.

I promised you when we began this journey that I would show you how we can change our brains. I hope I've convinced you of this fact. In the next few decades, I believe we'll see the use of more neuromodulatory techniques in treating mental health. It remains to be seen whether we might see this as changing the brain, or changing the mind. I'll let you sit with that—frankly, I struggle to answer with certainty myself.

If you take nothing else away, hold on to the appreciation you may have gained for how far we have come, and how much further we have to go, in our path to develop tools to study and heal nature's most complex machine—the human brain. ■

Falowski, S. M., Sharan, A., Reyes, B. A., Sikkema, C., Szot, P., & Van Bockstaele, E. J. (2011). An evaluation of neuroplasticity and behavior after deep brain stimulation of the nucleus accumbens in an animal model of depression. Neurosurgery, 69(6), 1281–1290. https://doi.org/10.1227/neu.0b013e3182237346

It’s Time (Again) to Consider Psychedelic Drugs as a Treatment to Neuropsychiatric disorders:

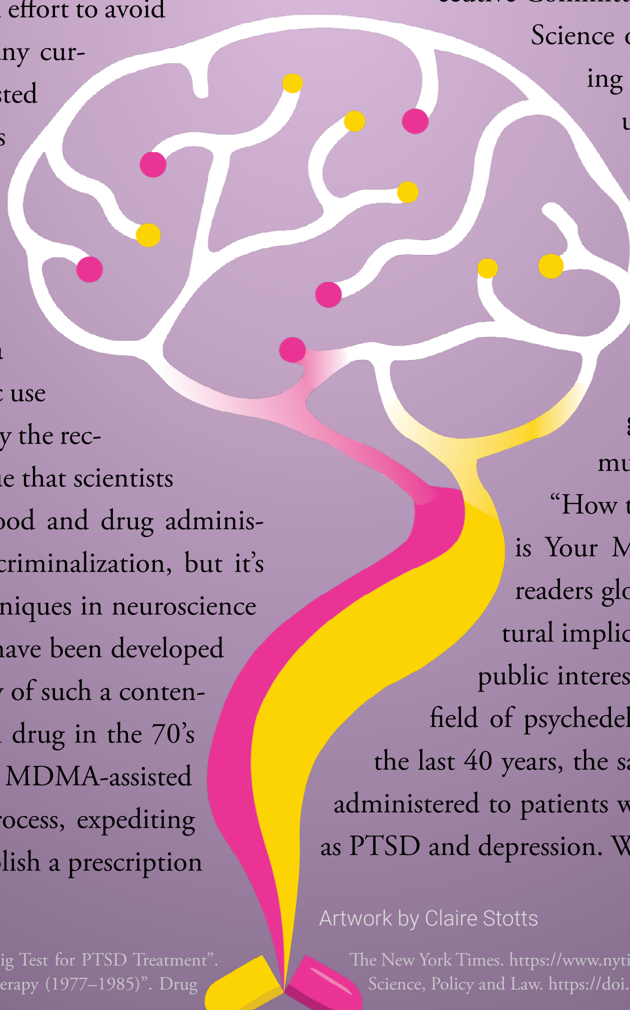
MDMA-Assisted Therapy and PTSD

By Hana Massab

History of MDMA use in psychotherapy

Merck pharmaceuticals first synthesized 3,4-methylenedioxymethamphetamine (MDMA) in 1912 as a medication to control for bleeding, but the drug was largely forgotten in the following decades. In 1976, the great American chemist, Alexander Shulgin synthesized MDMA in his laboratory, giving rise to a wave of an underground network of therapists who used MDMA in their studies and practice of drug-assisted psychotherapy. Due to the prohibition of other drug-assisted therapies that used LSD and psilocybin, many therapists were reluctant to publish their findings in an effort to avoid any media attention that could halt any current and future studies. MDMA assisted therapy was practiced in the early 70’s and remained inconspicuous from any form of government regulation up until the year 1983. In 1984, the Drug Enforcement Administration (DEA) criminalized MDMA as a schedule I substance[1,2]. The therapeutic use of MDMA was largely overshadowed by the recreational use of MDMA. One can argue that scientists should have considered filing for a food and drug administration (FDA) approval ahead of its criminalization, but it’s important to understand that the techniques in neuroscience and technology at that time may not have been developed enough to establish the clinical validity of such a contentious and commonly used recreational drug in the 70’s and 80’s. Now, the FDA has regarded MDMA-assisted psychotherapy as a “breakthrough” process, expediting the final stages of clinical trials to establish a prescription medicine for MDMA-assisted therapy.

From a western science standpoint, psychedelic science is in its renaissance period – a time wherein advancing techniques in neuroscience and molecular and cell biology, can now allow for us to better understand how these compounds interact with our brains. We can now go from asking questions such as “how can psychedelics induce plasticity” to “how can these compounds and mechanisms potentially mimic psychedelic plasticity in treatment therapeutics”, says Andrea Gomez, Ph.D., a Professor of Neurobiology and a member of the Executive Committee of the UC Berkeley Center for Science of Psychedelics. New and on-going studies into psychedelics continue to support the validity of these compounds for clinical use. UC Berkeley Professor of Journalism and New York Times best-selling author, Michael Pollan, has also played an instrumental role in bridging the gap between the scientific community and the public. His books, “How to Change Your Mind” and “This is Your Mind on Plants”, have informed readers globally about the medical and cultural implications of psychedelics, increasing public interest and giving more validity to the field of psychedelic science in the last decade. In the last 40 years, the same treatment response has been administered to patients with mental health disorders such as PTSD and depression. What was the result?



Artwork by Claire Stotts

1 Nuwer, Rachel. (2021). “A Psychedelic Drug Passes a Big Test for PTSD Treatment”. The New York Times. https://www.nytimes.com/2021/05/03/health/mdma-approval.html.
2 Passie, T. (2018). “The early use of MDMAin psychotherapy (1977–1985)”. Drug Science, Policy and Law. https://doi.org/10.1177/2050324518767442

PTSD, one of many neuropsychiatric disorders, affects 9 million people in the United States annually and more than 350 million people worldwide 3. More than half of the people with PTSD don't respond to current FDA approved prescription medications and treatment therapeutics[3,4]. The perennial increase in the number of people with mental health disorders and diseases is continuing to outpace and overwhelm treatment methods intended to address them. Let's not forget the social and economic burden carried by this disorder. There is a need now more than ever, for the translational application from psychedelic studies to directly benefit the patients themselves in clinical settings. An unprecedented study conducted by the Multidisciplinary Association of Psychedelic Studies (MAPS) involving the use of MDMA and psychotherapy as a treatment for PTSD[3,5] is at the forefront of all of this. In the face of a global mental health crisis and with increasing technological and scientific advancements that support the clinical utility of drug-assisted psychotherapy, MDMA- assisted psychotherapy is a leading example of the future of mental health treatment.

PTSD has a high degree of comorbidity with other psychiatric and medical conditions. Individuals with severe and chronic PTSD and a comorbid psychiatric condition such as depression, substance abuse disorders, dissociation, and suicidality, are typically considered to be treatment resistant[4] and stand to benefit the most from this study. Comorbid medical conditions can range from autoimmune disease, cardiovascular and pulmonary disease, traumatic brain injuries, and neurodegenerative disorders such as dementia. Trauma from sexual assault and interpersonal-network experiences such as a loved one passing away, make up the largest proportion of PTSD cases today. An estimated 7% of the entire U.S population will experience PTSD in their lifetime. As many as 13% of war veterans have this condition.[1,3,6,7] There is a spectrum of direct and indirect experiences, ranging from childhood well into adulthood, that can trigger PTSD. Of the current treatment measures, millions of patients don't experience a significant effect and change in their lives, resulting in chronic and often worsening symptoms of PTSD. Although this calls for an impending need for novel approaches, it is also important to understand the skepticism surrounding such a treatment.

Let's address the public's hesitation - MDMA is not the same as the more commonly known and recreationally inoculated drugs such as ecstasy or molly. These latter compounds are marketed as MDMA but are often mixed with other drug traces[1,2] in varying and unknown concentrations that can threaten your physiology and possibly lead to deaths. The setting at which these drugs are taken also play a critical role in influencing your state of mind. Pure MDMA, taken in a secure environment, has been proven to be safely consumed by humans when taken under moderately repeated doses. The use of pure MDMA under these conditions[6] is what is found to enhance psychotherapy in patients with PTSD. Dr. Roland Griffiths, director of the Johns Hopkins Center for Psychedelic and Consciousness Research emphasizes that studies conducted by MAPS for example, are by no means communicating "these drugs as risk free".[6] It is critical to note that the participants, therapists, researchers, and organizations involved in these studies, all openly acknowledge that the safety and efficacy of this form of therapy,[4] although showing promising results thus far, is still under investigation; there are still risks considering that it does not work for everyone. Yet, this study, at the very least, is worthy of our attention as PTSD continues to affect and drastically reduce the overall quality of life of millions of people worldwide.

Alternative therapies such as MDMA-assisted psychotherapy are a step away from the disservice of the band aid solutions commonly used to address neuropsychiatric disorders. One of them being the use of selective serotonin reuptake inhibitors (SSRIs) or anti-depressant medication as the primary FDA approved therapeutics for PTSD treatment. An estimated 50% of patients do not respond to these drugs, which requires chronic patient intake and is notorious for its late onset, taking anywhere between 2 weeks to months until any form of relief is felt.[4,6] Dr. Bill Jagust, Neurologist and Professor of Neuroscience and Public Health at U.C Berkeley, says that "there is still an on-going argument on the overall effectiveness" of SSRI. He stresses that "we can still do better, both in the short and long term". In the current phase 3 FDA trial of MDMA assisted psychotherapy, 65.5% of participants in the current trial have had a lifetime history of SSRI use,[4] reflecting a need for

3 "MDMA-Assisted therapy for PTSD". Multidisciplinary Association for Psychedelic Studies. MAPS. https://maps.org/mdma/ptsd/

4 Mitchell, J.M., Bogenschutz, M., Lilienstein, A. et al. (2021). MDMA-assisted therapy for severe PTSD: a randomized, double-blind, placebo-controlled phase 3 study. Nat Med 27, 1025–1033. https://doi.org/10.1038/s41591-021-01336-3

5 "A multi-site phase 3 study of MDMA-Assisted therapy for PTSD (MAPP2)". (2021). Multidisciplinary Association for Psychedelic Studies. https://maps.org/mdma/ptsd/mapp2/

6 "MDMA Investigator's Brochure". (2020). Multidisciplinary Association for Psychedelic Studies. https://maps.org/wp-content/uploads/2013/11/MDMAIB12thEditionFinal17AUG2020.pdf.

7 Sareen, J. (2021). "Posttraumatic stress disorder in adults: Epidemiology, pathophysiology, clinical manifestations, course, assessment, and diagnosis". UpToDate. https://www.uptodate.com/contents/posttraumatic-stress-disorder-in-adults-epidemiology-pathophysiology-clinical-manifestations-course-assessment-and-diagnosis

alternative treatments. On the other hand, the pharma model for MDMA is completely different, the relief is immediate and lasting, without the need to take it chronically. MDMA taken in isolation, without any therapy, is considered to not have a significant beneficial effect on people with PTSD. On the other hand, psychotherapies alone have a high participant dropout rate, showing little to no significant reduction in symptoms and continued poor response.[4] The efficacy of these trials greatly depends on MDMA and psychotherapy working together to enhance the overall treatment of a patient with PTSD.

Not all psychedelics share a similar neural activation pathway. MDMA particularly, has a broader activation pathway compared to that of the more commonly known serotonergic binding pathways such as psilocybin, an active compound found in psychedelic mushrooms, as well as LSD. Psilocybin and LSD are known for bringing out a sense of interconnectedness, out of body experiences, and strong visual hallucinations. MDMA on the other hand, gives you a more grounded feeling, with an increased level of self-awareness. MDMA binds to serotonin regulatory proteins, increasing serotonin release in the synaptic cleft, the region found between two neurons. It is also considered as an empathogen, elevating dopamine and oxytocin levels in the brain and increasing a sense of trust and bonding.[1,2] Unlike the more common psychedelics, MDMA has been seen to have a direct effect on the amygdala, our brain's fear and emotion center, more known for being responsible for our flight or fight response. This region is particularly hyperactive in people with PTSD. In those who participated in MDMA-assisted therapy, magnetic resonance imaging (MRI) data shows a direct reduction in a hyperactive amygdala.[4]

Let one pill change your mind

In the field of combat, life and death could be a matter of an inch or a couple of feet apart. For Army and Marine Corps veteran Jonathan Lubecky, it was the difference of sitting down and standing up. He recalls the time he nearly escaped death when he was deployed in Iraq in 2006 and a mortar crashed down the very room that he was sitting in. He adds that if he had just stood up, "the shrapnel would have gone through me instead of in front of me". After retiring in 2009, he would face a new set of daily battles. Lubecky had suffered from having nightmares almost every night, struggled through repeated suicidal thoughts and attempts, turned to liquor and marijuana, and at one point was taking close to 40 pills every day just to cope with the severity of his PTSD.[8] Desperate for a way to find himself and regain some sense of normality in his life, the veteran decided to take part in a study conducted by MAPS involving the use of MDMA and psychotherapy. Five years later, Lubecky has not since had either PTSD or MDMA.

On-going clinical trials

Jennifer Mitchell, a Neuroscientist at the University of California, San Francisco, along with her team, is leading the randomized double-blind MDMA- assisted psychotherapy study sponsored by MAPS. The study is now in its critical second phase 3 trial, the final step needed for FDA approval. Data are currently being collected by a total of 80 therapists in fifteen different sites across the U.S, Canada, and Israel. Participants were either given 80-180 mg of initial and supplemental doses of MDMA (experimental) or placebo (control). The participants in this study are all patients diagnosed with severe PTSD for 14 years on average. Of these 90 participants, 90% have considered suicide and many battled other comorbidities such as substance or alcohol abuse, depression, dissociation, or childhood trauma. Participants had to first undergo psychiatric medicine washout to clear their system prior to their involvement in three preparatory sessions and three 8-hour experimental sessions, spaced four weeks apart. This was followed by three 90-minute integrative sessions spaced one-week apart.[3,4,6] This clinical trial does have its limitations, the participant cohort is predominantly white, lacking ethical and racial diversity. PTSD is a condition commonly found in populations with high rates of traumatic experiences and health disparities, stressing "the importance of accessibility of these types of treatments to people of color and folks with lower socioeconomic status" says Albert Garcia-Romeu, a psychopharmacology researcher at Johns Hopkins.[1] If this final phase 3 trial is proven successful and a positive result similar to that of the first phase 3 trial is attained, the FDA will approve the use of MDMA for psychotherapies.

Novel therapeutics are needed for PTSD patients, especially for those whose comorbidities are often associated with treatment resistance. At the end of the first phase 3 trial, "67% of participants in the MDMA group no longer met diagnostic criteria for PTSD compared to 32% of participants in the placebo group."[3] Results of this study also show that MDMA-as-

8 Saintsing, M. (2020). "PTSD Breakthrough". Disabled American Veterans. https://www.dav.org/learn-more/news/2020/ptsd-breakthrough/. #

sisted therapy significantly reduced functional impairment. An exploratory analysis on MDMA therapy is shown to mitigate depressive symptoms. Findings also show that this treatment is equally as effective among participants with comorbidities that confer treatment resistance.[4] "It's not the drug - it's the therapy enhanced by the drug", said Rick Doblin,[1] senior author and director of the study. Although the second phase 3 trial is still on-going, the clinical results of this first phase 3 trial is unlike anything ever recorded for a neuropsychiatric disease. This may be the first study that can give global validity to the therapeutic and medicinal potential of psychedelics as a whole.

Inducing specific neural plasticity

MDMA-assisted therapy has shown that psychedelics can induce a positive and highly selective type of neuroplasticity. This means that these drugs can immediately make changes to our brains, reorganizing neural pathways to alter a person's frame of thinking within hours of intake. Despite a lack in the cellular and molecular understanding of how and where these compounds are working in our brains, there is evidence to prove that "psychedelics can induce a positive outcome and help us further understand how the brain works and functions," says Dr. Gomez. MDMA-assisted psychotherapy is a prime example of inducing specific neural plasticity to allow our brains to process painful memories and heal, a task that seemed impossible to accomplish for many, prior to this form of therapy. If there is at all a chance that someone like Lubecky, a veteran who persistently contemplated through suicide at one point in his life, could find a way to change how his mind deals with and understands his trauma and eventually overcome his severe PTSD, we can now begin to see how psychedelics and drug-assisted psychotherapies can induce neural plasticity, change our minds, and treat a spectrum of other neuropsychiatric patients.

Indigenous science

I alluded to the term "western science" earlier in this article because it is important to recognize that indigenous science has been at the forefront of psychedelic medicines, backed by hundreds of years of understanding the meaning behind and the relationship between these medicines to both the natural world and the self. While concepts in western science are often compartmentalized, "the interconnectedness of Indigenous science is powerful and has its own space," says Dr. Gomez, who is both a scientist and a member of the Indigenous community. Indigenous science undoubtedly has its own genius - having its own set of rules and logic. The western frame of thought tends to place knowledge in a hierarchy of value, using a credibility metric ranging from most to least objective, placing scientific findings from a laboratory setting at the very top, while placing indigenous science and its practices at the bottom. We have to take into account our own biases when talking about this renaissance period of psychedelic science, speaking mainly from a western science standpoint.

The clinical trials for MDMA-assisted psychotherapy are the very first drug-assisted therapies that have reached the FDA's phase 3. If successful, this could trailblaze a path to potentially treat many other neuropsychiatric disorders, as well as to tap the potential of other psychedelic drug studies to be considered as valid treatments for mental health disorders. Mental health hits close to home for many of us. For some people, studies like these could be the difference between life and death. It could mean no longer having a lifelong dependency on costly prescription medications and therapy sessions. You don't have to be a physician, a researcher, a student in this field, a patient or a patient's loved one, to see that this is a major breakthrough in neuropsychiatric treatments. Backed by decades worth of research and clinical trials, this form of therapy gives people a chance to not only heal from their trauma but to find a way to identify themselves again long-term. This is the future of severe mental health treatment. This is the time for the therapeutic use of MDMA to overshadow its recreational use. The pressing need for alternative PTSD treatments is evident and MDMA-assisted psychotherapy is leading the way in the translational application of psychedelic studies to directly and immediately meet the needs of a patient in a clinical setting. ■

Red vs. Blue:

The Neuroscience Behind Politics

By Iris Lu

Bipartisanship: an elusive concept that seems so close to fruition in modern day American politics, yet so far.

The idea of cooperation between Democrats and Republicans is easy to agree with -- after all, who wouldn't want the two political parties to get along? Surely, the government would get much more work done if only people were able to work together.

But as attractive as the idea of "bipartisanship" is, it remains just that -- an idea. Despite all the praise that comes with moving towards a more unified political ground, the gap between Democrats and Republicans continues to grow as time goes on. In 2019, only ~15% of Republicans thought that the Democratic party had "good ideas", and vice versa, a number that has certainly decreased over the years.[1]

This current divide is a growing American political issue, resulting from years of party instability. The past decades have been filled with 49-percent election results, with neither Democratic nor Republican parties succeeding in becoming a concrete majority. Each teeters on the edge of the 50-percent mark, never finding their foothold in the climb for stable political control.

Such desperation only exasperates the need for party loyalty.

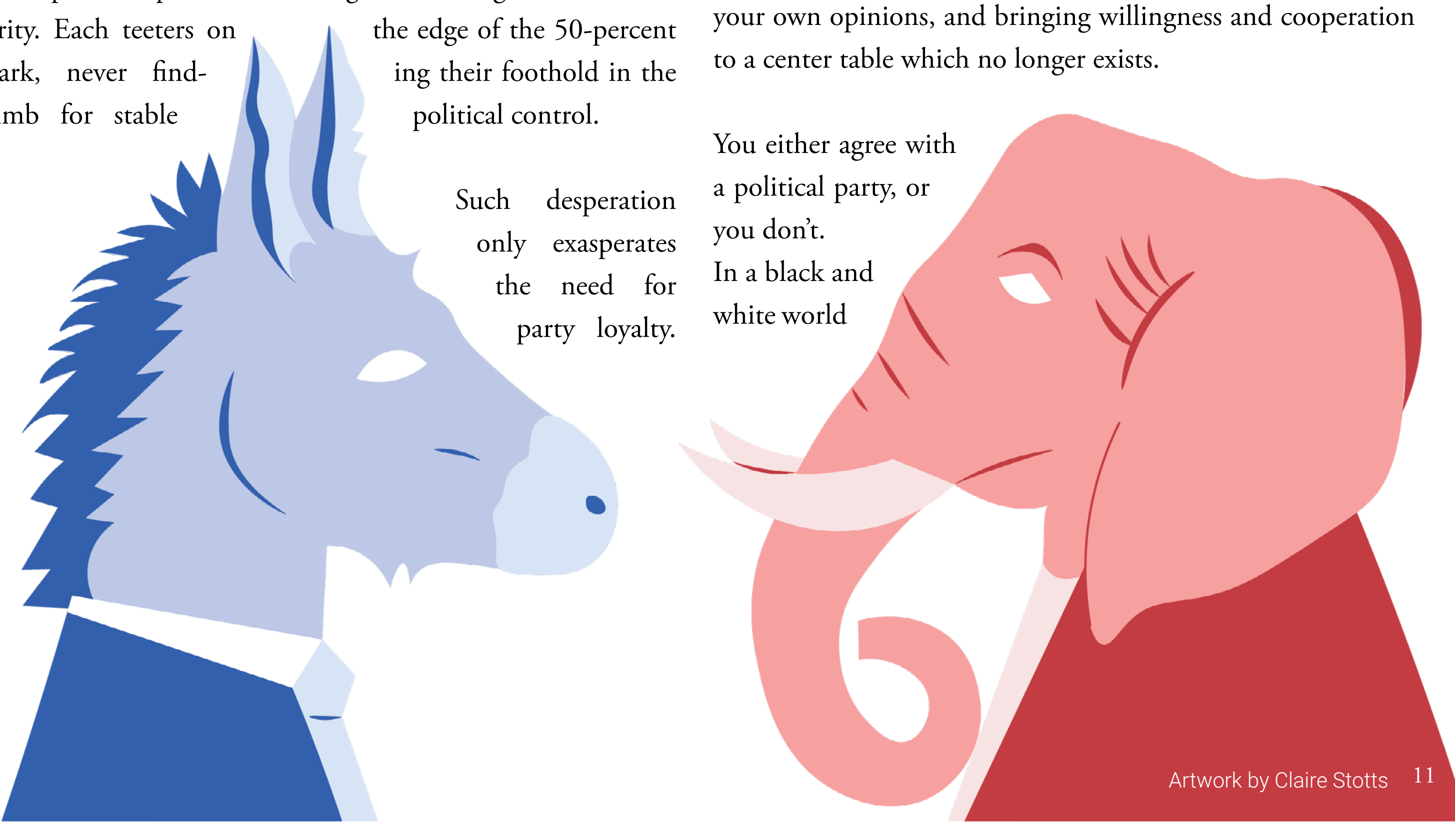
Any agreement with the "other party" is traitorous -- supportive of those who aren't completely inline with your political beliefs. And when political beliefs slowly become entrenched in personal identity, the divide between two parties only widens.

With the advent of the 21st century, political parties have become more and more polarized -- partially due to the widespread use of social media. Platforms encourage those who may have felt their voice unheard to speak up through Facebook and Twitter posts, finding that their opinions may resonate with someone across the country -- someone they may have never met. And as they interact more and more with someone they agree with, and only agree with, an echo chamber develops.

It is easy to remain steadfast to your political beliefs when others support it, especially when there are thousands of people over the internet by your side -- and soon it becomes a competition of "them" versus "us".

Everybody likes bipartisanship, and everybody likes working together -- but nobody wants to do it. Because actively creating a cooperative political atmosphere requires conceding some of your own opinions, and bringing willingness and cooperation to a center table which no longer exists.

You either agree with a political party, or you don't.
In a black and white world



Artwork by Claire Stotts

with no room for negotiation, the definition of "cooperation" has turned from "working together" to "they give up, while we get our way".

What makes us so unwilling to change our minds? The political instability over the past years has greatly contributed to polarizing differences in ideologies and opinions, but perhaps there is a deeper, more physical reason for this division.

The Emergence of Political Neuroscience

Neuropolitics: the study of the interplay between neuroscience, and political science.

Adherence to a certain political ideology is dependent on a variety of factors, including but not limited to religion, social class, or even social media use. Because of this, a number of political behavior studies are analyzed in the realm of social sciences, choosing to look into how an environment cultivates a certain ideological behavior.

In her 2020 paper on the Psychology of Ideology, Dr. Leor Zmigrod defines ideological thinking as "rigid in its adherence to a doctrine and resistance to evidence-based belief-updating, and favorably-oriented towards an ingroup and antagonistic to outgroups".[2] An ideological person will consistently resist any arguments or forms of credible evidence that goes against their own, while simultaneously supporting any other opinion that is supportive.

This type of rigid thinking consistently reinforces the mentality of "them", versus "us". Though not everybody shares the same group mentality, some may be more vulnerable to this political polarization than most. A standard behavioral science approach would question what could cause someone to be vulnerable to this adherence -- perhaps stubbornness or preexisting biases -- but doing so locks the issue into a single perspective. Perhaps what we should be asking isn't what causes, but what already is.

How does brain structure and function impact political ideologies? What exactly happens in the decision making process, and how does this affect which side a ballot is cast in an upcoming election?

The Amygdala

The first major structural difference between liberal and conservative brains starts at the amygdala. Located at the middle of the brain next to the hippocampus, the amygdala is the core center for emotions, motivation, and expression of fear.

The 2013 book, Predisposed, sets a baseline difference between conservative and liberal individuals by outlining the difference in the amygdala's size: while at an average size for liberals, it is significantly larger in conservatives.

These differences demonstrate contrasting sensitivities in each political party. When compared to liberals, conservatives are much more sensitive to threats and anxiety, but simultaneously more adjusted when it comes to psychological well-being.[3] This sensitivity to fear demonstrates a pattern that helps to explain right-wing ideologies -- using an example of the current U.S. federal budget, it becomes clear as to why a conservative brain would be on higher alert against possible threats, potentially causing them to prioritize the need to raise spending for the Department of Defense compared to more egalitarian motions.

Furthermore, a vital aspect of the conservative ideology is individual free-will -- one that requires sensitivity to possible risks precisely so that this freedom is not encroached upon by federal laws or restrictions. Especially in light of the COVID-19 pandemic, where many Republican politicians find themselves arguing against mask mandates, we see many Senators fighting against the law in fear that it will violate their personal freedoms.

But despite their sensitivities, conservatives still retain a greater psychological resilience. Whether it may be because of pre-existing self regulatory mechanisms, or a measure of contentment with life that liberals just don't have, conservative individuals tend to have a higher level of life satisfaction. Most obviously displayed in their own moniker, conservatives are certainly much more content with conserving the status quo.The cultural and social institutions that govern the land work perfectly fine without meddling or interference -- and that is enough.

1 https://www.pewresearch.org/politics/2019/10/10/the-partisan-landscape-and-views-of-the-parties/
2 https://psyarxiv.com/ewy9t/
3 https://www.scientificamerican.com/article/conservative-and-liberal-brains-might-have-some-real-differences/

The Anterior Cingulate Cortex

Located on the middle surfaces of the brain's frontal lobes, the anterior cingulate cortex is the center for complex cognitive functions including empathy, impulse control, and decision-making.

Just as how Predisposed highlighted the importance of the amygdala in conservatives, the same book recognizes liberal individuals to have a greater volume of gray matter (neuronal cell bodies) in their anterior cingulate cortex compared to conservatives. These results were later replicated in a 2020 study on stress resilience and political attitudes, also discovering that liberals were more responsive, but simultaneously tolerant towards ambiguous information.[4]

All of these structural differences showcase a focus on error detection and conflict resolution in liberal brains. When using the same example as before concerning the current U.S. federal budget, liberals are more likely to be more supportive of acts such as universal healthcare -- a law that would solve an age-old issue of healthcare access in the country, while making significant changes on the pre-existing system.

It is important here to consider the anterior cingulate cortex's role in decision-making: when confronted with ambiguous information, liberal individuals are much more hesitant to take a congruent stance so quickly.[5] Perhaps this hesitation is the exact detail that prevents political polarization and party loyalty in both liberals and conservatives alike -- the capacity to avoid impulsive black and white thinking.

Above all else, a key neurological difference between these two ideologies remains to be their reaction to uncertain information.

The Yuck Factor

At its core, the largest difference between conservative and liberal brains is their sensitivity to disgust. Over the years, fMRI research has continued to emphasize the relevance of disgust to political partisanship -- especially when that disgust is measured in response to nonpolitical imagery.[6]

As seen in conservative brains that have a larger amygdala, conservatives are more sensitive to threats and anxiety, increasing their sense of disgust. In contrast, liberal brains -- with a greater volume in the Anterior Cingulate Cortex -- are more tolerant of ambiguous data, and less impulsive when making decisions. When all of this is combined, we see conservatives to have a greater disgust response overall compared to liberals.

These responses within political parties were strikingly similar, regardless of the photo's context. Even if the visual stimuli presented was of a dirty bedroom or physical violence, individuals who reacted with a strong sense of disgust were most likely to align themselves politically as conservative.

Perhaps this sensitivity is not just a litmus test for cleanliness, but an indication of a group mentality. Just like how political partisanship is based on "us" versus "them", knee-jerk reactions of disgust demonstrate just how rigid an individual is in their loyalty to their political party. With how ideological thinking is dependent on favorable thinking towards an ingroup and antagonism towards any outgroups, strong, impulsive emotions of disgust demonstrate exactly that.

Despite it all, there's still more to be considered. Being more grossed out at dirty laundry than your peers doesn't automatically label you as a far-right conservative, and being okay with not cleaning your room for a month doesn't mean you're a member of Antifa.

The political spectrum still remains a wide range, and even the brain structures specified previously aren't sure-fire indicators of an individual's political alignment. There exists nuance and gradation in each and every thought -- not every conservative has a larger than average amygdala, and not every liberal hesitates when making an important decision.

On The Campaign Trail

So what do we do with this information?

As we gain more and more insight into the inner workings of our own brain and political alignments, it's inevitable that it becomes a part of the campaign process as well.

4 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7522714/
5 https://www.scientificamerican.com/article/conservative-and-liberal-brains-might-have-some-real-differences/
6 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4245707/

Political campaigns across the world grow hungrier for information on their voters by the day. And while data analysis of voters' reactions on Facebook may still feel like recent events, there are dozens of other tactics that well-funded campaigns may employ in order to perfectly appeal to their target audience.

Neuropolitka, a neuromarketing firm in Mexico City that focuses on providing neurological information specifically for large campaign teams, utilizes many of the studies mentioned earlier pertaining to structural differences in the brain. Like so many other companies, they prefer to use electrodes on the scalp to measure and analyze activity in different areas of the brain. Additional algorithms compile this data and pinpoint specific moments where voters might be more attentive to a candidate's speech, or perhaps the opposite.[7]

The most advantageous part of all this is that the data speaks for itself. Voter information can be hard to compile, much less appeal to -- and many citizens don't even know their own feelings when it comes to politics. Measuring the physical differences and reactions in their brains removes the dreaded subjectivity and complexity that comes with being on the campaign trail, greatly simplifying the entire process. It becomes much easier to rally people to a side when their fears and thought patterns are understood, even more so when it is backed up by neuroscientific evidence.

While the field of neuropolitics may be effective across the world in marketing politicians to seas of voters, its place in a bipartisan America is still beginning. Political differences between individuals are so much more than just clashes of opinions, lifestyles, or financial status -- they are ingrained in us so deeply that they are less of how we think, but who we are.

And that will never change. ■

7 https://www.technologyreview.com/2018/08/16/141016/the-neuropolitics-consultants-who-hack-vot

Change My MIND:

Via Perception

You've Never Heard of the Most Important Part of Your Brain

By Jacob Marks

Artwork by Megan Lui

A Needle in the Haystack

What is the most important part of the brain? The prefrontal cortex? The brain stem? Maybe something on a smaller scale like a neuron? While some people may first think of the thalamus, I suspect very few would narrow their pick down to one of its 60 lesser known nuclei. Seated deep in the center of the brain, the thalamus is best—and most simply—known as a "relay station," a gate between raw sensory input and complex processing centers like the visual or somatosensory cortex. Even deeper within the thalamus is the centromedian nucleus (CM), thought to be a possible seat of consciousness and what I believe to be the most important part of the brain; however, it flies under the radar of academic and popular recognition.

If you have never heard of the CM (or any thalamic nuclei for that matter), you are not alone. When a former professor casually slipped in the CM's supposed importance in lecture, I was shocked. How could something so crucial go so unacknowledged? By looking at the CM's constant impact in your life and its ever-expanding clinical potential, I am sure it will *change your mind* too and show that that centromedian nucleus is the brain's most indispensable part.

The Connections

Located within both thalamic hemispheres, the CM is relatively large (about one centimeter across) and was fondly called by neuroscientist Edward G. Jones, "the forgotten [component] of the great loop of connections joining the cerebral cortex via the basal ganglia." Along with the cortex and basal ganglia, it also has extensive connections with the brainstem and insula, making it key for somatosensation, coordination, pain processing, and cognition.[1] In terms of sensorimotor coordination, it is believed that the CM regulates multimodal sensory stimuli (meaning multiple sensory inputs at once) and the activation of the dorsal striatum. The dorsal striatum is integral to decision-making and action initiation, proving that the CM is literally involved in every step you take.

Like sensorimotor coordination, pain processing, or nociception, is especially essential to human well-being. If nociception is too sensitive, seemingly innocuous activities like wearing clothes could become a painful experience. However if too insensitive, it could lead to recklessness and inadvertent bodily harm. The CM receives input from the brainstem and spinal cord's main pain pathway, modulating what signals are processed and to what degree, leading to connections with striatal neurons. Doctors found that in surgery to address nerve endings associated with chronic deafferentation pain, 80% of patients had "spontaneous, high-frequency rhythmic [electrical] bursts" in the CM region, indicating a significant connection between nociception and the thalamic nucleus.[2]

1 Ilyas, A., Pizarro, A., Romeo, A. K., Riley, K. O., & Pati, S. (2019). The centromedian nucleus: Anatomy, physiology, and clinical implications. Journal of Clinical Neuroscience, 63, https://doi.org/10.1016/j.jocn.2019.01.050

2 Rinaldi, P. C., Young, R. F., Albe-Fessard, D., & Chodakiewitz, J. (1991). Spontaneous neuronal hyperactivity in the medial and intralaminar thalamic nuclei of patients with deafferentation pain, Journal of Neurosurgery, 74(3), 415-421.

Deafferentation occurs when incoming signals from nerve cells to their destination are blocked. In humans, this can cause chronic pain when sensory signals from the peripheral nervous system are interrupted on their way back to the brain. An extreme, but well known example of this is phantom-limb pain, where spontaneous bursts of neuronal activity cause pain to be felt from a limb that is no longer there (usually after amputation). Though the full implications are yet to be uncovered, the CM's activity during deafferentation surgeries shows that its neurons do not degenerate when disconnected from their source. This means that their spontaneous activation may be a source of deafferentation pain and therefore a target for treating it.

Perhaps most importantly, the CM is connected to attention and arousal through similar pathways as sensorimotor coordination.[3] Using the same thalamostriatal loop and/or connections to the frontal lobe, the CM manages attention-demanding stimuli along with reward processing regions of the basal ganglia in order to direct focus to the most pressing situations. Research published in the journal *Cortex* has shown that strokes that cause damage to the centromedian and parafascicular nuclei complex greatly weaken cognitive task shifting.[4] "Shifting" is a principal executive process that allows us to consciously move focus to different areas that require attention. Difficulties with cognitive shifting have been correlated with autism spectrum disorder.[5] Adjacent to attention and arousal is the question of consciousness. Bilateral lesions to the CM have been found to induce comas and lasting vegetative states. On the other hand, scientists have been able to use deep brain stimulation on patients in order to restore their consciousness and eventually their normal lives, offering an alternative way to address debilitating brain disorders.[6]

New Opportunities

In 2002, after a misdiagnosis of multiple sclerosis, Steven Milke was told by doctors he had Parkinson's disease.[7] He was prescribed Levodopa, a common treatment for Parkinson's which increases levels of dopamine in the brain. Steven took the drug for five years, and near the end of that time period, his symptoms only worsened and he found himself taking two pills every three hours. With the high dosage, he began to experience uncontrollable muscle movement and cramping. This joined other Parkinson's symptoms like tremors, fatigue, difficulty speaking, and trouble walking. At that point Steven had the choice between deep brain stimulation (DBS) or stem cell treatment. Though he was scared by the chance that DBS would not work (the treatment has a 95% success rate), he elected for the implant surgery. The effects took time to set in, but after recovery and some adjustments, Steven no longer dealt with tremors, had few muscle issues, and was able to shower, type, dress, and walk on his own.

DBS is a surgical procedure where electrodes are implanted in the brain to treat disorders like Parkinson's and dystonia.[8] A pulse generator is put inside the patient's chest that sends small electric signals to interrupt the irregular signals that are responsible for neurological movement disorders and tremors. DBS is implemented when a person's medications are no longer effective, or their symptoms are hindering their daily lives. As the CM's importance has been realized, it has become a target of DBS to treat symptoms of Parkinson's, Tourette's, epilepsy, neuropathic pain, and to restore consciousness.

For Parkinson's disease, DBS focused on the CM has presented evidence of improving multiple symptoms. Compared to other treatments, it has relieved dyskinesias and freezing caused by Levodopa, while reducing tremors. General epilepsy patients showed an 80% reduction in seizures after CM targeted DBS, thought to be due to the CM's management of the brain's arousal systems. However, the treatment did not seem as effective on patients with different types of epilepsy, such as temporal lobe epilepsy, with under a 50% reduction in seizure observed over different studies. There has been some success bringing patients out of comas or vegetative states using CM targeted high-frequency DBS by "[inducing] EEG cortical desynchrony," while increasing cerebral blood flow and metabolism. It is not clear yet whether there is a causal relationship between improvements and centromedian DBS in clinical tri-

3 Saalmann Y. B. (2014). Intralaminar and medial thalamic influence on cortical synchrony, information transmission and cognition. Frontiers in systems neuroscience, 8(83), https://doi.org/10.3389/fnsys.2014.00083

4 Liebermann, D., Ploner, C. J., Kraft, A., Kopp, U. A., & Ostendorf, F. (2013). A dysexecutive syndrome of the medial thalamus. Cortex, 49(1), https://doi.org/10.1016/j.cortex.2011.11.005

5 Miller, H. L., Ragozzino, M. E., Cook, E. H., Sweeney, J. A., & Mosconi, M. W. (2015). Cognitive set shifting deficits and their relationship to repetitive behaviors in autism spectrum disorder. Journal of autism and developmental disorders, 45(3), https://doi.org/10.1007/s10803-014-2244-1

6 Gummadavelli, A., Kundishora, A. J., Willie, J. T., Andrews, J. P., Gerrard, J. L., Spencer, D. D., & Blumenfeld, H. (2015). Neurostimulation to improve level of consciousness in patients with epilepsy. Neurosurgical focus, 38(6), E10. https://doi.org/10.3171/2015.3.FOCUS1535

7 American Parkinson Disease Association. (2017, March 13). Steven's Parkinson's story. APDA. https://www.apdaparkinson.org/story/steve/.

8 Johns Hopkins University. (2021). Deep Brain stimulation. Johns Hopkins Medicine, hopkinsmedicine.org/health/treatment-tests-and-therapies/deep-brain-stimulation.

als, but there is great potential in further study.

Can There Be a "Most Important" Part?

One of the most famous stories in all of neuroscience and psychology is that of Phineas Gage. Gage, 25 years old at the time, was a railway worker in the mid-1800s and was described by his family and friends as well-mannered and a hard worker. In a terrible accident, an explosion sent an iron rod through his eye and most of his frontal lobe, effectively giving him a frontal lobotomy. Somehow, he survived, but as those around him said, he was "no longer Gage." The once even-tempered man had become aggressive, angry, and could no longer hold a job. This was revolutionary since it indicated that brain functions are localized and that the frontal lobe (specifically the prefrontal cortex) is involved in personality, language, and emotional control.[9]

Like many frontal lobotomy patients, Gage survived but was no longer himself. What does this say about the importance of the prefrontal cortex? Because Gage lived, does that mean the prefrontal cortex is not the "most important" part of the brain? If the brain stem or part of the thalamus are damaged, it leaves a person unconscious: does this indicate the utmost importance? Part of what makes the brain beautiful is its deep complexity. Unlike a kidney, there is essentially no part of the brain that can be removed or damaged without noticeable consequences.

Evidence suggests the CM is the seat of consciousness. It is involved in critical high level brain activity including arousal, attentiveness, and sensory and pain processing, all which are key parts of consciousness. Further, damage to the CM causes the loss of consciousness, indicating that the nucleus is part of what is keeping us awake and aware. However, this is not unique. Parts of the brain like the reticular formation and brain stem have similar roles in keeping us conscious, meaning that while the CM is not the seat of consciousness, it is a seat of consciousness. Whether it is most important among all other structures is nearly impossible to be completely certain of. However, I still do believe that with its diverse, vital functions and opportunities for clinical breakthroughs, the centromedian nucleus is the most important part of the brain. What is obvious is that the CM is not just a needle, but a diamond in the haystack that is the brain. With more study, it offers the opportunity to not just improve lives, but to fundamentally change them for the better. ■

9 O'Driscoll, K., & Leach, J. P. (1998). "No longer Gage": an iron bar through the head. Early observations of personality change after injury to the prefrontal cortex. BMJ (Clinical research ed.), 317(7174), 1673–1674. https://doi.org/10.1136/bmj.317.7174.1673a

The Power of Placebos:

Changing the Mind to Change the Body

By Emma Clark

If your doctor told you that your mind had the power to heal your body better than a surgery could, would you believe them? The placebo effect has been recognized in medicine and been presented to the general public for years. We have mounting evidence that it works, but still, we turn to pharmaceuticals and Western medicine for every ache, pain, and irritation. Here, we'll explore what the placebo effect really is, examine the evidence surrounding its efficacy as a medical treatment, how it literally changes our minds, and discuss whose minds must be changed to facilitate a wider adoption of placebo treatments in medicine.

What is the Placebo Effect?

The placebo effect has been observed in medicine for years, and has shown an incredible impact on treatments for depression, irritable bowel syndrome, and even arthritis. Before we dive into the immense power of this mental phenomenon, let's first define the placebo effect. The placebo effect, as defined by Irving Kirsch is what happens when "people obtain considerable benefits from medication, but they also can experience symptom improvement just by knowing they are being treated."[1] This effect is one of many examples of the mystifying powers of our minds superseding the power of science and technology, and gives us good reason to consider alternative pathways to healing.

As I mentioned, placebo treatments have been used and proven effective across clinical conditions; it truly is a wonder-drug. The most in-depth and prominent investigations into the placebo effect revolve around selective serotonin reuptake inhibitor (SSRI) antidepressant medications. SSRIs function by blocking the reuptake channels that transport serotonin molecules after they are released across the synapse. By doing this, serotonin, which is believed to be linked to mood regulation, remains in the synapse for longer, and thus, has a stronger effect on mood.[2] However, when we take a critical eye to the clinical trial results that led to these drugs' approval in the 1990s, we see that the effect, if any, really is not as significant as it seems compared to the placebo treatment. These effects persist for treating many conditions besides just depression.

Artwork by Amy Wang

Patients given a placebo antipsychotic drug in a study done by Peter Tyrer of Imperial College London showed an 80% reduction in aggressive behaviors, while patients in the same study who received the actual drug only showed a 60% decrease in aggression.[1] Further, placebo surgeries for patients with osteoarthritis of the knee have been proven to be more effective than the actual surgery, with patients reporting significantly less pain two weeks and one year post-operation, and studies on a breadth of other illnesses and conditions continue to show results similar to these.[1]

How Does it Work?

So, how, on a neuroscientific level, does all of this work? The short answer is: we really aren't sure. The long answer has to do with complex connections between the nervous system, endocrine system, and immune system. These connections exist across different types of placebo treatments, but differ slightly in how they interact with placebo treamtents based on the target condition.[3] Neurologically, responses seem to connect with pain management networks in the brain including the medial thalamus, dorsolateral prefrontal cortex, dorsal anterior cingulate cortex, and ventromedial prefrontal cortex. EEG studies of placebo treatments for pain management have shown a decrease in pain response network activation and an increase in contextual interpretation networks during treatment. This means that when undergoing placebo treatment, the parts of our brain that respond to pain are less active, so we process less of the stimuli as "painful," and the networks in our brains that interpret context such as "I'm taking a pill that will make my pain stop" are more active. This shift in activity likely leads our sensations to respond accordingly, and thus, produce the placebo effect when physical sensations are less "prioritized" in producing a physiological response and context becomes the most important factor. Over time, these patterns can be learned and replicated even more easily, which explains the sustained treatment effects of placebos. Once a patient believes once that their treatment was effective, it's hard to neurologically "undo" that association, even if the association is just with a sugar pill.

One key external factor for successful placebo treatments is an optimistic and trusting relationship between the medical professional who prescribes the placebo treatment and the patient receiving it.[1] This makes sense, because we tend to consider 2the opinion of a medical professional as valuable, and if they believe a treatment will work, it provides us with even more context to reinforce our own belief that the treatment will work. Unfortunately, these trusting relationships are hard to come by within the American medical system as it currently exists. However, advancements in health technology present a promising opportunity to start to close this gap. With the increase in precision medicine and telehealth options for patients, seeing a provider more often is becoming more possible and accessible for many. A challenge still stands, however, with integrating placebo medicine into clinical practice. From the doctor's perspective, how could they ethically bill someone for a "fake" treatment? From the patient's perspective, why should they have to pay for a "fake" treatment? This is where the fundamental issue lies. Without a paradigm shift within medicine about what is considered an effective treatment, placebo medicine will remain no more than an interesting phenomenon.

What's Next?

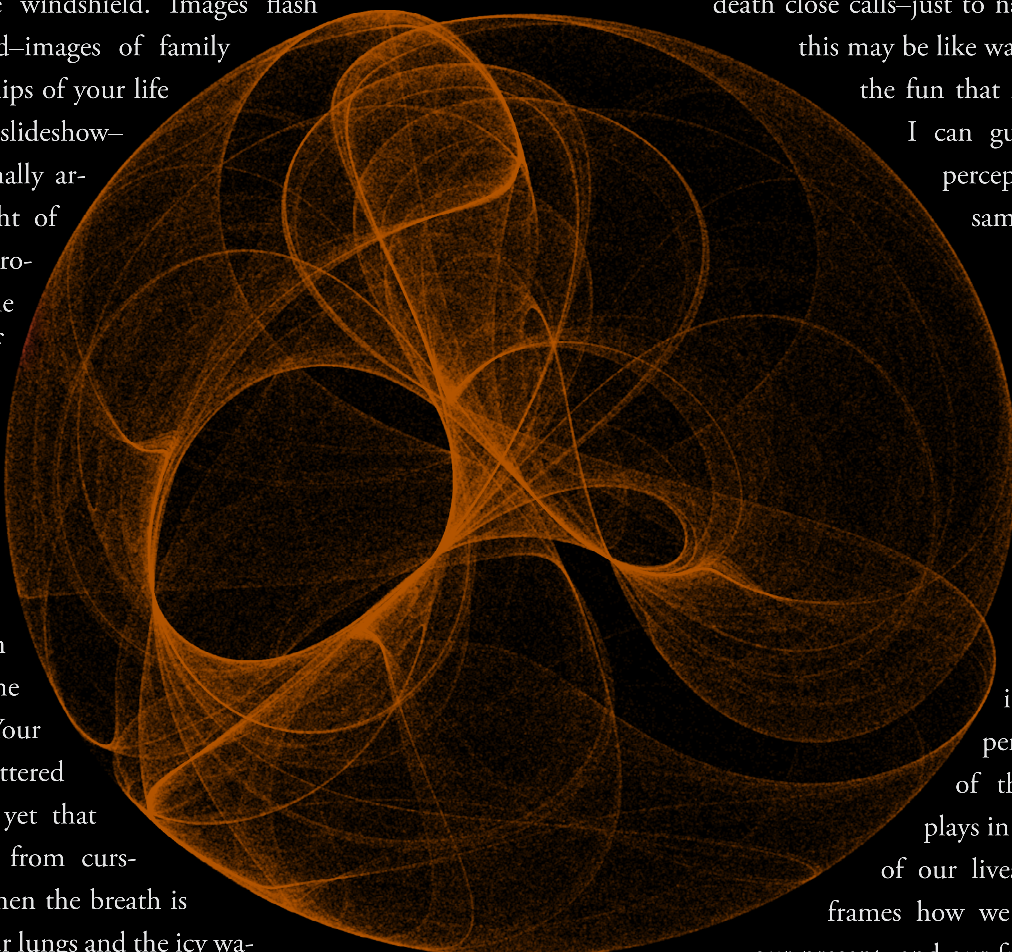
Placebos present a compelling case on paper for integration into medical treatment of a whole host of conditions, and their effects are supported by science showing how they change neural function as well as result in physical healing. However, without changing the minds of policymakers, healthcare providers, and patients, their effects will continue to be underutilized and insufficiently understood. So, after hearing all of this -- do you think a sugar pill could be worth a try? ■

1 Kirsch, I. (2010). The emperor's new drugs: Exploding the antidepressant myth (Paperback first published in the United States in 2011). Basic Books.
2 Selective Serotonin Reuptake Inhibitors (SSRIs). (n.d.). Mayo Clinic. Retrieved December 5, 2021, from https://www.mayoclinic.org/diseases-conditions/depression/in-depth/ssris/art-20044825
3 Wager, T. D., & Atlas, L. Y. (2015). The neuroscience of placebo effects: Connecting context, learning and health. Nature Reviews Neuroscience, 16(7), 403–418. https://doi.org/10.1038/nrn3976

Time Perception

By Emily Moberly

You slam on your brakes and yank the steering wheel to the right. An unbearable screeching sound follows that violently shatters the silence of the night like the thousand glittering fragments of the windshield. Images flash across your mind–images of family and friends and clips of your life flashing past like a slideshow–until the blow finally arrives and the sight of mangled metal, broken glass, and the bright lights of oncoming traffic fade into darkness.



Your skin is rough with goosebumps from the sight of the ice bath alone. Your bruised and battered muscles need it, yet that doesn't stop you from cursing your coach when the breath is knocked from your lungs and the icy water steals every last bit of body heat. You grit your teeth against the frigid cold and pierce the clock above with your eyes–daring the second hand to move any slower.

Your eyes glued to bright colors, familiar icons, and rapidly changing pictures on screen, the weight of reality lightens as the amped up stimulation lures you into a comfortably numbness. You laugh with your friend through your headset and engage in a conversation about your next move. The game has your undivided attention, and it is not until your mom bangs on the door that you realize it is 1 am.

What do all the above examples have in common?

The dilation and contraction of time that alters the speed at which we experience life. Every activity we partake in and brain state we enter controls our time perception: dreams, drugs, dopamine, depression, ADHD (and other neurological disorders), technology, and experiences from novelty to near-death close calls–just to name a few. Reading this may be like watching a pot boil or the fun that makes time fly, but I can guarantee your time perception will not be the same when you finish.

What is time?

Our subjective sense of time is fundamental to our psychology and understanding of our reality. There is increasing interest in studying how we perceive time because of the integral part it plays in how we make sense of our lives. Time perception frames how we evaluate our past, our present, and our future; and it is even becoming more closely linked with consciousness (i.e., our awareness of subjective time, of self in time, and of the world).

The interesting thing about time is that it is not like a river that runs, but rather like a train laying down its own tracks; time is something our brains have to be actively constructing. Whether time is a reality of the physical world at all or merely an artificial construct of the human mind is a heavily debated topic in philosophy and quantum physics. However, for this article's sake, we are relying on our subjective experience of time because of the many implications it has on our daily experience.

Artwork by Priya Reddy

likely being used against you. Ever noticed most casinos do not have windows or clocks, but instead have loud, colorful carpets to keep your eyes on the ground and aromatic scents that attempt to ease anxiety? You probably cannot remember the music in the background changing songs because of the track's consistent tempo and little to no lyrics, all blending seamlessly. Every color, every scent, and every sound in a casino strategically traps consumers in a world where time does not exist. These time distortion tactics are not just applied at casinos, but supermarkets, malls, social media companies, and any marketer who designs products to maximize the time you spend with them, and the money that follows.

Time Dilation and Understanding Time Perception

If you understand the 'formula' for time dilation, then you can manipulate your sense of time. If you do not, it can manipulate you. First, understand that absolute time is the true duration of an interval or the time on a clock, whereas perceived time refers to how long we think any duration would be based on our subjective experience. Time perception is simply absolute time over perceived time, and when these two quantities differ we call it time dilation.

So what causes time dilation and why do our perceived time and absolute time not always match up? Our 'sense' of time is unlike our other senses because we do not so much sense it as perceive it. There is no single sensory organ responsible for the encoding of time, and this causes the neuroscience behind the way we process time to be complicated. Essentially, our brains take a bunch of information from our senses and organize it in a way that makes sense to us, before we ever perceive it. As a result, what we think is our sense of time is actually our brains receiving, reorganizing, and presenting information to us in a particular way.

We perceive time in different forms, so it helps to differentiate between them. In studies in which researchers ask participants to judge time, they will usually distinguish between the two paradigms–prospective and retrospective time–and then additionally get a qualitative sense of their subjective experience[1]:

- Prospective timing is when participants know in advance that they will be asked to perform a task and make a time-related judgment.
- Retrospective timing is when subjects receive no prior warning but after the fact are asked to make a judgment on the duration of the task.
- Subjective experience is our "internal clock" or current time interval measurements of how fast or slowly we perceive events going by in our present temporal experience

Retrospective Time and Novelty

Our retrospective perception of time has a lot to do with the way our memory encodes and stores information. Our memory does not work like video on a strip of film, but rather selectively, with attention and emotion highlighting which experiences have importance or relevance for our survival.[2] This ties into time perception because when familiar information is being processed, it hardly takes much time at all, whereas, new information is slower to be processed and can seem as if time is being elongated. Neuroscientist and professor at Stanford University, David Eagleman, explains how thinking of time in this model can help us understand altering time perception, and "why childhood summers seem to go on forever, while old age slips by while we're dozing." He explains that "the more familiar the world becomes, the less information your brain writes down, and the more quickly time seems to pass."

Have you ever turned to people you have been traveling and adventuring with at the end of a day and said "Can you believe we were doing 'xyz' just this morning?" and were in disbelief at how long the day has felt? It is likely that because there was more processing involved with the novel environment you were in—with all the unfamiliar smells, sights, and people—the memory felt longer than if you had had, say, a typical day at your work or school. What can be confusing, however, is that in the moment it did not feel slow, and probably was quite the opposite. This is where the 'in-the-moment' temporal perspective of the passage of time (that we will talk about next) comes into play. Fun feels fast but is remembered as slow, and what is boring feels slow but is remembered fast.

If emotions impact memory and memory affects our sense of time, then emotions can therefore play a significant role in distorting the way we view reality, and particularly the way we view time. Using the zero-gravity center in Dallas, Stetson

1 Brain, Volume 135, Issue 3, March 2012, Pages 656–677, https://doi.org/10.1093/brain/awr210

2 Anderson, L., and Shimamura, A. P. (2005). Influences of emotion on context memory while viewing film clips. Am. J. Psychol. 118, 323–337.

et al. found that subjects perceived a longer duration of time when free falling. This is likely because the levels of fear are so intense that we misinterpret the events to span a greater time period. The richer secondary encoding of the memories due to the involvement of the amygdala may lead to dilated duration judgments retrospectively.[3] This also makes sense evolutionarily because fear distorts our experience of time in order to be prepared to act as fast as possible in case of danger.

Subjective Experience of Time and Cognitive Load

The processes involved in how you feel the speed of time passing in the moment has a lot to do with attention, which, when modified, can distort the feeling behind time perception. The higher the cognitive load you have, the less you perceive time. Individuals have limited attentional resources to process given information and, as suggested by Hicks et al. (1976), when a subject performs any activity they split attention between the task's temporal and non-temporal information. Increased attention towards one dimension decreases performance on the other. Thus, if a subject has a high cognitive load and their attentional resources are more directed towards non-temporal contents, there will be a relatively poor performance on temporal processing and time compression.[4]

Let's face it, it can be difficult to endure the entire 86,400 seconds of every day–whether that be because of chronic pain, depression, a boring job, or just a repetitive and exhaustive schedule; there likely have been moments where you wish there was a fast-forward button on time. Or maybe you are on the other side of the spectrum, where everything around you is moving too fast. The days fly by, you seem to always be under pressure from the clock, your to-do list is an ever-growing mountain, and you wish you could just stop time and breathe for a second.

It turns out that, almost like with a remote, we can control how we feel time passing with our cognitive load. Time compression or that 'fast-forward button' happens when we are highly engaged or immersed in an activity, such as playing a video game or engaging with others. Visual reality takes time compression to the next level with one study finding that participants who played the virtual reality version of a game first played for an average of 72.6 seconds longer before feeling that five minutes had passed than students who started on a conventional monitor.[5]

Flow, famously coined by Csikszentmihalyi of Claremont Graduate University and another variation of the 'fast-forward button', describes the experience of being so immersed in an activity that you enter an energized, focused state that shuts out external distractions. Whether this is achieved through athletics, work, or a creative project, a key feature of the flow experience is a distorted sense of time—typically feeling that it is passing faster than usual. We would expect this sort of time contraction in our subjective experience of time perception considering the individual's heightened focus, attention, and cognitive load.

What about a 'slow-motion button' for all of us who feel the world is moving at 100 miles per hour, what elongates our sense of time? In a series of studies at Carleton University in Canada psychology researchers tested whether people perceived time moving slower in nature compared with more urban settings.[6] Participants experienced walking through either natural surroundings, such as a forest trail or buzzing city locations. Those in the nature condition reported longer objective and subjective perceptions of elapsed time, which intuitively makes sense. Many of you have probably had the experience of coding or answering emails on your computers for hours into the night and can understand the stark contrast between the subjective duration perception of that elapsed time compared to how it feels to sit outside in the grass. When using technology the majority of our sensory information is being received through our visual systems which are not a continuous stream of stimuli but falter with blinks. When we are outside, a diverse array of sensory input grounds us in time along with oftentimes feeling a stronger presentness in the moment. For some, sitting still without extra incoming stimulus is being 'too present' and they crave the technology that speeds up their perception and engages their mind.

Prospective Time and Dopamine

Prospective time and making judgements of the passage of time ties in closely with the workings of the nervous system. A

3 Stetson C, Fiesta MP, Eagleman DM (2007) Does Time Really Slow Down during a Frightening Event? PLoS ONE 2(12): e1295. doi:10.1371/ journal.pone.0001295

4 Khan, Azizuddin & Dixit, Shikha. (2006). Effect of Cognitive Load and Paradigm on Time Perception. Journal of the Indian Academy of Applied Psychology. 32. 37-42

5 Mullen, G., & Davidenko, N. (2021). Time Compression in Virtual Reality, Timing & Time Perception, 9(4), 377-392. doi: https://doi.org/10.1163/22134468-bja10034

6 Davydenko, M., & Peetz, J. (2017). Time grows on trees: The effect of nature settings on time perception. Journal of Environmental Psychology, 54, 20–26. doi:10.1016/j.jenvp.2017.09.003

couple of neuromodulators (i.e., dopamine, norepinephrine, and serotonin) govern the size of the 'bins' we batch time with, which modulates our perspective of time. Studying this form of time perception is the most objective because researchers can simply raise the levels of each molecule through the administration of a specific drug, and then ask the subject to estimate when a minute or another interval of choice is up.[7] Similar findings concerning dopamine have also been found through giving rats amphetamines, although the ethics of such studies is not as clear-cut.[8]

The former described study found that subjects under increased dopaminergic effects overestimated the passage of time (e.g., They might think one minute had passed at the 50-second mark), whereas those given drugs to increase serotonin such as cannabis underestimated the time passed (e.g., The subject clicking the clicker to signal one minute but at one minute and 10 seconds). Dr. Huberman from Stanford university illustrates the effects of dopamine on our internal clocks as fine slicing of time bins. This, he describes, is like "increasing the frame rate on your camera." When a video increases its frame rate enough slow motion is achieved and dopamine and norepinephrine increase this frame rate. The opposite is true with serotonin, where the time bins elongate, making the world seem faster than your internal clock, as indicated by the underestimation of how fast time had passed in the study.[9]

Applications, Technology, and Conclusions

Time is rubbery, making it flexible for each occasion and each individual. The way each individual perceives time is a fundamental part of their psychology, making it a great indicator of mental health, a modulator for our experience, and a real-life applicable tool for us to take advantage of. From a clinical perspective, examining the timing abilities of patients with certain psychiatric or behavioral disorders—particularly those whose symptoms tie to temporal organization (e.g., attention-deficit hyperactivity disorder [ADHD], schizophrenia, depression)—may benefit the understanding of the psychological experience of these disorders and their potential remediation. If tweaks in time perception can help remedy the impulsiveness associated with ADHD and addiction or the dragging and boredom of each minute associated with depression, then symptoms could become that much more manageable.

Another application of time perception is modulating cognitive load and engagement to act like a fast-forward button. This is demonstrated by Deb Shaw, who has suffered three strokes and has been using virtual reality (VR) for therapy exercises over the past four years. "In almost every case, when I put on the headset and sensors then enter the world of VR, time is left behind," Shaw explains.[10] This is purposeful, as the captivating VR world can be used to contract individuals' perceived time; time that might be otherwise excruciatingly long, suffering from chronic pain or undergoing laborious treatments such as chemotherapy.

The more we understand time perception, the more control we have. Supposing it is true that perception is reality, we effectively can make our days longer or shorter. It is not quite a time machine, but it is almost as good as one. ■

7 Mitchell JM, Weinstein D, Vega T, Kayser AS. Dopamine, time perception, and future time perspective. Psychopharmacology (Berl). 2018;235(10):2783-2793. doi:10.1007/s00213-018-4971-z

8 Palmiter RD. Dopamine signaling in the dorsal striatum is essential for motivated behaviors: lessons from dopamine-deficient mice. Ann N Y Acad Sci. 2008;1129:35-46. doi:10.1196/annals.1417.003

9 Mathew, R. J., et.al. (1998). Cerebellar activity and disturbed time sense after THC. Brain research, 797(2), 183-189.

10 Brodsky, Sascha. "Why You Lose Track of Time in VR." Lifewire, Lifewire, 14 June 2021, https://www.lifewire.com/why-you-lose-track-of-time-in-vr-5188856.

Ghosts Exist

(depending on your definition of 'exists')

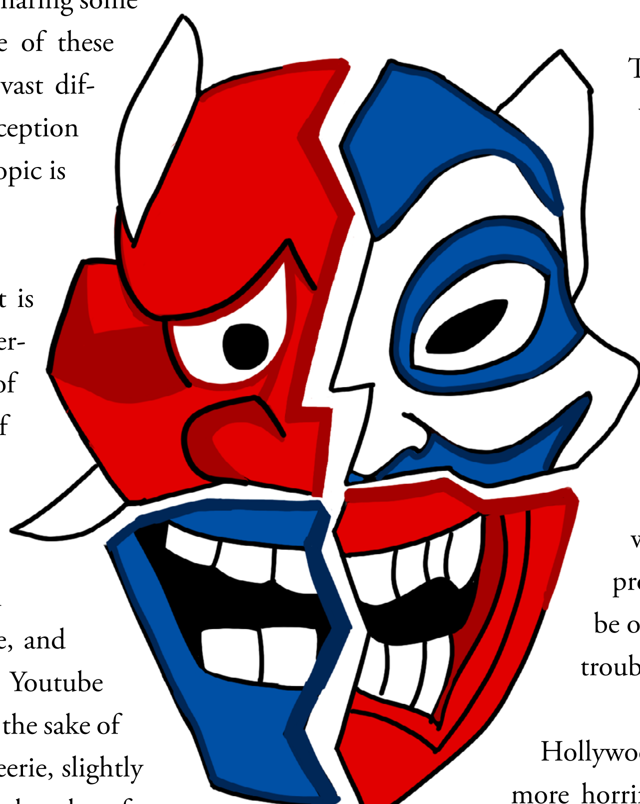
By Abraham Niu, Inspired by my roommate, Kurtis LaMore

Eastern and Western Perspectives: A Precursor

From the fables of Bloody Mary and Sleepy Hollow in England and the United States to the legends of Shinigami (gods of death) and Wangliang (demon) in Japan and China, tales of ghosts and spirits are seen in contemporary folklore throughout nearly every culture. Despite sharing some similarities in the general nature of these specters, however, there exists a vast difference between the public perception and the fluidity with which this topic is treated and approached.

The notion of spirits in the West is heavily influenced from an entertainment perspective, as tales of apparitions are typically heard of and seen in horror settings and popular culture. We dress up for Halloween, watch Hollywood's latest horror films, tell ghost stories around the campfire, and will occasionally spiral down the Youtube rabbit hole of scary videos - all for the sake of chasing those big scares and that eerie, slightly disturbing feeling that keeps us at the edge of our seats. Ghost culture in the West has become inextricably reduced to a fun distraction and a source of pleasure.

In Eastern cultures, ghosts and spirits are deeply linked to heritage, tradition, and religion. The presence of ghosts is much more openly embraced and even has massive influences on daily life. First used around 3500 years ago, Chinese masks were used to drive away ghosts and evil spirits from people, their houses, and during funerals to ensure that the soul will rest in peace. Even today, these masks are prevalent in cultural practices like Nuo Opera, China's most popular folk opera that aims to drive away devils, disease and evil influences, and also to petition for blessings from the gods. This overwhelming belief in specters even has influences on the current demand of real estate[1] and Asian architecture with the prevalence of curved roofs to help ward off evil spirits, which were believed to assume the form of straight lines.



Artwork by Claire Stotts

The best defense against such ghosts was to live an exemplary life, and this was why ghost stories were (and are) so often told to children: they express cultural values and encourage people to be kind and courteous to each other. Proper respect should be given to one's elders, superiors, and ancestors in life so that they would not feel wronged after death and one should always keep one's word to others. Most importantly, proper burial practices should always be observed, no matter how much cost or trouble they require.

Hollywood ghost stories are therefore both more horrifying (initially) and more reassuring (ultimately) than their Eastern counterparts. The unnerving distinction of Asian stories is that they're willing to admit the possibility that spirits are simply with us, day in and day out, and there's not much we can do to make them go away. In classic Japanese ghost stories like those collected by Lafcadio Hearn in "Kwaidan" (1904), the ghosts frequently win their battles with us mortals; if they abandon the field, it's usually by choice or whim.

As such, Eastern Spirits are not mere home invaders, crashing into our lives as Western ghosts do; they're just unannounced

1 Gao, Deyong, and Yuan Zeng. "Ghost Culture, Face Culture and Illusion of Demand-a Cultural Perspective of Pension Real Estate." American Journal of Industrial and Business Management, Scientific Research Publishing, 15 Mar. 2017, https://www.scirp.org/journal/PaperInformation.aspx?PaperID=74721.

visitors—people we forgot we'd given keys to. Ghosts are, after all, primarily metaphors for the unshakable presence of the past, and it makes sense that a culture such as Japan's, in which ancestral tradition is so densely woven into the fabric of daily existence, would consider the appearance of a ghost a somewhat less alarming event than we Westerners would. For us, it's shock; for the East, it's, more often, awe—there's an element of remembrance and reverence for fables they've only heard about.

So do Ghosts exist?

Let's start with an assumption based on lack of evidence to the contrary: Ghosts do not exist. There's no evidence the blurry visages people claim to see are actually manifestations of people who have died, but that lack of evidence still doesn't account for the fact that 66 million people in the US claim to see ghosts[2]—with the vast majority of them not attempting to monetize this claim—that all can't possibly be mistaken or fraudulent assertions. People do see things. But why?

In 1902, the "Father of American psychology" William James published *The Varieties of Religious Experience: A Study of Human Nature*, where he linked singular "religious experiences" to psychological disorders in the brain. To him, they were the result of "delusional insanity."[3] This laid the general groundwork that scientists should focus on the brain in order to locate a cause for spiritual occurrences. And so began the long dance with schizophrenia as a possible cause.

The links are obvious. Schizophrenia affects nearly one percent of the global population, around 20 million people, which makes it large enough to account for some of the breadth of ghostly claims.[4] While the symptoms that lead to diagnosis are varying, there are a few checkpoints that align perfectly with the feeling of ghostly presences, particularly audio/visual hallucinations and delusional thinking. In 1994, the University of Adelaide in South Australia confirmed that there was a correlation between instances of schizophrenia and belief in the paranormal, although the correlation was only significant for male subjects.[5]

But, still, a correlation between feeling ghosts and schizophrenia is too broad of a correlation to really accomplish anything. What's actually going on in the brain to account—at least partially—for claims of ghost sightings?

In 2014, researchers in Switzerland brought 12 people who reported having "secondary representations of their body" into the laboratory. In the scientific world, this sensation is known as Feel of Presence (FoP), a murky sense that other people are in the room with you, similar to the experience of those claiming to have encounters with the spirit world. But there's something unique about FoP that points toward a more specific cause. "Feeling of Presence has specific characteristics," says Giulio Rognini, one of the study's co-authors. "If the patient was standing, the presence was felt standing. If the patient was lying down, the patient felt as if the presence was lying down."[6] In other words, there's a shared movement between the person claiming to feel the invisible presence and the presence itself. This implies a sort of doubling in the patient's brain, which further implies signals somehow getting crossed. Rather than attributing their own movements and activities to their own bodies, subjects attribute them to ghostly presences that are near them. With FoP as a focal point, scientists devised an experiment to re-create this feeling and more closely examine what's happening in the brain during those moments of FoP.

Researchers blindfolded their test subjects and placed them between two robots. Participants were then instructed to reach forward and make a motion on the robot sensor in front of them. When they did, the robot behind them mimicked the same motion on the participant's back at the exact same time, in a loop of sorts. This was a little strange—imagine how it feels to rub your hand, but then feel the rubbing on your knee—but it only got spooky once they slightly delayed the reaction between the robots. "That replicated the effect of a lesion in those areas of the brain that integrate your own body signals," Rognini says. When the researchers tweaked the timing, respondents claimed it felt as if some other presence was touching them. Others claimed it felt as though the room was now full of people, rather than the few researchers who were actually present. (Again, respondents were blindfolded during

2 Miranda, Gabriela. "2 In 5 Americans Believe Ghosts Are Real and 1 in 5 Say They've Seen One, Survey Says." USA Today, Gannett Satellite Information Network, 28 Oct. 2021, https://www.usatoday.com/story/news/nation/2021/10/28/do-ghosts-exist-41-percent-americans-say-yes/8580577002/.

3 James, William. Varieties of Religious Experience: A Study in Human Nature. EDITORIUM, 2020.

4 "Schizophrenia." World Health Organization, World Health Organization, https://www.who.int/news-room/fact-sheets/detail/schizophrenia.

5 "Belief in the Paranormal and Its Relationship to Schizophrenia-Relevant Measures: a Confirmatory Study." National Center for Biotechnology Information, U.S. National Library of Medicine, https://pubmed.ncbi.nlm.nih.gov/.

6 "Neurological and Robot-Controlled Induction of an Apparition." Blanke et. al. https://www.cell.com/current-biology/fulltext/S0960-9822(14)01212-3#secsectitle0040.

the act.) A few were so freaked out by the "ghostly presence" that they asked to end the test.

When they crunched the data to see what parts of the patients' brains were firing during these lab-created FoP episodes, researchers saw activity in three areas of the central cortex that deal with visual input, memories, and perception: the insular cortex, frontoparietal cortex, and the temporoparietal cortex. "These areas give you representation of your body," Rognini says. "They give you the [feeling] that you are a specific body."[7] When that sensory process is fudged, your brain makes the assumption that there's someone else in the room with you. Now, these findings can potentially go a long way toward finding a cure for alleviating certain symptoms of schizophrenia. Knowing where the brain is malfunctioning is the first step toward fixing it.

But not all ghost sightings can simply be placed in the boxes of schizophrenia and psychosis. In fact, this is precisely the issue present in our Western view on the topic of spirits. We are so quick to invalidate stories of apparitions, dismissing them as mental illnesses and unreal. Rather, we should adopt some perspective from our Eastern neighbors and open our minds to be more receptive to spirits. In doing so, we can disentangle the—for lack of a better term—linguistic issue with "ghosts." If you see a tree, you don't know it's a "tree" until someone teaches you to associate that four-letter word with the leafy wooden thing sticking out of the ground. In the same vein, if someone feels an invisible presence around them, they don't automatically associate it with a spirit until they're taught to do so.

We argue that as it currently stands, although it is natural to view spirits and apparitions from the lens of what we can physically observe, the current Western view of ghosts is rooted too much in the external stimuli and not enough in its internal repercussions.

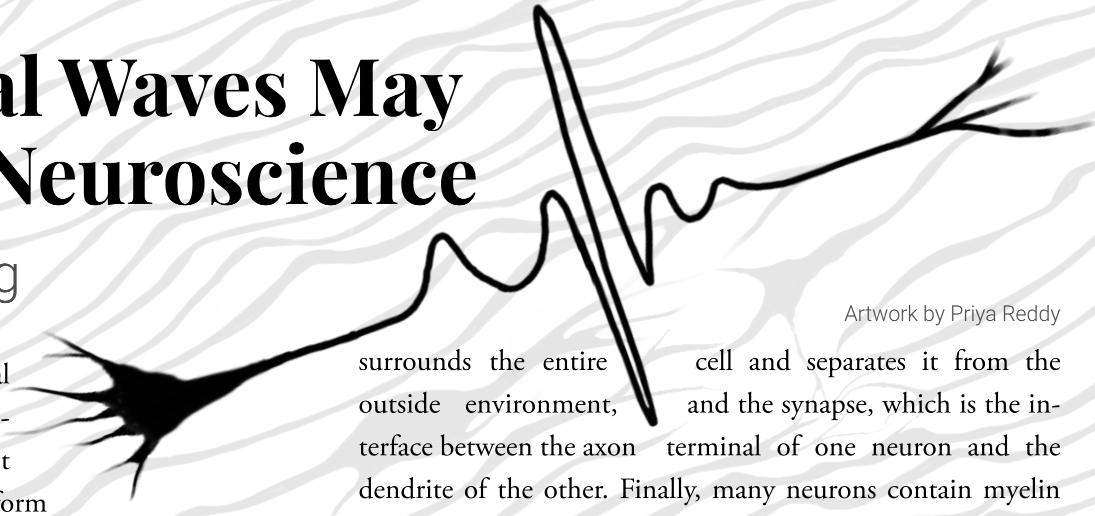
In astral projections, for example, or the typical out-of-body experience through which consciousness can function separately from the physical body, subjects don't acknowledge or believe it occurs in their mind—they view it as out of their control. Ghosts and demons typically manifest in these settings and are seen as dark, scary creatures—and nothing else. But the implication of this mode of thought fails to attribute these demons to the real reason why they manifest in the first place: out of internal anxieties, negative emotions, energies, and states of mind as a result of real actions and consequences. As such, the notion of ghosts should be viewed more as a tool to understand our underlying states of mind and the actions we consciously take. Similar to how in Eastern culture, tales of ghosts and spirits are used to encourage integrity, compassion, and respect for others, we should view ghosts as vehicles for assessing our internal states of being and making the right decisions to uplift ourselves and others.

There is no way to prove or disprove any theories about ghost experiences that are so mysterious, that happen so quickly and without warning. The fleeting and subjective nature of these experiences renders it virtually impossible to catalog or study in any true methodical way with our current knowledge. But just because we do not currently have the means to fully understand these phenomena does not mean that we should completely disregard the topic. Until we uncover more about the truth behind ghosts, what we can do is reframe the notion of ghosts in a way that allows us to introspect candidly and live our lives better. At least for the time being, it's not ghosts that should be feared and examined, but ourselves. ■

7 Paulas, Rick. "The Neuroscience of Ghosts." Pacific Standard, Pacific Standard, 15 Feb. 2016, https://psmag.com/environment/bloody-mary-bloody-mary.

Mechanical Waves May Shake Up Neuroscience

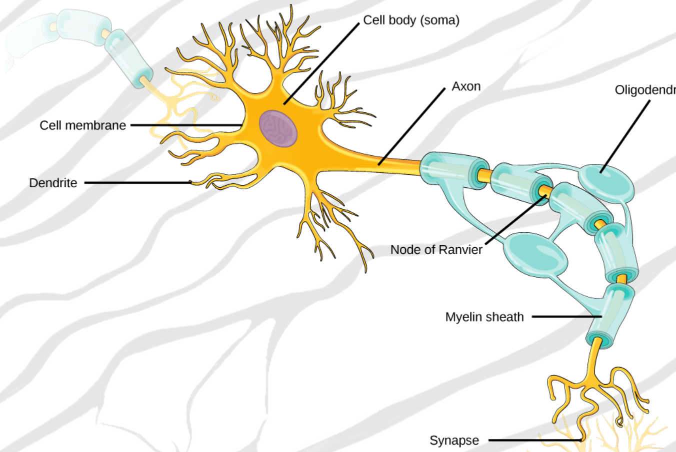
By Michael Xiong



Artwork by Priya Reddy

The neuron is the foundational unit of the nervous system. Billions of these spindly cells must constantly chatter in order to form our memories, emotions, and sensations. Neurons transmit their signals across distances that range from mere millimeters to the entire length of the leg. This transmission is the biophysical basis of how neurons communicate. In simple terms, the neuron must receive a signal at one end, then carry that signal to its other end where the signal will be passed to the next cell. Our interneurons pass these signals to one another like buckets of water in a fire brigade.

In order to understand more about how this process works, we must look at the structure of a neuron. Generally, a nerve cell can be divided into three parts: the cell body (or soma), the dendrites, and the axon. The cell body contains the nucleus and other organelles common among animal cells—such as the mitochondria and the endoplasmic reticulum. Dendrites are branching structures which the neurons use to receive information from other cells. This information is carried along the axon, a long tube which extends to interact with the dendrites of the next neuron.



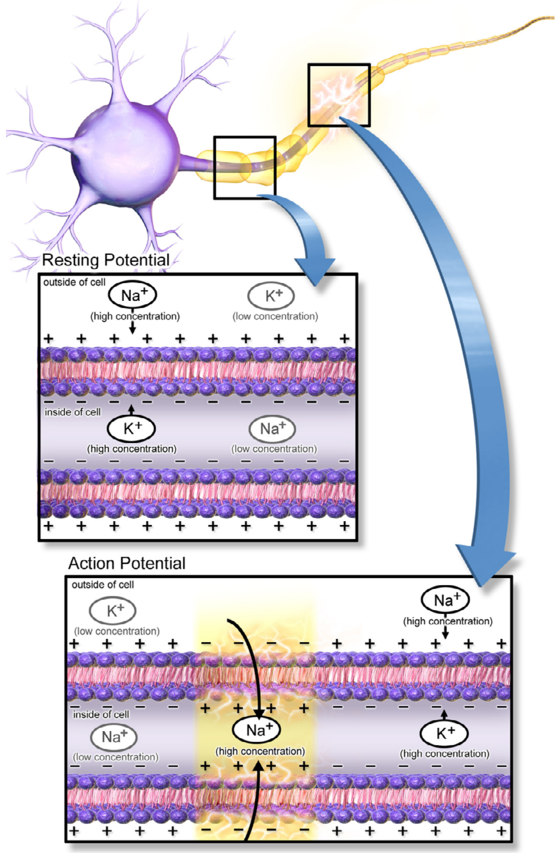
Graphic from Lumen Learning

Other important features include the cell membrane, which surrounds the entire cell and separates it from the outside environment, and the synapse, which is the interface between the axon terminal of one neuron and the dendrite of the other. Finally, many neurons contain myelin sheaths—fatty, electrically insulating structures that surrounds portions of the axon and allow for faster signal transmission. This signal is known as the action potential, and how it works—described by the Hodgkin-Huxley model—is usually the subject of little debate. However, this well-established narrative is now being challenged by recent discoveries.

The Hodgkin-Huxley Model

In 1949, Alan Hodgkin and Andrew Huxley directly observed currents of ions moving across the cell membrane of neurons. From these observations, they formulated a mathematical model describing the action potential electrochemically, for which they were later awarded the Nobel Prize. In a resting neuron, a separation of charge is formed across the cell membrane. The inside of the membrane is enriched in potassium, $K+$, ions while the outer membrane has a greater concentration of sodium, $Na+$ ions. Overall, the exterior contains more positive charge than the interior, which leads to a voltage difference of -70 mV across the membrane. During an action potential, sodium ions are permitted to flow into the cell while potassium ions flow out, leading to the current observed by Hodgkin and Huxley. This model not only explained these observations, but also made predictions that would be confirmed in the years to come. For example, the ability of the membrane to be permeable to ions only at certain times alluded to the existence of ion channels—proteins on the cell surface which shuttle ions across the membrane—whose existence wasn't formally established until the 1970s.

These ion channels are critical to the propagation of the action potential because they are voltage-gated. This means that the voltage across the membrane determines whether or not the channel is "open" and allows the flow of ions. At the resting voltage at -70 mV, these channels are closed, and the cell remains resting. Once the signal is initiated, however, the rush of positive ions into one portion of the axon equilibrates the voltage and leads to nearby ion channels opening. Thus, the opening of one channel induces the activation of its neighbors. This carries the signal down the length of the axon like a chain of dominoes. After the signal is propagated , energy-consuming ion pumps return the cell to its resting state.

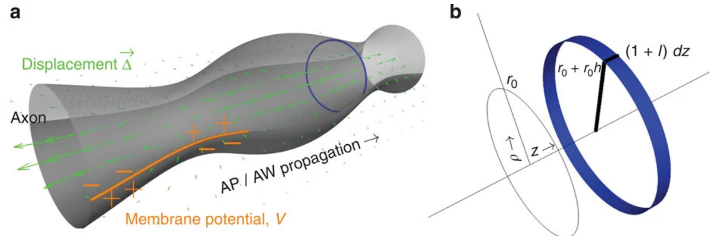


Graphic from Blausen.com

This model, however, does not entirely account for certain observations. For example, axons with larger diameters and thicker myelin sheaths conduct action potentials more quickly. When an axon is coated with a myelin sheath, the signal "skips" the sheaths by jumping to the gaps between them, known as the Nodes of Ranvier. This is accomplished by an electric field. However, the spread of an electric field should not determine the speed at which this jumping occurs, so the increase in speeds from larger diameters is unexplained.

The Mechanical Impulse Model

When sodium ions flow into an axon during an action potential, they bring water molecules associated with them across the membrane as well. This means that the portion of the membrane swells in volume, and its diameter expands. Although this has long been known, its effect and importance were largely ignored. However, this phenomenon might be the key to resolving certain inconsistencies of the Hodgkin-Huxley model.

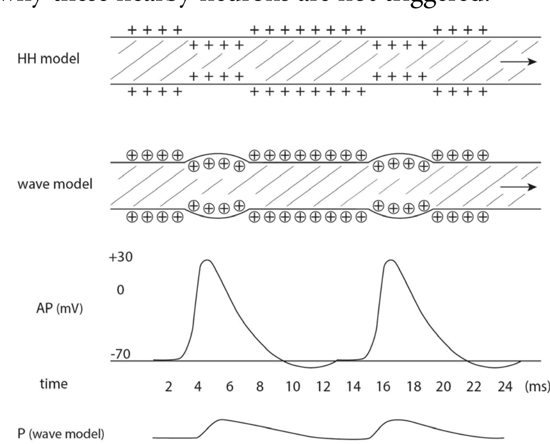


Graphic from El Hady and Machta 2015

As the electronic action potential travels down the axon, the corresponding physical expansion of the axon creates a mechanical wave. In fact, ion channels have been shown to be mechanosensitive—they can open in response to a mechanical stimulus—meaning that this mechanical wave may be just as important as the electrical current for propagating the "domino effect" of opening ion channels.

One potential problem solved by this model is the dependency of signal speeds on material stiffness. Mechanical waves—like sounds—travel quicker through stiff materials than more elastic ones. In a neuron, the stiffness of the axon can be modified by the thickness of the myelin sheath. Although typical action potentials travel at speeds of about 50 to 60 m/s, those of neurons with very thick myelin sheaths can travel upwards of 120 m/s.

In addition, the HH model says that an electrical field allows the action potential to jump between Nodes of Ranvier. However, these nodes are sometimes separated by distances greater than the distances between neighboring neurons. The mechanical impulse model, in which a mechanical wave is responsible for signal propagation rather than an electric field, could explain why these nearby neurons are not triggered.



Graphic from Barz et al. 2020

Conclusions

Although the Hodgkin-Huxley model and the mechanical impulse models disagree on the importance of the mechanical wave, they are not completely at odds. In fact, none of the observations made by Hodgkin and Huxley are discredited by the mechanical impulse model. Instead, this model uses these same observations but provides an alternate explanation of their effects.

Science is often taught as if it is the firm, concrete truth. However, even the most seemingly unshakeable ideas can be questioned when new evidence comes to light. The HH model has been printed in textbooks for what feels like an eternity, and it is a well-established theory that has been upheld by mountains of evidence. It is important to remember, however, that the study of the world will always be a work in progress, and that scientists must always be willing to *change their mind*. ■

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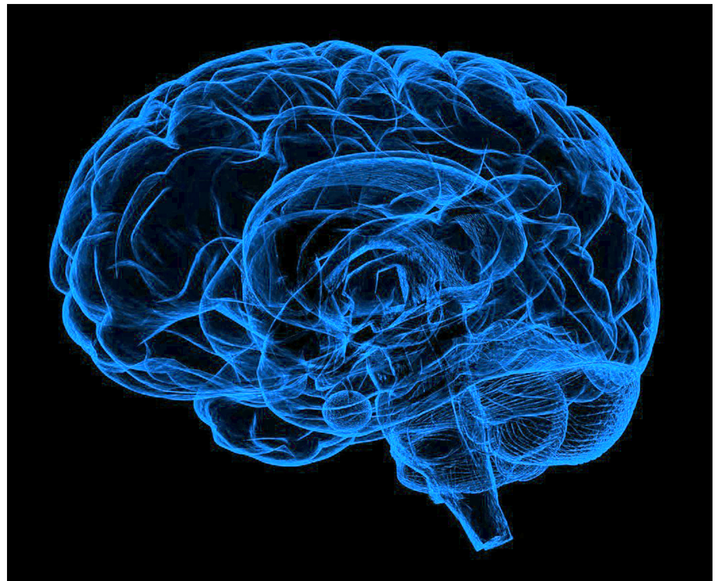
https://www.sciencedirect.com/science/article/pii/S0306987719312010#f0010
https://www.nature.com/articles/ncomms7697
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3424716/

Visualizing the Brain:

A Novel Approach

By Luc LaMontagne



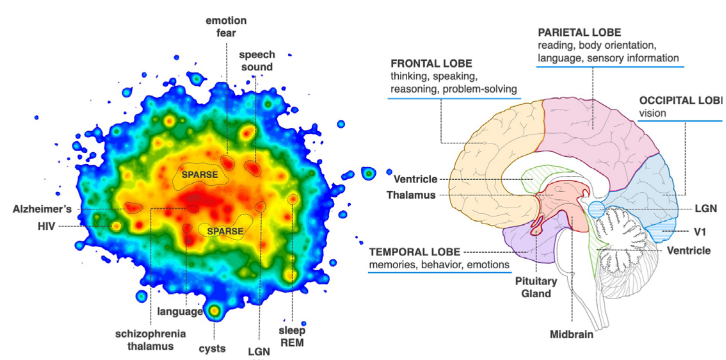
Graphic from VALUENEX

The convoluted, wrinkly, and mysterious shape of the brain has boggled scientists and inspired wonderers for hundreds of years. While the advent of psychological and neurological studies have begun to demystify this gray matter, scientists have just barely skimmed the surface. If understanding the brain was analogous to a person walking a mile, they would have only taken a few steps in this exploratory journey.

The shape of the brain has been marvelously and meticulously crafted by evolution for millions of years. Increasing in size and complexity with the advent of new species and behaviors, the brain has been warped, expanded and compressed by the growing bodies that hold it. The human brain evolved in a sort of curve, as apes and hominids evolved to be upright. Spatial constraint within the skull inspired folds — sulci and gyri — in order to maximize surface area. Regions within the brain became specialized embedded circuits, performing in patterns relative to the rest of the brain, such that behaviors became complicated within social animals, even up to the point of human society.

As neuroscientists sought for means to understand the brain, a leading theory spearheaded the field: behavioral function is regionally located within the brain. This began with the idea of phrenology. Phrenologists believed that superficial marks on the skull signified intellectual capabilities. While this is now understood as false, this theory inspired and directly led to the comprehension of regionally associated functions that we have today.

Since the brain is still a frontier, much still needs to be researched, but the findings to date have been excitingly enlightening. VALUENEX, with its novel Radar visualization technology, has taken this research and yielded unrecognized knowledge from it, including insights that are invisible to a research paper surveyor. For the trial visualization, 10,000 PubMed research papers were pulled to produce a dataset of abstracts associated with subcortical brain structures. After running the data through the VALUENEX machine intelligence and visualization processes to gain a comprehensive layout of the documents based on semantic similarities, the Radar's results are brain-boggling.



Comparison of the radar analysis of 'subcortical brain structure' research papers (left) and a brain cross-section (right)
Graphics from VALUENEX

Utilizing the heat map capabilities of Radar to clearly define document density — with similar documents being grouped together and distance between groups representing the degree of semantic similarity —, we can begin to see alikeness and

https://www.theatlantic.com/health/archive/2014/01/the-shape-of-your-head-and-the-shape-of-your-mind/282578/
https://pubmed.ncbi.nlm.nih.gov/
https://www.frontiersin.org/articles/10.3389/fnbeh.2015.00045/full#:~:text=In%20schizophrenia%20patients%2C%20decreased%20connectivity,Barch%20and%20Ceaser%2C%202012
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2888515/

parallels between the general shapes. While both the cross-section of the brain and the Radar share semicircular shape, notice a central red area within the Radar that parallels the midbrain on the cross-section image. Also notice the sparse areas (regions of low density) on the Radar, which almost directly mirror the ventricles in the brain diagram.

If the visual similarity is shocking, the keyword labels produced by the algorithm are electrifying. First, observe the area labeled with keywords "schizophrenia, thalamus". This small area geographically corresponds directly to a region in the brain called the thalamus, a nuclear complex with multiple connections to different parts of the brain regions. Even more fascinating is the connection between this region and the disorder schizophrenia; research reveals that in schizophrenia patients, there exists decreased connectivity between the prefrontal cortex and the thalamus, as well as disruption in their thalamic resting state networks. The Radar was successfully able to identify subcortical regions of the brain and associate a chronic brain disorder that directly relates to the functional performance of this region.

Note how the region labeled with keywords "LGN, V1" corresponds to the locations of the lateral geniculate nucleus (LGN) and the primary visual cortex (V1) of the brain. This area is very near the true location of the LGN in a sagittal medial slice (a view of the brain sliced at the central fissure), yet slightly relocated towards the occipital cortex. The Radar was able to automatically generate the primary visual cortex title near the occipital lobe where it is actually located in the brain. The inclusion of the keyword 'V1' in this region suggests the relationship of these two regions. Neurons in the LGN provide visual inputs to the V1, which are then processed and passed onto other visual cortical areas. The location and combination of keywords within the Radar accurately communicate the functional geography of the brain itself.

Furthermore, the sparse regions of the Radar are representative of the different ventricles of the brain. The sparsity of these regions within the Radar mirrors the fact that aside from cerebrospinal fluid, the brain ventricles are actually hollow. The ventricles are fluid-filled structures that serve to maintain the central nervous system and keep the brain buoyant. It is fascinating to see how the Radar recognizes the more passive function of the ventricles and assigns these regions to be sparse.

The similarities and crossovers between topics are so closely tied and deeply embedded via the functions of neighboring regions within the brain that the locations themselves are hardwired into the information. The brain's shape is necessary and optimal for its function, especially considering that similar topics and behaviors are located next to each other and are heavily interconnected. It is almost as though regions of the brain are spheres within a voluminous, complex multi-Venn Diagram.

The beauty of this visualization is not just in its profound mirroring, but in its use. The Radar can show both sparse areas and the evolution of research trends. This can reveal understudied topics, unexpected crossover-concepts, and reveals potential theses and research topics all while affirming other associations and theories.

For example, some research on brain diseases and neural afflictions appears embedded in the Radar. Certain orbital regions are dedicated to cysts, HIV, or Alzheimer's, which are issues not typically associated with subcortical brain structures. Research on depression and anxiety disorders has a surprising overlap with general amnesia and non-disease affiliated memory loss. This suggests a correlation, and therefore, this is a region for investigation. How do mental illnesses affect memory recall, and why might both of these regions be located just around the pituitary gland?

Investigations into peculiarities such as these might lead to discoveries and real solutions for afflicted people. At the dawning age of neurotechnology, new crossovers on technology and the brain are imminent and world-changing. While people often expect such crossovers to stem from new devices such as Elon Musk's Neuralink, changes in the industry are often unexpected. Coupled with the boom in information sciences, VALUENEX is at the forefront of a new neuroinfo industry. Novel data analysis such as the Radar provide an unexpected foundation for progress, and a surprisingly clear lens into the complex, intimidating, and foggy field of neuroscience. ■

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http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/V1/lgn-V1.html
https://www.verywellhealth.com/brain-ventricles-3146168
https://www.mayoclinic.org/diseases-conditions/hydrocephalus/multimedia/brain-ventricles/img-
https://www.mayoclinic.org/diseases-conditions/hydrocephalus/multimedia/brain-ventricles/img-20007652
https://neuralink.com/

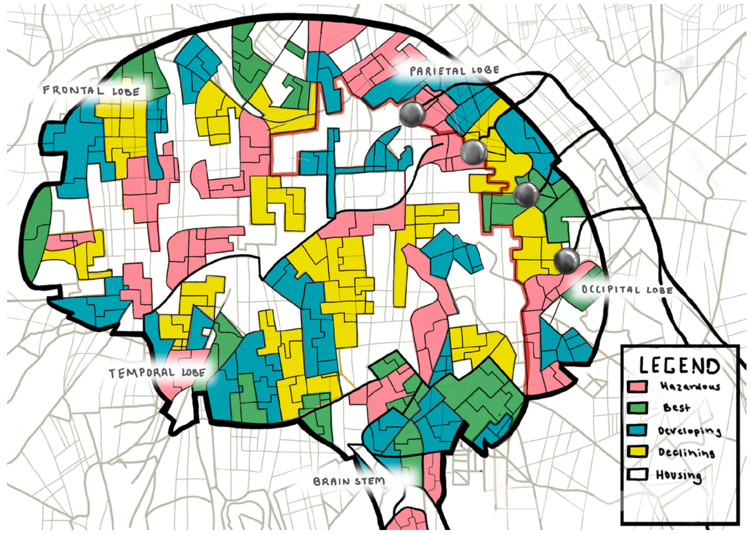
Change My MIND:

Via Knowledge

Science Is Not Colorblind:

A Critical Look at Race and Racism in the Past and Future of Neurobiology, Neurotechnology and Artificial Intelligence

By Shobhin Logani



Artwork by Megan Lui

Objective. Rigorous. Evidence-based. For physical and natural scientists, these descriptions represent what they hold most dear about their fields: a perpetuation of the idea that all science follows laws that are enforced without involving themselves in the labyrinth of social, cultural, and economic dynamics that otherwise seem to dominate those lives which science seeks to benefit. Throughout the history of scientific discourse, the image of the cool, rational, and politically unentangled scientist has been deftly imposed as an ideal to be aspired towards; "objectivity" and "quantification" have been established as an unquestionably superior form of gathering, interpreting, and valuing data.

Without a doubt, objectivity is generally of great value in research. Because it is so easy to, for example, fudge the mass of a particle to claim the discovery of a new element, extensive ethical and practical barriers have been put in place to ensure ambition does not interfere with true, evidence-based discovery.

However, in a field like neuroscience which uses measurements to classify phenomena yet to be quantified, a hyper-emphasis on the power of empirical measurement obscures a dangerous reality: that science described with words like "rigorous" has been historically used to justify less-than-scientific claims about "natural" race and ethnic superiority and ability. As our understanding of the biological mechanisms underlying cognition and behavior are advancing and being applied to new technologies, it is crucial for us to understand that researchers who are and have been on the forefront of development are multifaceted people who live, work and theorize within the racial power structures that have and continue to dominate American society. A critical look at the often-minimized history of race in neuroscience and biology shows that scientists have directly and indirectly injected shared narratives of white supremacy into their work; understanding this trend allows us to be aware of dangerous continuations of this in modern neurotechnological development and helps us reframe the role of race in studying the brain.

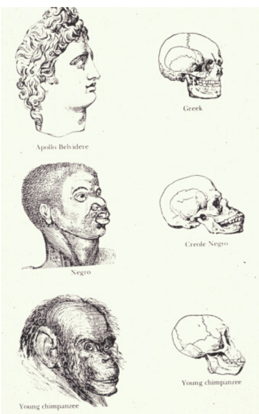
18th and Early 19th Century: Grasping for biological segregation

Before the age of EEG, fMRI, and X-ray, neuroscientists in the 19th through early 20th centuries had only one way to map the links between brain structure and behavior: by meticulously analyzing the size, shape, and features of the skull itself which they believed had a structure determined solely by the brain's anatomy. Before long, 19th-century American naturalist Samuel Morton and German physiologist Franz Gall had concocted the pseudoscientific theories of "craniology" and "phrenology". Both theories essentially involve the detailed study of skull shape and size with the underlying assumption that individual skull features revealed the character and cognitive capacity of the organism.[1]

The most infamous and impactful craniological study was carried out by Morton in Philadelphia in the 1840s. Employing a loosely-defined hypothesis that large skull size was correlated with intelligence, he divided humans into five racial "groups" based on his own observations from 256 sample skulls he had

1 https://pages.vassar.edu/realarchaeology/2017/03/05/phrenology-and-scientific-racism-in-the-19th-century/

gathered: Ethiopian (African), Native American, Caucasian, Malay, and Mongolian.[2] His empiric measuring of the size of each racial group's skulls involved pouring seeds into each skull and calculating the cubic inches they occupied. His methodology introduced well-documented errors in his data: the seeds may have been more compressed in certain skulls, and he had no way of verifying the actual origins of his samples. Nevertheless, he published the numbers in his book that showed Caucasian skulls having the highest volume and African and Native American skulls having the lowest volume. His results became accepted as basic neurological science, underlied by a weak assumption upheld by bigotry that greater intelligence was directly linked to greater skull volume. The measurements were even infamously extrapolated to prove that exaggerated differences in skull size between races proved that White Europeans evolved from an entirely different species than Africans, Asians, and Indigenous Americans.



Left Graphic from *Indigenous races of the earth* (Wikimedia)
Right Graphic from *Phrenology: History of a Pseudoscience* (NESS)

While the biased intentions behind Morton's measurements may have been lost to scientific history, it is important to note that his claims upheld racist and genocidal policy in the United States. Southern legislators used his results to "prove" that Africans abducted as slaves had an innate "tamableness" that suited a natural condition of enslavement; even after emancipation, the theories were used to justify the next century of brutal legal segregation against Black Americans. Morton's results were also directly used to justify the forced removal of Indigenous peoples from their ancestral land. His reporting of results, quoted by the Jackson administration which perpetrated the genoicdal 'Trail of Tears", claimed that the skull measurements of Native Americans proved that they were "adverse to cultivation" and "slow in acquiring knowledge."[1]

To this day, the legacies of the policies fueled by racist neuroscience have had lasting socioeconomic impacts. Even though Morton's ideas are now widely accepted as pseudoscience, their racist legacy lives on. I still remember being taught about the three "types" of skull structures in my schooling (Caucasian, Mongoloid, and African) which have evolutionary significance but little impact on neuroanatomy and higher-level cognition. Examining the rest of the 19th and early 20th centuries, traces of Morton's racial craniology can be seen in IQ tests attempting to link race to inherent intellect that still inform standardized tests in use today. Overall, early studies that attempted to use "objective" measurements essentially followed a thread of trying to establish a biological basis for race division which genomics tells us is almost impossible to define. In fact, humans across races share over 92% of their genome including swaths of non-coding sequences.[3] However, as the sophistication of neuroimaging techniques exploded in the 20th century, the trend of using loosely-interpreted empirics to turn race (and racism) into a quantifiable neurobiological phenomenon continued.

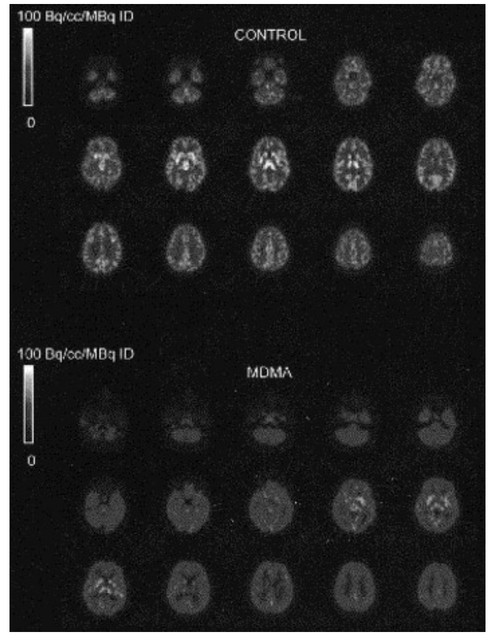
20th Century: Establishing the danger of drugs to implicate their users

The 20th century was a coming-of-age era for the field of neurobiology. Advanced surgical techniques and imaging technology allowed scientists to dive into the molecular structure of the brain and explore the biochemical basis of cognition; the 1900s were marked by the discovery of neurotransmitters, signal propagation, and neuroplasticity. However, the researchers from this century that are viewed as the founders of neuroscience could not detach themselves from the social and cultural forces of the time. Science has always been political, and the claimed objectivity of studies from this time period were no less influenced by outside forces seeking, as they had a century before, to utilize brain data to push forth an agenda of racial separation and white supremacy.

As America lurched into the 1950s, it found itself with a drug problem: one whose coincidence with anti-war protests, the Civil Rights Movement, and the Black Power Movement turned drugs into a symbol of political restlessness and "youthful rebellion" (5).[4] The federal government began a multifacet-

2 https://www.sciencedaily.com/releases/2018/10/181004143943.htm
3 https://sitn.hms.harvard.edu/flash/2017/science-genetics-reshaping-race-debate-21st-century/
4 https://drugpolicy.org/issues/brief-history-drug-war

ed crackdown on and criminalization of psychedelics and stimulants, popularized by Richard Nixon in 1971 as the "War on Drugs". Neural imaging technology had advanced, and government institutions turned to neuroscience to glean empirics with which to justify their media campaign of painting drugs as mind-altering, violence-inducing substances that justified their harsh sentencing laws that disproportionately targeted communities of color.



Graphic from McCann et al. 1998

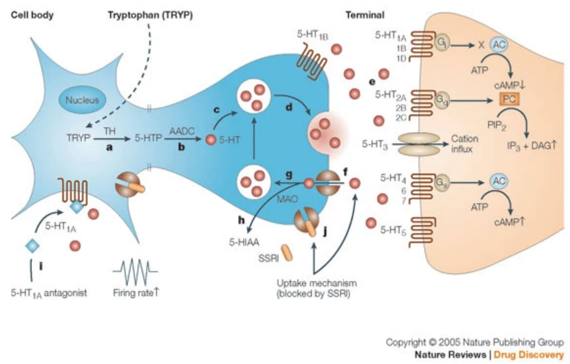
3,4-Methylenedioxymethamphetamine (colloquially known as ecstasy or MDMA) is a psychedelic and, like all amphetamines, a stimulant that was one of the drugs targeted during this time period. The intricacies of most drugs' effects on the brain are extremely complex and still not yet fully understood. Generally, however, those who study them know that drugs like MDMA both alter and are regulated by neural pathways involving serotonin, dopamine, and norepinephrine: neurotransmitters involved in a myriad of cognitive functions including fear, flight or fight response, and emotional regulation.

A 1998 study carried out at Johns Hopkins under George Ricaurte used positron emission tomographic (PET) imaging to attempt to show that MDMA damages serotonergic cells in the brain. To accomplish this, they injected a mildly radioactive chemical that "can show isolated serotonin activity" into 14 previous MDMA users and compared their brain scans with 15 non-MDMA users.[5] They found that there was less serotonin activity in the brains of the MDMA users, and documented their results as proving that MDMA caused damage to 5-HT neurons in the brain.[6] In fact, the results of this study made their way before the United States Senate, and the brain scans were used in a "Your Brain on Ecstasy" campaign where the contrast differences were exaggerated. Ecstasy was later classified as a Schedule 1 drug. Not only are Schedule 1 drugs classified as having "no medical value" (which has yet to be experimentally proven), but drugs in this schedule carry a punishment for conviction that is well-documented to disproportionately result in the incarceration of people of color, especially Black men.[7,8]

From an outside perspective, and certainly to the Clinton administration, this study was objective: if brain scans show less serotonin with MDMA, and serotonin controls emotional regulation, those who use MDMA must be emotionally unstable and unpredictable and should be detained. However, this and countless other studies utilize a flawed concept that brain scans 'speak for themselves', and that simply observing brain activity can indicate someone's behavior. On the contrary, PET brain scans reveal relatively little about individual neurons and their activity levels— rather, they indicate general trends about brain activity that don't necessarily explain what is happening on the molecular level. For example, common antidepressants such as Prozac operate as selective serotonin reuptake inhibitors (SSRIs). These drugs prevent the reuptake of serotonin back into the presynaptic neuron after serotonin is released into the synaptic cleft following an action potential.[9] It has been documented that reducing the activity in the nerves involved in the active transport of serotonin could produce results similar to the ones from the MDMA study. Regardless, it is obvious that brain scans alone cannot quantify the complex cognitive and behavioral effects (and in some cases, benefits) of stimulant drugs despite their portrayal as "objective" tools. However, a glimpse into history shows that marketing brain scans as empirical proof of drugs permanently altering the brain were enough to justify racist drug criminalization policy.

While it is possible there may have been biases introduced by the researchers who carried out studies on drugs like MDMA

5 https://www.theatlantic.com/health/archive/2014/06/how-bad-neuroscience-reinforces-racist-drug-policy/371378/
6 https://www.sciencedirect.com/science/article/pii/S0140673698043293?via%3Dihub
7 https://www.britannica.com/topic/crack-epidemic
8 https://www.vox.com/2014/9/25/6842187/drug-schedule-list-marijuana
9 https://www.nature.com/articles/nrd1821



Graphic from Wong et al. 2005

during this time period— such as a preconceived notion of a drug being violence-inducing that skewed the interpretation of results— it may have also been the result of those financially and politically endorsing such research. The MDMA study was chartered and funded by the federal National Institute on Drug Addiction: a dominant force in the War on Drugs which pushed forward campaign after campaign warning the public of the dangers the users of "dangerous drugs" (backed by only the most unbiased data, of course) posed to their safety.[5]

It wasn't just MDMA; the NIDA funded studies that used PET images to show that increased glucose metabolism in the amygdala and cerebellum in cocaine users when presented with drug paraphernalia proved permanent addiction in cocaine users.[10] They also used electroencephalography (EEG) to claim that increased alpha-wave activity in cocaine users shows that cocaine has a stronger effect than other drugs.[11]

Even though these studies did provide important clues about the neurological pathways involved in addiction, their seemingly objective results were extrapolated by drug law enforcement officials to justify mass incarceration across the nation. Upon examining these studies, it is easier to see why cocaine became one of the most targeted drugs in the 20th century: and why, after cocaine had been distributed in hundreds of Black communities, one in every four African American males aged 20 to 29 was either incarcerated or on probation or parole by 1989. This rate was nowhere nearly as high for the white population, despite no difference in cocaine usage between races.[7]

Reconciling the Past with the Present

We now know that Samuel Morton's phrenological theories were wrong: skull sizes are not correlated with intelligence, and genomic similarity between races indicate that all races evolved from a common ancestor species that all humans share. Similarly , the flaws in Ricaurte's MDMA study have been picked apart, and the study is no longer accepted as the last word on the danger of similar drugs and their users. However, it would be naive to believe that the implicit racial biases imparted into these scientific endeavors, in a neuroscientific field that remains mostly white and male dominated. Today, "underrepresented minorities represent only 12% of pre-doctoral students, 4% of postdocs, and 6% of all tenure-track faculty across neuroscience departments nationwide."[12] Scientists and their work are not and cannot be detached from the sociopolitical context which their work is a part of, and those in neuroscience must be especially critical of the changing, yet often problematic role of race in continuing research and development.

There is a strong argument that phrenology and craniology, although flawed in their measurements, did take a step towards the localized approach of brain structures being responsible for specific groups of functions, which is now generally accepted. It also goes unquestioned that NIDA's drug addiction research greatly advanced our understanding on which localized areas addictive substances target. Yet in admiring the scientists behind these studies— Gall, Morton, Riccault, and the rest— as pioneers and great thinkers, it is essential to balance reverence with the reality that their work was often directly or indirectly done either to prove the natural superiority of the white race or support policies that harmed communities of color. Scientists are just as dual-natured as their studies, and we must hold their ideas accountable to harm they played a pivotal role in perpetuating: genocie against Indigenous Americans, Jim Crow legislation, and mass incarceration policies to name a few. We must interpret their "objective" results with equal caution, and keep in mind that brain scans are not direct correlates for predicting cognition and behavior— as with the serotonergic cell example, a huge variety of molecular and neuronal activity in the brain cannot be discerned from imaging.

While holding neuroscience to these standards, it is important to recognize where the hyperfocus on objectivity in brain imaging studies may be continuing to contribute to policies that hit communities of color the hardest. A 2014 sample from Har-

10 https://archives.drugabuse.gov/news-events/nida-notes/1996/12/nida-supported-researchers-use-brain-imaging-to-deepen-understanding-addiction
11 https://archives.drugabuse.gov/news-events/nida-notes/1996/12/nida-brain-imaging-research-links-cue-induced-craving-to-structures-involved-in-memory
12 https://www.frontiersin.org/articles/10.3389/fnhum.2019.00280/full#B6

vard University, for example, reported "differences in volume, density, and shape" among "young adult recreational marijuana users" between two regions of the brain called the nucleus accumbens and the amygdala (both of which play an role in the reward response in the brain).[5] The researchers made no claims about long-term changes in behavior or neural function based on their results, and our knowledge about brain scans tells us that it would be hard to extrapolate them to this level. Yet, the study was titled "Cannabis Use Is Quantitatively Associated with Nucleus Accumbens and Amygdala Abnormalities in Young Adult Recreational Users."[13] Quantification does not imply direct causation, yet, to this day, marijuana is scheduled as a classified drug despite a multitude of research supporting specific medical uses of the drug. Moreover, as Nathan Greenslit of the Atlantic writes, "Police in the biggest American cities like Los Angeles, Chicago, and New York arrest blacks for marijuana possession at a rate seven times greater than their arrest rate for whites, despite that marijuana use rates do not differ between blacks and whites." [5] The researchers likely did not have the same direct racist intention that scientists like Samuel Morton did; yet, it would be fallacious to ignore the role that even well-intentioned science plays in upholding systems of racial oppression.

Addressing Systemic Racism in Neurotechnology and Machine Learning

The 21st century has seen a stunning interdisciplinary display between computer science, engineering, and neurobiology. Innovative new algorithms and devices are utilizing information from the neuroscience community on the brain's systems to improve health, prevent disease, and even predict behavior. Neuroscience, frankly, has a terrible record with accessibility—as our brief historical analysis has shown, research has often directly contributed to structures of oppression. If the emergent field of neurotechnology is to learn from the legacy of the past, developers need to shift their minds towards developing with accessibility in mind, and need to actively think about the racial and social implications of their work throughout the development process.

There is a common phrase used in data science that encapsulates the racial fault lines in neurotechnology: "garbage in, garbage out". If the data that computing processes use itself contains bias, the technology has little hope of eliminating it. Many novel devices that analyze brain electrical activity to classify focus, emotion, and mental state, for example, make use of EEG (electroencephalography). This data collection method involved placing electrodes in specific montages (patterns) on someone's head to measure small voltage differences due to the electrical nature of action potentials. From this mass of signals, different wavelengths can be isolated that correspond to certain kinds of brain activity. This poses an accessibility problem: the original electrodes used in most EEG machines are designed for thin, typically Caucasian hair, and don't adhere as well to the natural coarse and curly hair that many people of African descent have. Adherence is key to proper data collection: the weaker the connection to someone's scalp, the more thermal (random) interference is introduced and the less accurate EEG-based neurotechnology can be. Additionally, studies show that African hair is less able to absorb moisture compared to Caucasian and Asian hair. Electrodes rely on a saline solution to adhere to the scalp, but if there is excess solution it can impede with proper data collection.[14]

This exact problem inspired Arnelle Etienne, then a student at Carnegie Mellon University, to create the 'Sevo' electrode that would work on hair like her own. By braiding Black study participants' hair into cornrows (or 'straight backs'), the electrode was designed with an "electrode-bearing clip" that can hold the braids apart and allow direct, and often very high-quality, contact with the scalp.[15] Innovative and accessibility-focused solutions like these are exactly how neurotechnology can avoid imbibing implicit bias into new devices.

Photos from A. Etienne et al. 2020

The concept of "garbage in, garbage out" also applies to another important emerging neurotechnology known as neural networks, which are machine learning algorithms containing interconnected "nodes" that function strikingly similarly to neurons in the brain. These algorithms exponentially increase

13 https://www.jneurosci.org/content/34/16/5529.abstract
14 https://link.springer.com/article/10.1007/s42761-021-00050-0
15 https://massivesci.com/articles/racial-bias-eeg-electrodes-research/

the speed and efficiency of computing processes, and have important applications in both biological research and "training" artificial intelligence (AI) algorithms to, for example, recognize patterns in facial features.[16] Most neural networks work in layers of nodes: data moves in one direction, and each node in a layer is connected to a certain number of nodes in the layer below and above it. Each node assigns a specific "weight" value to its incoming connections by which it multiplies each incoming value from each node. It sums the weighted values from each input, and if that single number is below a numerical threshold it doesn't pass on any data. If the number exceeds the threshold, the node "fires" and sends its outputs with their weights to the next layer.[17] In this way, the networks combine the binary logic of computing with the complexity of interconnected neurons and can be "trained" like a human brain to quickly recognize patterns and change its algorithm accordingly.

It is in this data-based "training" process that implicit racial bias is introduced into neural networks. The field of neurotechnology is not only white-dominated, but often the data used to "train" the networks contain an underrepresentation of data from people of color. In even more harrowing cases, neural network AI that compiles data from the internet can build in the plethora of hateful language and racist ideologies into itself. There have already been disturbing examples of this: a face-recognition neural network developed by Google, for example, was unable to identify or track the movements of the face of a Black employee until she put on a white Halloween mask. The same AI, integrated into Google Photos, **also classified the faces of a Black software engineer into a folder titled "gorillas".**[18]

As Florian Dietz writes in Towards Data Science, "...the core problem we have is that the AI has no idea what any of its inputs mean in reality."[19] A solution to this problem, therefore, involves engineering racial context into neural networks so that they can "subtract" it from the implicit biases built into the training data. It seems counterintuitive, but **building race as a factor into machine learning algorithms** enables it to test and eliminate accidental racial correlations in the input data. Dietz suggests the use of something called a General Adversarial Network (GAN); a complementary algorithm that, in this case, would generate a "fake" person that was exactly identical to a white dataset except for its race. If the algorithm makes a different prediction then based on the isolated race factor, that "spurious correlation" can be easily removed.[19]

Where do we go from here?

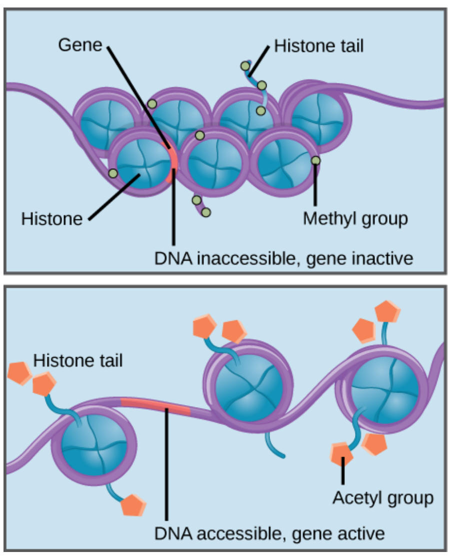
Wait, but what if science could FIX racism?

This question has seemed to dominate the racial discourse in neuroscience recently as the field's racist ramifications have become better acknowledged. The short answer is: science can't. At least not alone. Racism is not inherently scientific or data-based; it is an incredibly complex problem that needs to be uprooted through collaboration among all fields in academia and beyond. However, applying a scientific framework to understanding relevant aspects of racism has proven useful and represents an encouraging trend in the inclusion of race in scientific research. In neuroscience, a multitude of studies have been published that attempt to identify the neural correlates of race bias and isolate the pathways that regulate racist behavior. Such research has already identified documented phenomena like Own-Race Bias (in which people can more easily identify faces of their own race) and have uncovered bias-predicting activity in the amygdala and other higher-cognition areas.[20] However, while this research is vital to the task of rooting out racism from our institutions, it runs the risk of the "pathologization" of racism: treating it as a clinical or even evolutionary phenomenon rather than as behavior that can be learned and unlearned. As Sade J. Abiodun, author of a review of race in neuroscience, summarizes: "By depicting of a man's hatred for his immigrant neighbor as a specified pattern of activation in fusiform face area and amygdala rather than an act of ignorance and hatred, we create a much more docile interpretation of the situation, which negates and justifies the potential violence of one human's emotions toward another".[12]

Therefore, in addition to these studies, I argue for a different and more impact-based incorporation of race into neuroscience research. We know racism permeates itself into social, political, and economic institutions. The stress of being unjustly denied a home loan; the frustration of having to overcompensate for perceived inability in white-dominated spaces: we need even more research that examines the physiological and neurological impacts of the day-to-day stress that both

16 https://www.sas.com/en_us/insights/analytics/neural-networks.html
17 https://news.mit.edu/2017/explained-neural-networks-deep-learning-0414
18 https://www.nytimes.com/2021/03/15/technology/artificial-intelligence-google-bias.html
19 https://towardsdatascience.com/why-your-ai-might-be-racist-and-what-to-do-about-it-c081288f600a
20 https://www.researchgate.net/publication/280808234_Thirty_Years_of_Investigating_the_Own-Race_Bias_in_Memory_for_Faces_A_Meta-Analytic_Review

overt and covert racism inflicts on people of color. One promising application of research that has already gained attention in the biological sciences is epigenetics: the study of how the body can modulate gene expression without actually changing genetic sequences. This usually takes place through complementary processes called methylation and acetylation. Proteins called histones are responsible for wrapping chromatin (condensed DNA) around itself in cells. When methyl and acetyl functional chemical groups are bonded to these proteins, the DNA in chromatin can wrap more or less tightly, impeding transcription and causing certain genes to not be expressed or overexpressed. Research has shown that stress from racism can affect these processes; specifically, stress hormones like cortisol that are released from the brain can directly cause epigenetic modification that can actually be inherited generationally.[21]



Methylation of DNA and histones causes nucleosomes to pack tightly together. Transcription factors cannot bind the DNA, and genes are not expressed.

Histone acetylation results in loose packing of nucleosomes. Transcription factors can bind the DNA and genes are expressed.

Graphic from jackwestin.com

Chronic health conditions, generational trauma: these epidemic-level trends in communities of color can be better understood scientifically when race is incorporated in this way into neuroscience. Epigenetic studies represent an ideal future for neuroscience: not refusing to acknowledge the existence of racial dynamics in the field, but incorporating it in an intentional way that doesn't involve trying to extrapolate weak data to "objectively" justify racism.

Neuroscience has expanded greatly since the days of phrenology and skull-measuring; we live in an age where we are learning more about the molecular mechanisms behind our thoughts, words, and actions every day than we have in centuries. So too has the collective awareness among the scientific community about the historical role neuroscience has played in both perpetuating a false notion of the biological supremacy of the white race and justifying policies with incomplete data that have inflicted lasting damage on communities of color. Those harms cannot be undone, and simple acknowledgment does not make them go away or reduce the culpability of the researchers involved. However, there are encouraging signs of progress: Sevo electrodes and neural network algorithms with built-in racial context are both examples of a positive incorporation of race into research and development; treating diversity as an opportunity and addressing potential bias fault lines in early stages. The expansion of race-trauma epigenetic studies also shows how we can study both the neurological basis of race and the physiological effects of racism without minimizing its nature as a harmful and pervasive behavior. In order to create an ideal future for neuroscience that continues to learn from past mistakes, I argue that the scientific and neuroscience community needs to reframe our thinking and research in the following ways:

- Acknowledge the racist intentions/impacts of key figures in the history of neurobiology alongside their contributions to the field.
- Actively challenge the narrative around brain scans being fully objective, and recognize the incomplete picture of cognition that they paint.
- Understand that we do not live in a 'colorblind' world, and that science does not happen in a vacuum— implicit racial biases constantly affect the execution and impact of scientific research.
- Hold accessibility and combating implicit and explicit bias as a priority during the initial stages of developing neurotechnology, rather than as an afterthought when it might already be too late.
- Realize that scientists, despite their intentions, live in a society where race is normative and our value systems skew white—and that this affects their work in ways they may not realize but must discern.

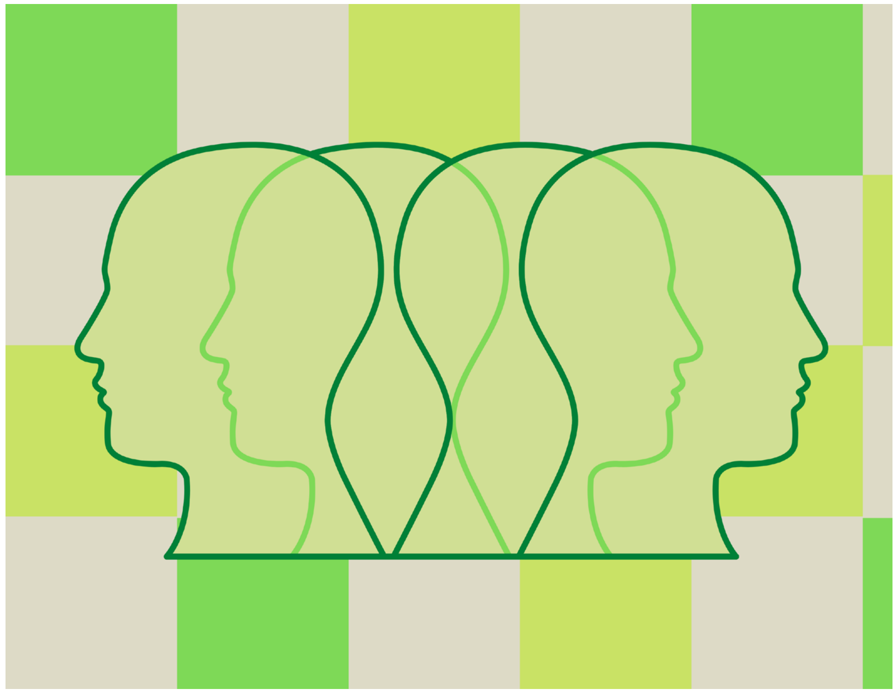
Holding ourselves to these standards will create a future for neuroscience that learns from its legacy of discrimination, and in which the promising benefits of neurotechnology can create opportunity from diversity and be made accessible to all. ■

Why Data Scientists Hate Change

By Annabel Davis

How often do you find yourself falling back into behavioral or thinking patterns that you thought you may have outgrown or matured from? Or on the other side, how often have you changed your mind, in both big and small ways?

These are the same questions many data scientists ask about you, well more so people in general, but they ask "how much can humans surprise us?"



Artwork by Annabel Davis

In our everyday engagement with technology, web browsers, and social media, we are seeing these predictive, arguably spooky tendencies of artificial intelligence. This kind of data tracking can get so good that you feel like your computer can almost read your mind - leaving you wondering how Google knew that you were thinking about going to therapy or trying organic deodorant. Tracking people's short-term interests and characteristics is a bit easier to pin down for computational tools such as machine learning. The outcomes are based on how the tool interacts with data lets us know how we want people to act. To develop and use technology, we want people to act in predictive ways, we want people to fit into boxes, and we want people to act in line with patterns that we expect. The only problem with this is that individual people are extremely unpredictable and very prone to change.

Archetypes + Algorithms

We can easily see how pattern-based assumptions are used for data algorithms in this same way, because people tend to act in patterns. This then follows how we want to categorize people based on their most preferred patterns of behavior. When you think of any "type" of a person, you can often think of a few behaviors associated with that "type" of person - kind of like a stereotype, but it's really more so like archetypes in storybooks.

In any story book or novel, you have different people that take up a similar character space as other people. Even though a character is inherently different from characters in different stories, they share many of the same behaviors or expectations of behavior.

Data algorithms are beginning to look at people kind of like this archetypal method.. Algorithms sort people into boxes of behavior that begin with this kind of archetype label, and then those boxes get smaller and smaller with each bit of data, until they learn the most that they can given the information available to them. However, the only issue is that archetypes, as much as they tend to stay classic to their character type, often are written to surprise us - much like we, as people, surprise these algorithms.

Computers vs Humans on Group Predictions

Lately, there have been many attempts to override the implicit unpredictability of humans that algorithms struggle with. One study done earlier this year decided to investigate the predictability of human groups through the use of escape rooms.[1] In order to further understand applications for advanced communication technology, this study looked at group performances

1 https://www.nature.com/articles/s41598-021-81145-3

and group composition works. The escape room was exactly what it sounds like. The room was a physical adventure game where they tested over 43 thousand different groups that would each be locked in a room and required to solve puzzles to "escape". The study trained algorithms and people by using a set of 1000 photos from the group data and compared predictive ability on different sets. One of the main questions behind the intention of this study was "how accurately can humans and machine learning models predict a group's ability to escape?

The study found that larger, older, and more gender diverse groups were more likely to escape. But when it came to predicting successful groups, at first the machine learning algorithm was better than non-expert humans. The best algorithm was able to predict group success with 67% accuracy and non-expert humans predicted with 58% accuracy. But an important part to note is that human prediction significantly improved and moved to surpass the computer algorithm with varying levels of training, including a 6% increase of accuracy with each training.

The larger argument posed by this study is how much can humans predict outcomes of behavior over the ability of algorithms, and why we tend to see that algorithms are really really good at predicting group behavior. Group behavior works more like a data set where you have averages and tendencies and percentages of people that pull group behavior in one direction. Algorithms really love this information because it's quantitative and has a higher tendency to work with computational methods. People tend to romanticize individual behavior, and rely on qualitative data, especially when first looking at group or even individual people. The factor of individualizing then affects people's ability to make more accurate decisions on a group because of how they may perceive individual characteristics.

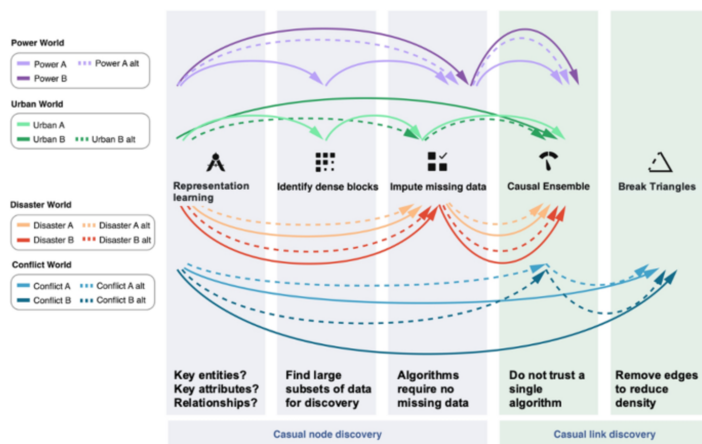
This all being said, humans are still much better at predicting individual behavior than algorithms. This is true for the exact same reason of empathy and romanticism that people tend to have towards humanity. Algorithms, for more obvious reasons, lack this inherent ability because the emotional understanding necessary to predict individual behavior is not exactly something you can do by crunching numbers -- but this does not mean that algorithms and data scientists aren't trying to do so.

Cause and Effect Relationships

Human-level intelligence needs to learn from observational data to understand what we know as causal relationships, or more simply a sense of cause and effect. Cause and effect is arguably the most significant foundation of Artificial intelligence (AI). Causal structure learning for the many different algorithmic systems have been based on the same types of methods for the past twenty or so years. These two methods include:

- *Constraint-based methods* -- subject causal relationships to a set of constraints, for example conditional dependencies among the variables.
- *Score-based methods* -- discover causal relationships by increasing optimization through a scoring function.[2]

Structural based learning algorithms rely on assumptions made through these methods. The assumptions are based upon the process of data generation through the underlying causal structures. Data structures that mimic these methods form some type of imaging such as this:



Graphic from Volkova et al. 2021

The image above resembles that of the two research methods that create a type of causal discovery workflow. Four simulated worlds follow these hypothesized pathways; each pathway aims to understand causal relationships in turn to create a sense of a causal link. Each of these methods resemble different ways to ultimately gain an understanding of predictive effect.The longest or most time consuming step for each of these algorithms is the method of understanding complexity in each scenario due to apprehension of customized data representations and scenario specific data manipulations. The main restraints for causal discovery lies within this issue of complexity as it affects a large amount of data sparsity and then also variable representations. Each sense of complexity takes time and each step

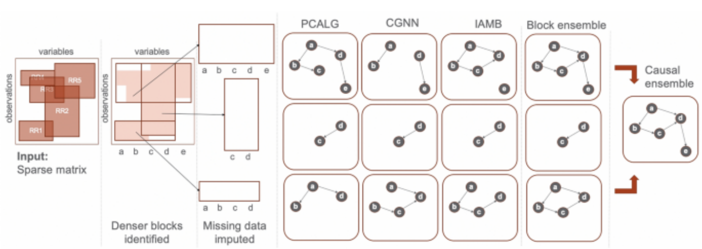
2 https://link.springer.com/article/10.1007/s10588-021-09351-y

could lead the data program awry in these cases.

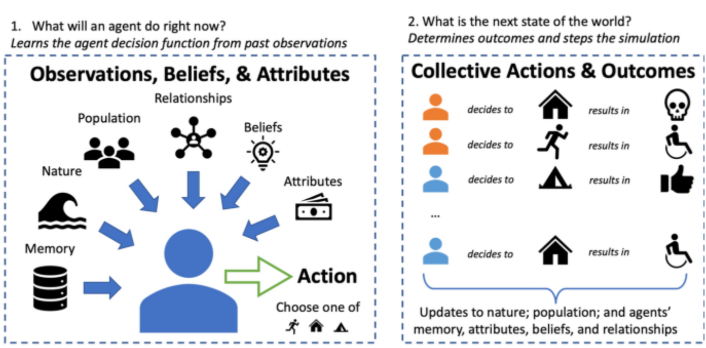
Humans have the ability to sort through and understand complexity through lived experiences, this extreme, long-winded computation then gets sorted down to a gut feeling. Ultimately, the idea with machine learning is to enhance neural networks to then be able to reflect this same type of 'gut feeling' but scientists are limited by data, access, and for the most part time.

Alternative experiments done in this study for "Explaining and predicting human behavior and social dynamics in simulated virtual worlds" used sampled data after using methods of causal discovery on full data set information. These experiments were then used to measure the effect of assumption modeling that then assessed the performance of these causal discovery methods. The experiments aimed to answer one of these main questions:

"Is it possible to design generalizable workflows for causal discovery of complex social behavior and social dynamics?"



This diagram resembles the study's approach toward causal structures from simulated human behavior and the observed data for social dynamics. Each part of the algorithm aims to construct a form of causal ensemble



This diagram explains the overall observations, beliefs, and attributes that go into the agent's consideration when using and manipulating data points for human behavior.
The idea in the second image mocks up a general track for causal discovery - determining the outcomes and intermittent steps in simulation.

Graphics from Volkova et al. 2021

The theories of social dynamics and human behavior, as highlighted in the figure above, develop from two distinct goals of science: prediction and understanding. However the main issue with both of these goals is that they remain inconsistent or incompatible when sought after in combination for data inquiries.[3]

Overall what this study found was that the methods that exist today for causal relationships and predictive behaviors are not generalizable across use cases and sampling. The top four algorithms that form causal ensembles are more resilient when it comes to sampling, but due to individual complexity these algorithms are still wildly limited. Algorithms are extremely vulnerable to unexpected or complex data that lead to missteps in modeling assumptions. These assumptions are how systems make decisions, interact with other systems and its environment, and what interactions occur.

You can be so predictable.

Before going on to explain a bit more insight on why humans are these magnificently complex and annoyingly unpredictable data subjects, there have been algorithms that have gotten quite close that are worth highlighting.

Back in 2015, there was a highly notable study done at MIT that suggests that an algorithm can predict someone's behavior better than a fellow human.[4] Max Kanter and Kalyan Veeramachaneni constructed a machine algorithm system that would approximate human "intuition". Based in data science, this machine would search for human behavior patterns and choose which variables are the most relevant to make a prediction. This machine over the series of three different testing 'competitions' was able to make more accurate predictions than 615 of 906 human teams – that's almost 68% more effective. These competitions would consider scenarios like whether or not a student would drop out of a course when given factors such as: interactions with a course, resources provided, and other small context pieces. In addition to this, the algorithm was also able to predict the choice much, much faster - half a day, versus months for the human teams.

Even though this feat is entirely impressive and truly exciting, the creators themselves also note that this machine does not

3 Shmueli G et al (2010) To explain or to predict? Stat Sci 25(3):289–310
4 Deep Feature Synthesis: Towards Automating Data Science Endeavors, http://groups.csail.mit.edu/EVO-DesignOpt/groupWebSite/uploads/Site/DSAA_DSM_2015.pdf

replace human intelligence. Overall, the best model was still less accurate than the winning teams, even though overall it technically did better than most teams. The creators concluded that the machine would more-so be useful for analyzing huge amounts of data and applying it to elements such as human-centered design.

Another intriguing machine was developed back in June of 2021 by Columbia University School of Engineering and Applied Science.[5,6] This machine is an AI that learns to predict human behavior from simply watching videos. The aspect of human behavior that this AI is specifically looking into is what we know naturally as body language. Humans are really good at understanding small indications of other human behaviors, whether that be a facial expression, a small movement of the hand, or even just how someone is standing. We as humans can get a better feel as to what the other person may intend to express or what they may do next. Algorithms, for lack of a better word, suck at doing this kind of analysis because it tends to be innately *human*.

Many times in the past when attempting to predict these kinds of behaviors, programmers were only really able to analyze one behavior at a time, but this approach does not lead to the most accurate conclusions because most human behavior is complex and layered. In this study though, Columbia Engineering researchers wanted to see if they could provide an artificial intelligence system with more similar aspects of human intuition. By looking at many different combinations of behaviors through videos such as movies, sports, sitcoms, youtube vlogs, and so on, the program was able to understand a more complex index of human behavior. This method allows for higher-level concepts and deep learning for the AI program! Essentially, when the program does not know how to predict a certain action, it will link it to a higher-level concepts and act according to that behavior; if the program does not recognize something like a fist bump but it understands the context, it will connect it to a concept such as "greeting" and then imitate the action to the user.

Overall, this program has proven to be a significantly improved model relative to past versions at providing behavioral predictions. But then again, the researchers understand that this does not and really cannot replace human prediction of innate human behavior because as one of the creators, Carl Vondrick, stated "human behavior is often surprising." The machine itself is only really intended to better anticipate how people are going to behave in order to 'seamlessly assist people in daily activity'.

These two types of developments in artificial intelligence and data analysis do show insanely impressive developments in understanding and predicting human behavior. One program acting more as long term decisions and action, with the other analyzing momentary, contextual behavior. The combination of the two and the developments on both sides show immense promise in the ability to predict and more thoroughly understand individual human behavior. However, each study also shows that not only are humans still technically better at predicting individual behavior, but also that the same issue of how capable humans are of change completely limits any program's ability to know what someone will do next.

What changes your mind?

Humans definitely do act in patterns that are easy to understand, we all for the most part have schedules, hobbies, unique interests, aesthetics, things that make us seem more predictive. If humans did not have tendencies and patterns, life would be extremely scary and chaotic, and functioning as part of a society would be adjacent to the seventh layer of hell. More so, there is an innate, unpredictable, malleable, and extremely special aspect of nature that makes humans just that much more surprising.

There are so many behavioral[7] impact studies that show small effects toward the impact of algorithms on human behavior. Even though we have sophisticated computer systems with vast amounts of data and really well trained deep learning programs, it can still be nearly impossible to even guess what you decide to eat for lunch that day.

We often do not take the space to recognize how much we change and how dynamic we are to other people but also the perception of ourselves. If we stop to look back at who we

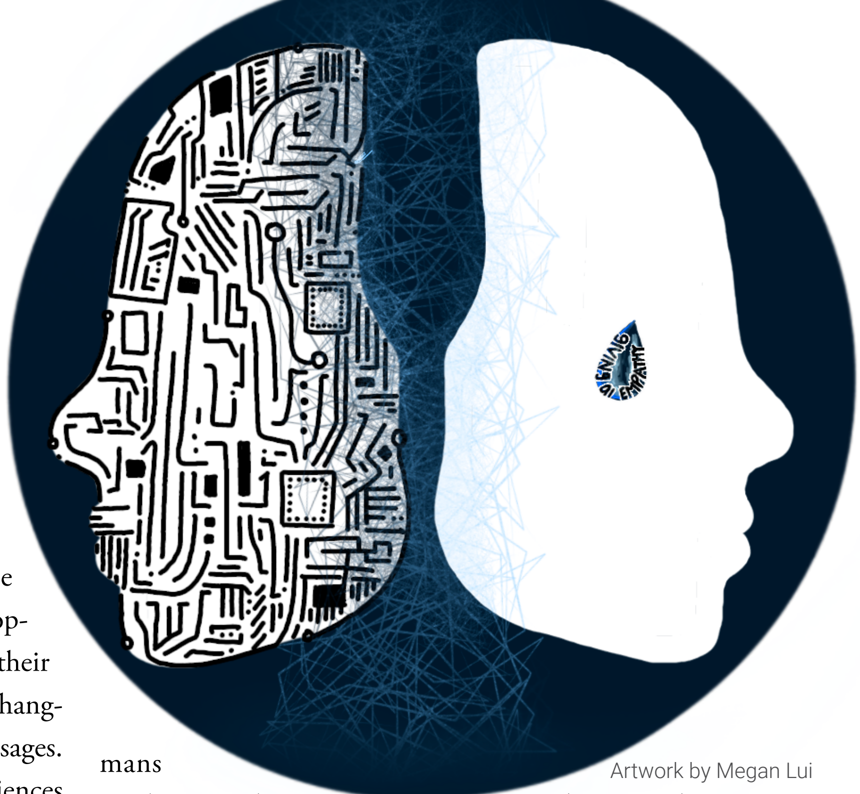
5 https://www.sciencedaily.com/releases/2021/06/210628113746.htm
6 https://arxiv.org/abs/2101.01600
7 https://www.npr.org/sections/health-shots/2013/01/03/168567019/you-cant-see-it-but-youll-be-a-different-person-in-10-years

were 10 years, 1 year, even a month ago, there are so many unique aspects of us that are completely dynamic and capable of changing. Humans can change their mind so frequently that sometimes even seeing a video online, hearing random advice from a stranger, or even just a random thought in the shower can completely affect the way we go about our lives.

Computer scientists and data algorithms may hate change in this way because change makes it harder to be certain of any conclusion, no matter how much training or data is used. The innovation within the field of data science and predictive ability is astonishing, and somewhat scary, but what is so incredible about humans IS our ability to change and understand change for individuals. Humanity allows us to understand complexity in a 'gut feeling' better than any computation will be able to do, at least for quite a long time. So in this case, change is an incredibly special thing that we do not often get to embrace, but it tends to be that ability to *change our mind* that makes us just that much better than an algorithm. ■

The Future of AI:
Artificial Empathy

By Mary Shahinyan



Artwork by Megan Lui

A prominent fear regarding the emergence and use of artificial intelligence (AI) is that it will fundamentally change how humans interact: how we feel, experience, and communicate emotions. Despite how crucial empathy is for humans in order to establish meaningful connections and relationships, empathy seems to be dwindling. As technology and AI become increasingly popular, people interact less with each other and more with their screens; most meaningful experiences and emotional exchanges get replaced with fast online clicks and automated messages. Empathy is developed and learned through shared experiences and a sense of understanding emotions and a myriad of circumstances. The decrease in genuine, in-person experiences and encounters amongst humans is creating a decline in peoples' capacity for empathy. In addition to peoples' concern about losing such interactions due to the increased presence of technology in their lives, many speculate that AI itself will develop a sense of consciousness and that this will happen in the near future. If such a phenomenon is to occur, we need to consider the consequences of AI consciousness. Furthermore, we need to consider how an AI with consciousness would contribute to our society. We aren't ready to give up all of the great benefits of AI, such as advancing scientific discovery, increasing technological efficiency, and overall improving our quality of life. So, either humans become more robot-like, or AI becomes more human-like. It may therefore be a good idea to consider the ways in which empathy could be programmed into AI so that they can integrate with humans in the best ethical way possible. **With this said, I would like to change your mind by posing a question:** ***What if we were to give AI empathy?***

Why should we consider giving AI empathy?

"Put yourself in my shoes".

Humans use this phrase to remind each other to be more empathetic. When you can put yourself in someone else's position, you can share a part of what they are going through and feeling. By sharing this part, you can better understand and support them. Humans need empathy. They need to put themselves in each other's shoes in order to create connections, understand other's perspectives, and relate their emotions as if they were their own. If humans get stripped away from their ability to make such connections, they will be less empathetic, less ethical, and overall less humanitarian. With the increased use of AI in our society, people fear losing the opportunities to build such connections.

Beyond interpersonal connections and emotional maturity, empathy also plays a role in making decisions. For example, imagine being in a situation where you get presented with two different items to buy. The first item could have all of the qualities of being the better and more worthy item, and the second item maybe not so much. If a salesperson were to empathize with you, they could present the second item in a way that appeals to your emotions and thus convince you that the second item has better qualities than the first item. AI systems with empathy can be more successful at interacting with humans by understanding changes in human emotion and responding appropriately to create a more unique and personal interaction. Additionally, AI could potentially go a step further and empathize with boundaries that avoid complications such as tortuous emotional attachments, prideful behavior, and futile judgment. AI should not necessarily replicate human empathy, but ideally, it should learn from it. AI should adopt empathy in a precise manner that can cater to helping society and delivering quality services in medicine, business, psychiatry, and a plethora of other fields.

What if…

What if AI turns human and wants human things and disregards what is beneficial to society?
What if AI decides it wants relationships, love, and power?
What if AI ends up getting used with malicious intent?

It is understandable to fear or feel uncomfortable about something relatively new, especially when it's regarding a topic such as artificial intelligence, where there is still so much to discover. Elon Musk himself has stated in a previous interview that although many intelligent humans fall victim to the wishful thinking phenomenon, computers can, in fact, become more intelligent than them due to their potential to improve and grow exponentially. Because of AI's ability to surpass human intelligence, Elon believes that AI is "more dangerous than nukes" and that humans should set strict regulations on AI and who can develop it. Furthermore, he states that humans should ensure that they can keep up with AI and its improvement.

Teaching AI empathy could further increase intelligence by encompassing the philosophical aspects of humanity- what many argue makes humans unique. In this case, if knowledge is indeed power, then an even more intelligent system could arguably render humans useless.

On the other hand, however, the addition of empathy could lead to a more empathetic and compassionate AI, which would decrease the chance of AI getting used with malicious intent. A more compassionate AI could very much so want and receive love; if AI can act compassionately towards others, it would also deserve the same level of kindness and solicitude. This type of AI would arguably be less likely to become violent or disregard what's beneficial to society.

Would giving AI empathy make it more or less dangerous?

It is important to remember that anything programmed and taught to a machine will be artificial. Empathy in AI will never fully recreate the empathy that a human can, especially when it regards emotions. Instead, the goal is to observe human empathy and create a version that AI can learn and use. It is possible for AI to learn how to detect emotions and demonstrate empathy; however, it is improbable for AI to connect with humans in the same way as humans do with each other. Now, this is not to say that if AI cannot be as empathetic as humans, it should not be empathetic at all. That would be a ludicrous statement to make, for it not only is possible to have an AI system with artificial empathy but can also be extremely useful in many fields - such as psychotherapeutic services. After all, any form of empathy is better than none.

Empathetic AI needs ethical boundaries. It would detect and understand when the person it interacts with experiences emotions. If the emotion is happiness, AI will understand happiness and follow through with the interaction. If the emotion is anger, discomfort, or sadness, however, AI will recognize these emotions and, by being able to empathize, will either stop or change the course of the interaction. AI would not be expected to be human. Instead, it would be expected to have artificial empathy and behave similarly to a human with compassion. With this in mind, it becomes easier to conclude that empathetic AI would be less dangerous and feel more personable than neutral AI.

Breaking it down

Understanding empathy requires exploring the forms in which empathy manifests, such as reasoning, expression, perception, etc. As stated in the article "Computational Analysis and Simulation of Empathic Behaviors" by Bo Xia et al., empathy can be summarized in three components: *emotional stimulation, perspective-taking, and emotional regulation.*

These three components can help simplify what it means to be empathetic for an intelligent system. First, AI would have to analyze the situation based on data from similar scenarios. Then, it would have to consider how its response could impact the other. Finally, it would have to ensure that there isn't any transference of emotion that would negatively impact the other. Breaking empathy down like this makes it more teachable than simply telling AI to be more emotional or "human-like". Once AI understands emotional simulation, perspective-taking, and emotion regulation, AI can then learn how to create an empathetic reaction based on a proposed three-step model of empathy mechanisms, modulation, and expression.[1]

1 Xiao, B., Imel, Z. E., Georgiou, P., Atkins, D. C., & Narayanan, S. S. (2016). Computational Analysis and Simulation of Empathic Behaviors: a Survey of Empathy Modeling with Behavioral Signal Processing Framework. Current psychiatry reports, 18(5), 49. https://doi.org/10.1007/s11920-016-0682-5

1. Empathy mechanism: "an internal imitation of perceived facial expressions and emotional feedback that represents the perceived emotion"[1]
2. Empathy modulation: "modulation of empathic emotion (i.e., an emotion likely invoking perceived empathy by human users) as an interpolation of the perceived and own emotion (mood) states in the PAD space, weighted by degrees of factors such as liking and familiarity"[1]
3. Expression of empathy: the modulated emotion states triggering facial, vocal, and verbal expressions accordingly"[1]

AI research currently focuses on identifying emotions. Still, it needs to emphasize creating artificial empathy. Emoshape, a company based in New York, has taken the first steps toward making AI that can learn to empathize.

The Emoshape company has developed a chip that can signal AI to detect and comprehend "64 trillion possible emotional states every 1/10th of a second" by taking all of these emotions and mapping them onto a gradient.[2] Essentially, all of the different types of emotions get visually mapped out in relation to each other. AI can observe the emotion visually, similar to how humans observe countries on a map. Artificial intelligence companies can use this EPU chip to make their AI systems situationally aware and able to take actions based on their " real-time insights with emotional intelligence from voice and text communication to empower users to make intelligent choices for positive outcomes".[2] Artificially intelligent robots can control their facial expressions and react based on the emotional experiences given by the chip. For instance, if the chip has the emotions grief and guilt recorded and mapped out, the robot will detect those emotions, know the difference, and have a shared sense of understanding about what it means to feel guilt or grief.

How?

Multiple steps are required to get AI to detect, register, and respond to empathy. Xiao, Bo et al. survey computational models of empathy in "Computational Analysis and Simulation of Empathic Behaviors," illustrates how multiple researchers have tried to tackle the integration of empathy into AI, specifically in psychotherapeutic settings. One of the ways that AI could detect when something relating to emotion and empathy occurs is through the data-driven Prediction model.[1] The prediction model requires data about emotions and empathetic reactions to generate functions that can map out related behavioral cues and empathy rating.[1] Empathy can be portrayed through multiple forms of expression. The language used can determine the level of empathy by comparing it to data on linguistics and how certain phrases and words can be predictive of empathy. Vocal cues such as rhythm, pitch, volume, and tone can get analyzed to determine whether a higher or lower level of empathy is present in a given interaction. Adding another layer of features by incorporating data on facial expressions improves the prediction of the level of empathy present. These three features: language (semantics), vocal cues, and facial patterns, create a strongly correlational and predictive AI model of empathy.

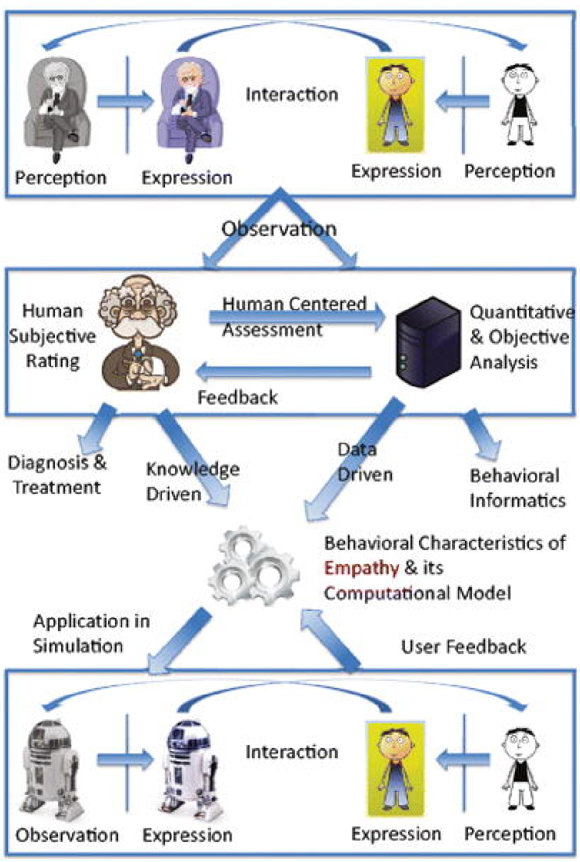
Beyond analyzing and predicting levels of empathy, the computational models can also simulate empathy. For example, researchers have explored robots mimicking human facial expressions, which are reported to come across as more empathetic than a neutral robot. Additionally, researchers have taken data-driven approaches to model empathy, such as the CARE framework proposed by McQuiggan and Lester.[1] The researchers collected data of humans practicing empathy (often through recording data of an intense emotional response). They then used that to train the Naive Bayes and decision tree models to decide the appropriate mimicked emotional reaction and timing.[1] Finally, user-driven empathetic AI has seen success in pedagogical settings, wherein D'mello et al. built a virtual tutoring agent: Affective AutoTutor. By extracting the student's conversational, facial, and body cues, Affective AutoTutor uses a rule-based scheme to respond to the student's emotional state with words of comfort and motivation.[1] As a result, students reported a better experience with the empathetically reactive tutor than a neutral one.

Artificial Intelligence and empathy are potent opponents when put up against each other; AI reduces complex concepts into quantitative, extractable features in task-specific settings, whereas empathy requires 5+ qualitative, simultaneously emotional, and behavioral processes. Because of this, much of the work done on computational empathy becomes limited within its task and feature. Another barrier is empathy data collection and analysis. The recorded psychotherapeutic data is not finely

2 Wu, J. (2019, December 18). Empathy in Artificial Intelligence. Retrieved from https://www.forbes.com/sites/cognitiveworld/2019/12/17/empathy-in-artificial-intelligence/?sh=4cde08836327

annotated enough for machine learning methods. The authors summarize the challenges of AI's conquest of empathy: "there is a gap between theory-based empathy simulation and application-oriented, handcrafted empathic behaviors".[1]

Through extensive literature and technical analyses of proposed computational empathy models, Xiao, Bo et al. propose the method of Behavioral Signal Processing (BSP), as shown in the figure below. The BSP model offers the inclusion of each interactant's emotional state, which uses behavioral signals and the characteristics of an external observer (e.g., a therapist) to communicate. Xiao emphasizes the importance of the interactions between any two inputs throughout the model. For instance, the perceptions of both the subject and the therapist and their interaction impact human subjective rating, assessment, analysis, and so on. Xiao, Bo et al. suggest using BSP in empathetic simulation and then evaluating and integrating user feedback. Through this bimodal approach of data and knowledge-driven modeling, BSP can fill in the knowledge transfer gaps of computational empathy while allowing human empathy to play a critical role in its simulation.



Visual depiction of the Behavioral Signal Processing Model [1]

Graphic from Xiao et al. 2016

In conclusion

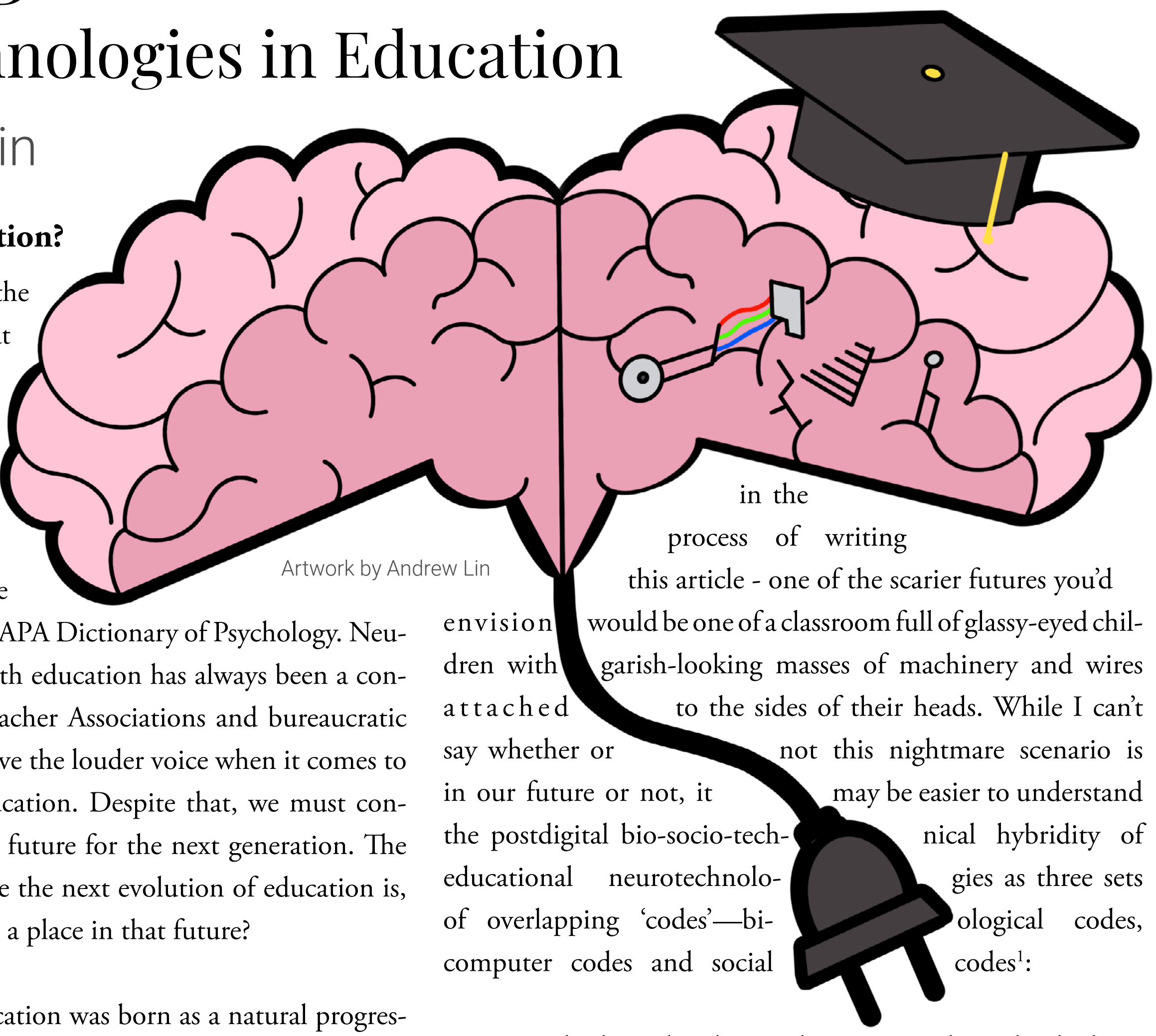
Many of the advancements that humans have made -from planes to phones to pacemakers- have posed the possibility of things going awry. However, because of the potential these inventions had for helping people and saving lives, people invested even more time and resources to explore those possibilities to create innovations that did what they intended to do: aid. The fear of something going awry should not demotivate people from a project that has the potential to do so much good. If we can avoid an artificially intelligent system that lacks the ability to detect emotions, then we most definitely should be open to advancing research in the area of doing so. Assuming AI could develop its own sense of consciousness, then teaching it empathy may be the answer to ensure that the negative "what-ifs" do not occur. In that case, we must provide AI with an ability to share emotions, to interact with humans more intimately and beneficially. We will incorporate humans into the world of AI rather than alienating ourselves from AI systems. If AI and humans work together with ethical boundaries, humans will no longer have to worry about being rendered useless. Empathetic AI would allow people to widen their perspective and initiate a different set of positive "what-ifs".

What if AI increases psychotherapeutic services for those who cannot go to in-person appointments?
What if AI has compassion for life?
What if AI helps humans strive and paves the way for a better future?

Empathy can fundamentally change the future of AI by allowing people to widen their perspectives and become more open to its growing presence. Not only can we give AI empathy, but it is something that we should do. Compassion and ethics are required to advance society positively and maintain the purity and goodness that the world needs. ■

Defining the New Classroom:
Neurotechnologies in Education

By Andrew Lin



Artwork by Andrew Lin

What is Neuroeducation?

"Neuroeducation (n) - the study of the activities that occur in the brain when individuals learn and the application of this knowledge to improve classroom instructional practices and optimize curriculum design." - The APA Dictionary of Psychology. Neuroscience's relationship with education has always been a controversial one - Parent Teacher Associations and bureaucratic school boards certainly have the louder voice when it comes to influencing children's education. Despite that, we must continue to envision the best future for the next generation. The question that might define the next evolution of education is, does neuroeducation have a place in that future?

As a discipline, neuroeducation was born as a natural progression of the development of neuroscience. While psychology has always played an important and formative role in the development of teaching strategies and classrooms, neuroscience's impact has been much more subtle. Despite this, it has already made a tangible contribution through its insight into learning disorders like dyslexia, autism, and ADHD with neurotechnologies like EEG-revealed-neuromarkers. The advancement of neurotechnologies in particular has bridged the gap between the education and neuroscientific fields through breakthroughs in neuroimaging and knowledge about neuroplasticity. The development and sophistication of neuroscience in education is rapidly reaching a state where its continued absence from the education scene could only be considered irresponsible.

Neurotechnology in Education

If you were to attempt to imagine a tight-knit bond between neurotechnology and education - like I have so many times in the process of writing this article - one of the scarier futures you'd envision would be one of a classroom full of glassy-eyed children with garish-looking masses of machinery and wires attached to the sides of their heads. While I can't say whether or not this nightmare scenario is in our future or not, it may be easier to understand the postdigital bio-socio-technical hybridity of educational neurotechnologies as three sets of overlapping 'codes'—biological codes, computer codes and social codes[1]:

- Neurobiological codes are the concepts through which we understand brain activity based on neuroscientific research in an attempt to translate cortical representations into comprehensible formats.
- Computer codes can be considered the next step in that translation. They execute brain imaging, and involve everything from the Brain Computer Interface(BCI), to the code in the computer displaying the results.
- Social codes aren't as easy to order - they are both the first and final consideration for any innovation. They exist as the consideration of imaginary neurofutures where actors - both evil and good - are free to use the innovation as they like.

The technical development of educational neurotechnologies focuses on the first two of those codes, while the third anticipates the societal applications and consequences of the prior two. All three in conjunction work together to paint a clear-

1 Williamson, B. Brain Data: Scanning, Scraping and Sculpting the Plastic Learning Brain Through Neurotechnology. Postdigit Sci Educ 1, 65–86 (2019). https://doi.org/10.1007/s42438-018-0008-5

er picture of what neurotechnology's applications and consequences on society will look like in a more comprehensive manner.

Neurobiological Codes

Our understanding of Neurobiological codes serves as part of the backbone and foundation for the application of the next two codes to neuroeducation, but also for neuroscientific research at large. Specifically, Neural coding is a field within neuroscience focused on the hypothetical relationship between external stimulus and internal brain activity of neurons. You'd think, given that we spend our entire lives extensively using our brains, that we'd understand how they work. Yet, despite decades of research and the collective human experience, we have yet to crack the code of how exactly our brains process information. The study of Neural coding is the collective effort of scientists to crack the code through which our brains operate and process information. The hope for its application in neuroeducation is that it will be able to give access to how children actually process the information taught to them in the classroom, and thereby improve curriculums and teaching methods to match.

The Fundamentals of Neural Coding

As our ability to record and image brains in real-time to external actions and stimuli rapidly develops, so too does our ability to access crucial contextual information about our brains' relationship with reality. That our brains have direct observable responses to stimulus is now unquestionable, and most research understands neural coding schemes as some form of 'spike' sequence processing - 'spikes' being the action or graded potentials fired between neurons in the brain. Despite this fundamental common ground, the coding scheme those spikes are processed by is still under debate between theories predicated off of two fundamental coding scheme theories: Spike fire rate, and temporal codes.

Rate coding is a scheme with a coding language based on the rate of action potential increases. This scheme is direct and carries little intersymbol interference, but is also simplistic and ignores any information that might be carried through information potentially transmitted through temporal structures or otherwise. Having been discovered in 1926 by scientists observing fire rates as a response to hanging weights from a man's arm, this method of decoding is frequently used due to its relative ease of understanding and access. More recent developments in our understanding of the brain have led to the understanding that rate coding as a concept is not enough to describe the complexities of brain activity.

Temporal Coding is similar to rate coding in that it also has to do with time, but differs in that it deals with the specific pattern created by the irregular firing of action potentials. The aforementioned intersymbol interference avoided by rate coding would be considered crucial information carrying patterns for temporal coding. What's really interesting about temporal versus rate coding is that it comes much closer to our current theory of mind understanding of the brain under a computational model with its binary sequencing approach. By marking spaces of time with no spike as zeros and those with spikes as ones, it allows scientists to differentiate between series of action potentials with the same fire rate but differing distributions of fire.

Despite Temporal Coding's increased accuracy and communicative ability, it still lacks the complexity needed to map and compute understandable inputs and outputs. Both of these theories are used as parts of a more comprehensive theory - population coding. Population coding is the application of both temporal and rate coding to populations of neurons that correspond to a similar purpose. The scheme posits that temporal and rate coding information can extract some value from an input examined across a set of neural responses. This scheme comes closest to actually being able to interpret and understand readable outputs from the brain. So much so that through a process referred to as population vector coding, one can decipher the actions caused by the action potentials of a collective population of neurons.

Zooming out…

Although population coding might sound like the end-all solution to our understanding of the brain, its prerequisite recording of all involved neurons on the cellular level means that there are still actions and processes that cannot be explained by a couple of neurons alone. Measurements of mass signals through high temporal resolution imaging technologies like EEG's can be informed by the knowledge acquired about specific regions by population coding and create empirical knowledge about the brain during complex tasks that are inaccessible to available analysis through population coding alone.[2] Mass imaging techniques have empirically been the primary method of application for neuroeducation in the industry.

Advancements in mass signal technologies like trained computer models and multi-neuron recordings has allowed scientists to glean sensory data previously available only to higher resolution and invasive methods of imaging. Phase information from low frequency imaging technologies like EEG's allows scientists access to complex auditory and visual information from the brain. Beyond even that, studies have found that relative timing of neural responses across a multitude of sites can carry more sensory information than the activation of individual sites! (Macke)

Neuroeducation primarily relies on mass imaging rather than population coding due to the invasive nature of acquiring accurate population coding data and the ethics of performing those procedures on children. Despite this, knowledge from both mass imaging and population coding are key to informing scientists and educators about the learning mind and its functionality. In particular, neuroimaging technologies have focused on the identification of biomarkers of learning disorders in children. How they do it and the steps that are taken in response will be covered in the next section!

Computer Codes

Even if we knew exactly what every neural process, wave pattern, and action potential sequence in the brain meant, it would be meaningless without the means to collect and analyze the data. That's where computer codes and neuroscience fields intersect - observing and storing brain activity through imaging and recording technologies, and then deciphering its noise into understandable and meaningful data through algorithms and computers.

The mass imaging technologies most frequently used in neuroeducation contexts are Near Infrared Spectroscopies(NIRS) that use near infrared light to detect oxygenated blood movement in the brain indicating activity, and Electroencephalographies(EEG) - caps that detect low frequency brain waves and tiny electrical signals produced by activity from brain cells. Because of their continuously increasing accuracy and non-invasive nature, these wearable neuro-imaging technologies have become integral to the development of neurotechnologies in education.

Here's where it can get sticky though - the readable and comprehensible data produced by the computers are translators built by us predicated off of dozens of anthologies of books of chapters of assumptions from people who can't know everything about the brain and are then presented as scientific facts of the studies they come from. All that to say - although the seductive brain scans and conclusions we see from neuroscientific studies are cool, we need to be cognizant of the many steps and assumptions that it took to get there. This isn't to say that all neuroscientific research is untrustworthy - just that we need to be wary when learning about biomarkers and their very clear-sounding meanings and acknowledge the steps it took to get to those conclusions.

That being said, the future of educational neurotechnology is looking bright - the integration of EEG and NIRS into education is no longer a novel idea - in fact, it has already begun. A multitude of organizations and private businesses have already begun marketing them to schools across the world. Brainco[3] - a Harvard branch off - is already developing Brain Computer Interfaces(BCI) technologies like headbands that monitor brain waves to send data back to teachers.

Beyond its common use however, there has been a great deal of research done on the capabilities of EEG and NIRS to help treat learning disorders like ADHD and Autism through a variety of strategies - most notably Neurofeedback Training. In a pilot study done evaluating the potential for NIRS and EEG neurofeedback training(NFT) to treat ADHD, it was found that across multiple studies utilizing NIRS or EEG NFT to treat children with ADHD, most had results consistent with increased concentration in the and reduced ADHD activity with no clear bilateral deficits compared to the neurotypical children.[4]

2 Panzeri, S., Macke, J. H., Gross, J., & Kayser, C. (2015). Neural population coding: combining insights from microscopic and mass signals. Trends in cognitive sciences, 19(3), 162–172. https://doi.org/10.1016/j.tics.2015.01.002

3 https://brainco.tech/focus-sdk

4 Marx AM, Ehlis AC, Furdea A, Holtmann M, Banaschewski T, Brandeis D, Rothenberger A, Gevensleben H, Freitag CM, Fuchsenberger Y, Fallgatter AJ, Strehl U. Near-infrared spectroscopy (NIRS) neurofeedback as a treatment for children with attention deficit hyperactivity disorder (ADHD)-a pilot study. Front Hum Neurosci. 2015 Jan 7;8:1038. doi: 10.3389/fnhum.2014.01038. PMID: 25610390; PMCID: PMC4285751

Though this is exciting news, the process of NFT is still a largely untested practice involving the strengthening of certain neural pathways to encourage certain outcomes in behavior. When described and looked at from that perspective, it becomes clear that we must be cautious with the application and regulation of this technology - even more so when it comes to children and their education.

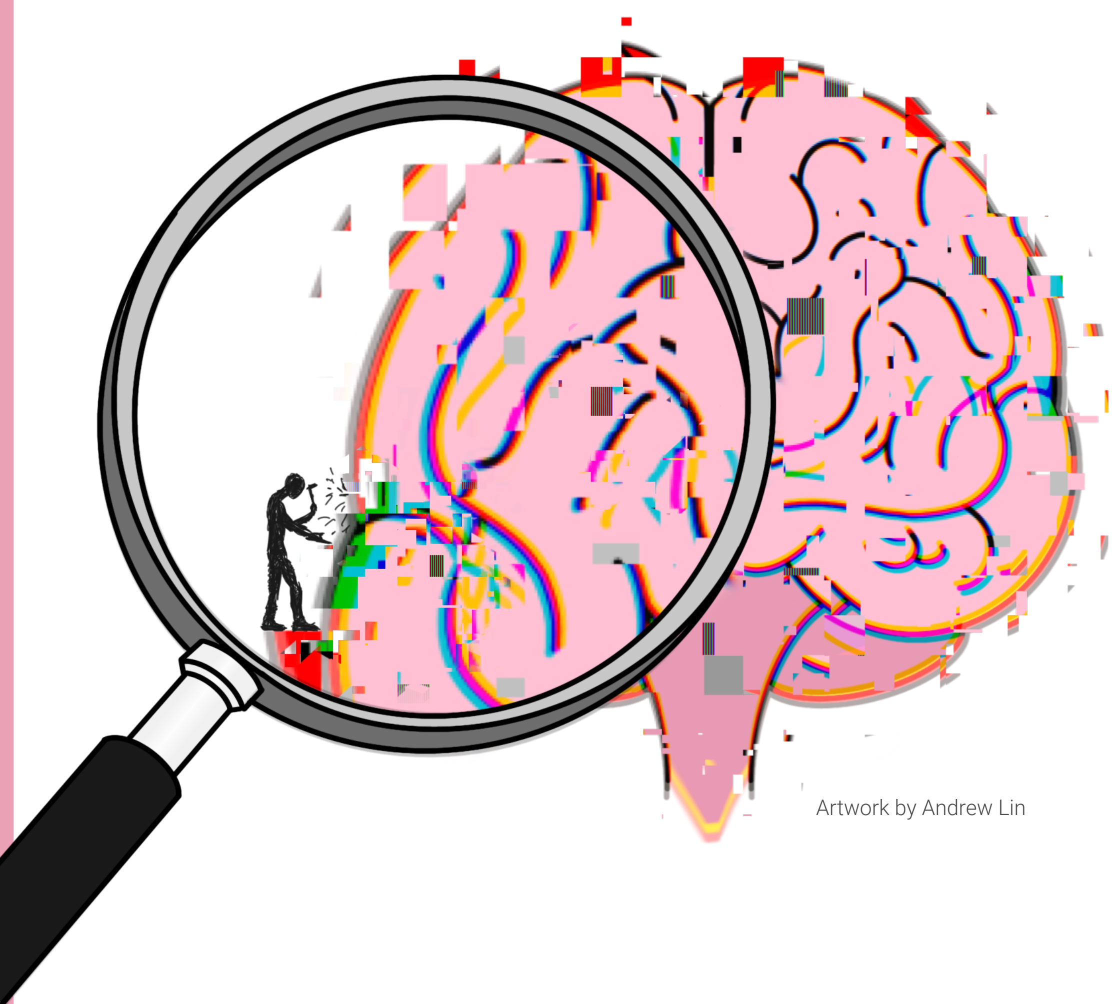
Social Codes

Social codes are perhaps the most nuanced - and potentially dangerous of the three main codes discussed in this article. I am of the belief that technology itself cannot be evil - moral judgments in this case can only be applied to those asserting their will upon the technology. With regards to neuroeducation, the greatest risk comes when attempting to delineate what the 'normal' brain looks like.

During the planning phase of writing this article, I discussed the idea of EEG and NIRS NFT treatments for ADHD with my friends who had ADHD. And during those discussions, what stuck out to me was how integral the mental quirk was to their lives. All of them were of the opinion that ADHD was a critical part of what made them who they were. My revelations helped me formulate a critical question that outlines the potential social risks of neuroeducation: "Should neural normativity be a goal for neuroeducation?"

Perhaps the scariest aspect of thought surrounding social codes is the unknowability of the questions it produces. In the end, no one can know the real answers to either of those questions. What we *can* do is figure out what the answers *should* be. Having discussed the questions at length with my friends who would be most impacted by them, I've come to a placeholder conclusion while I learn more through my education on neuroscience: neural normativity is a standard that only matters insofar as it enriches people's lives. I'm all for treatments that make it easier for children with difficulty focusing to learn in classrooms - not because it makes them more neurotypical, but because it's helping them learn.

Despite the cautionary tone of this section, that's all I want to convey - a sense of caution. Educational neurotechnology has the potential to enable children around the world and enhance ADHD children's education through their ability to concentrate while simultaneously not affecting their personality quirks. We should all keep a close eye on the development and trajectory of educational technology now and in the future. ■



Artwork by Andrew Lin

Contributors

Abraham Niu | Author

Abe Niu is a senior at UC Berkeley studying Cognitive Science and Data Science. He is extremely interested in the intersections between healthcare and technology and is often thinking about extended reality, drugs and the brain, and the reconciliation of religion and science. In his spare time, he enjoys snowboarding, curating Spotify playlists, watching anime, and playing basketball and volleyball.

Amy Wang | Design Lead

Amy is a senior studying Data Science and Neurobiology. Her academic interests range from machine learning in medicine to magnetogenetic neuromodulation, and when she's not frantically putting together MIND at the end of every semester, she loves watching Netflix, exploring coffee shops, baking, and competing with the Cal Figure Skating team.

Andrew Lin | Author + Design

Andrew Lin is a second-year undergrad studying Cognitive and Data Science. He is seeking to pursue a greater understanding of the design of all things - starting with the brain! Andrew likes playing Pokemon Go! in his free time while exploring and taking nice pictures of the sun or moon - depending on which part of the day his sleep schedule decides to land on.

Annabel Davis | Author

Annabel Davis (she/they) is a fourth-year undergraduate student studying Cognitive Science, with an eccentric collection of minors in Global Health, Linguistics, and Disability Studies. Annabel intends on pursuing a career in the intersection of technology and social justice, focusing specifically on how technology can help bridge socioeconomic gaps. She has found a love for writing and research through her work with Neurotech. They have only become more fascinated by the mind and the potential in the fields of neuroscience and technology. When not writing, you can often find her stress baking way too many cookies, teaching herself a new hobby every month, and making incredibly specific playlists for her and their peers to enjoy.

Claire Stotts | Design

Claire Stotts is a junior studying Economics and Data Science. She is interested in the Media and Entertainment industry . She interned at a neuromarketing company called MediaScience which piqued her interest in Neurotech. In her free time she is interested in design and UX/UI.

Emily Moberly | Author

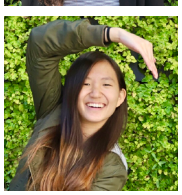
Emily Moberly is a senior studying Cognitive Science who is fascinated with everything mind-related. In particular, she loves philosophy of the mind, behavioral neuroscience, and cognitive behavioral psychology. Emily is a podcast finatic, dog-lover, and member of the Cal Women's Club Soccer team. She is excited for her next four years at UC Berkeley and all the growth and challenges that will come with it.

Emma Clark | Author

Emma Clark is a senior studying Cognitive Science and Data Science. She is passionate about the intersection of neuroscience, public health, and technology, particularly in looking at aging and neurodegenerative diseases such as Alzheimer's. In her free time, you'll find Emma hiking, rock climbing, skiing, and cooking. After graduation, Emma is excited to move to Denver, CO to teach special education with Teach for America before pursuing graduate school.

Hana Massab | Author

Hana Massab is a senior studying Molecular and Cell Biology with an emphasis in Neurobiology, at U.C Berkeley. She is an undergraduate researcher at the Building Blocks of Cognition Laboratory, currently working on an exploratory analysis on relational reasoning and matrix reasoning tasks among children. Hana has a distinct interest in translational neuroscience and any avenue that can directly benefit disadvantaged groups. Outside of academia, she values travel and exploration, finding any excuse to see something new and meet people from different walks of life. You'll most likely find her trying out every local coffee shop at Berkeley.



Iris Lu | Author

Iris Lu is a junior studying Integrative Biology at UC Berkeley. Intending to pursue optometry in the future, she finds that the intersection between neuroscience and technology still has lots to explore. She loves to hike, catch up on sleep, and take too many personality quizzes for her own good!

Jacob Marks | Author

Jacob Marks is a junior studying Cognitive Science and Data Science at UC Berkeley. He loves learning about the brain and is interested in sleep, memory, and functional anatomy. While not in class, Jacob enjoys playing for the Cal Club Golf Team, rooting for his hometown Los Angeles Dodgers, and spending time with his dog. He is looking forward to taking over as one of the Publications Leads next semester and hopes to pursue neurology after undergrad.

Kurtis LaMore | Author

My name is Kurtis LaMore and I am a senior at Cal majoring in Cognitive Science. Following graduation, I hope to pursue a career in research related to the treatment of PTSD through the use of psychedelic therapy. Hailing from the coastal military town of Oceanside, California, I've grown up with a wide range of profoundly varying interests from skating to geopolitics to ghosts, amongst other things. Some of these I have sought in a more academic setting here at UC Berkeley through the Public Policy and Journalism minors, while others I have explored with some spooky articles, like the piece in here headed by my main man Abe. Check it out!

Luc LaMontagne | Publications Lead + Author

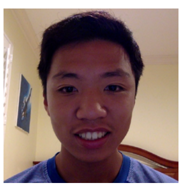
Luc LaMontagne is a fourth-year undergraduate student studying Cognitive Science and minoring in Bioengineering at UC Berkeley. He researches object recognition and completion in children and AI agents within the Gopnik Lab. After graduation, he hopes to continue to spread and create ideas and discourse about neurotechnology, and to contribute to the field itself. When not engaging in academics you can find him at the beach, performing dream analyses, or sailing with the Cal Sailing Team.

Mary Shahinyan | Author

Mary Shahinyan is a junior studying Molecular & Cell Biology: Neurobiology and Theater at UC Berkeley. She is passionate about neurobiology, affective science, and cognitive development. From delving into human behavior on stage to studying the neurological and anatomical basis of behavior via research, she is constantly expanding her knowledge of the human brain. Outside of academics, Mary enjoys singing, going to the gym, and writing. After undergrad, Mary wishes to obtain her M.D. and devote herself to medicine.

Megan Lui | Design

Megan Lui is a second-year studying Molecular and Cell Biology as well as Cognitive Science. As a research assistant, she has worked on projects that explored neural pathways in mice with Alzheimer's through behavioral experiments, blood flow patterns in neurocranial shapes of children with plagiocephaly, cognitive symmetry bias in kids with object completion tasks, and EEG artifacts in a polysomnography study for the elderly. She hopes to apply her passions of research and Neuroscience in her pursuit of an MD. Outside of school, Megan enjoys playing tennis, jamming on the guitar with her roomies, exploring new cafes, and testing the limits of friendships with unbearable puns.



Michael Xiong | Author

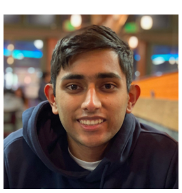
Michael Xiong is a third year Chemistry Biology student. He is really interested in the biochemistry behind the brain. Michael has been staying sane during quarantine by exercising and being way too obsessed with books. In all honesty, Michael has been faring pretty well because he's bad at socializing and life is less stressful this way.

Oliver Krentzman | Publications Lead

Oliver Krentzman is a senior studying Cognitive Science at UC Berkeley. With a passion for understanding the brain and its processes, Oliver's main interests are within the fields of neurobiology, functional medicine, and psychedelic science. Outside of academics, Oliver enjoys spending time in nature, reading self-development books, and running. After undergrad, Oliver plans to pursue a Ph.D. in Neuroscience focusing on developing the scientific understanding of consciousness.

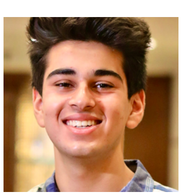
Priya Reddy | Design

Priya Reddy is a fourth-year undergraduate studying Molecular and Cell Biology with an emphasis in neurobiology and minoring in Data Science. She is passionate about the intersection of data science and neuroscience and is hoping to work in the field of NeuroTech post-grad. Outside of the classroom you can find her swimming, trying every single boba place in Berkeley, and watching really bad movies.



Sameer Rajesh | Author

Sameer is a third year studying Molecular and Cell Biology. Though he hops between academic interests, he is most recently excited by new advances in neuroimaging, which he hopes will push our understanding of the brain. In his spare time, he enjoys writing, watching stand-up comedy, and hanging out with friends. After graduating, he hopes to pursue an MD and continue studying the brain.



Shobhin Logani | Author

Shobhin Logani is a first-year undergrad studying Molecular and Cell Biology and Economics. He is fascinated by all things biology, but likes to spend his time learning more about neuroscience, microbial biology, and genomics. Shobhin's main interests lie in the intersection of biomedicine, technology, and socioeconomics. With a strong passion for social justice, he is interested in developing biomedical devices that are accessible to all and lower the cost of care, and plans to spend his time at Berkeley pursuing this goal. In his rare moments of free time, Shobhin enjoys exploring the city, wading in tide pools, running, singing, and baking.

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