mind

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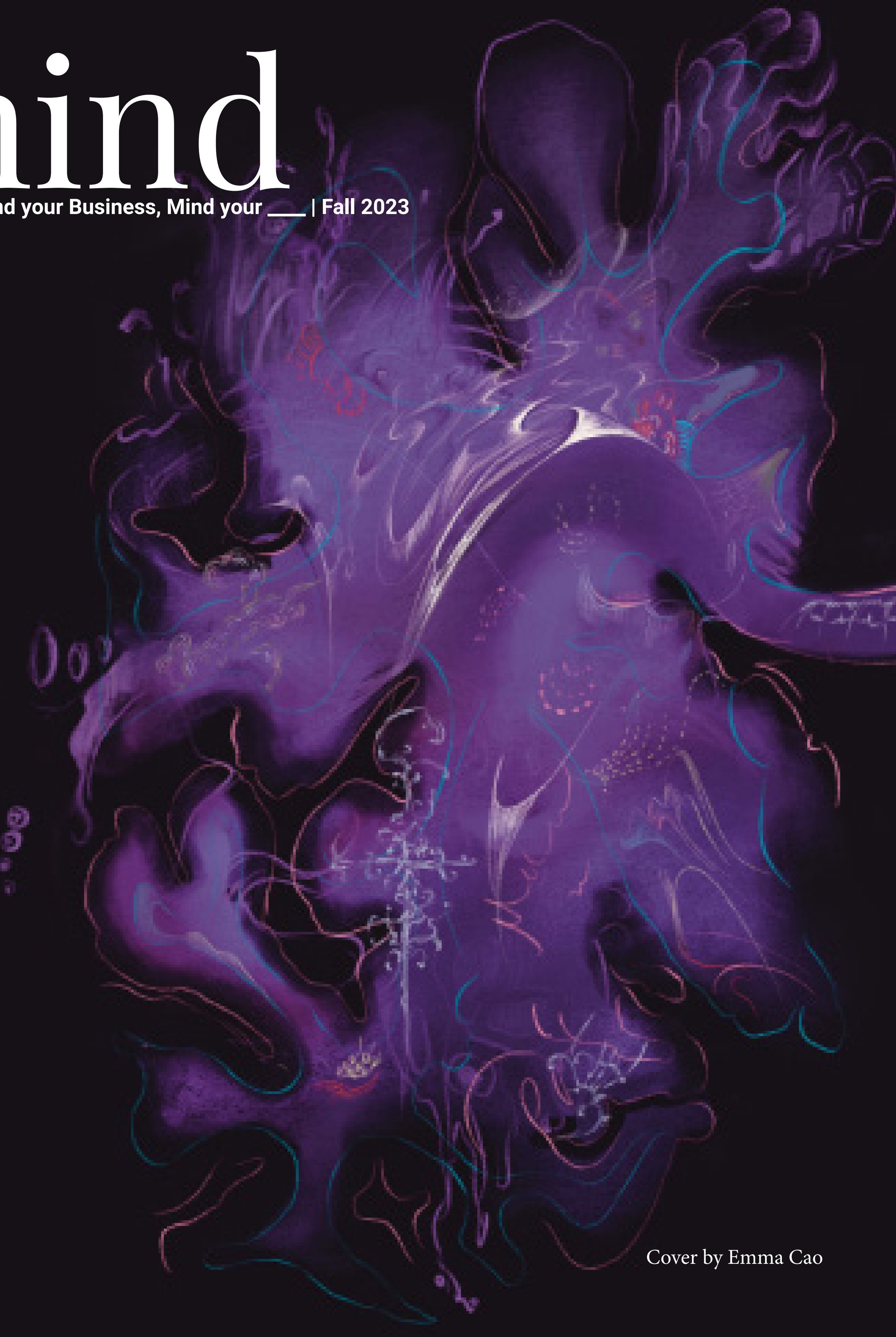

Cover by Emma Cao

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Letter from the Editors

MIND is a semesterly magazine published by the creative brains at Neurotech@Berkeley. Neurotech@Berkeley is UC Berkeley's student-run community for researching and educating about the rapidly-expanding field of neurotechnology. In addition to building our own devices and hosting industry events, we publish MIND to create an accessible source of distilled information that summarizes technological developments, explores ethical issues and regulatory affairs, and probes fundamental questions about human cognition. Each semester, our talented team of writers and designers embark on the 3-month journey of researching and pitching a topic, undergoing rigorous reviews of their drafts, and creating eye-catching graphics for the final product. Each issue has an overarching theme that centers all of the ideas and thoughts of the authors around a common question; however, each issue explores a wide variety of topics related to the exciting field of neurotechnology, one of which is sure to pique your interest. We hope you enjoy these pieces, and if you would like to learn more about our organization, explore previous issues of MIND, or contact us, please visit our website at https://neurotech.berkeley.edu/.

Happy reading!

Best,

Shobhin Logani
Aileen Xia
Editors-in-chief, Fall 2023

Formatting/Design: Hannah Corr

Mind Your Bias

By: Tess Gunatilake

During childbirth, Serena Williams was in excruciating pain and had trouble breathing. Due to her history of pulmonary embolisms, a fatal condition caused by a sudden blockage in the pulmonary artery, she had no doubt that she was facing the same life-threatening illness. Serena immediately alerted the nurse to order a CT scan, but the nurse suggested Serena was confused due to her pain medicine. Despite her healthcare team's disapproval, Serena persisted and the nurse reluctantly performed a CT scan which showed several blood clots in her lungs.

Not even the greatest tennis player of all time is immune to implicit bias in the healthcare system.

Can I avoid implicit bias?

Implicit bias occurs automatically and unintentionally. A Yale University study sampled a diverse group of American adults to watch a video of a boy who pricked his finger, and an identical video with a girl who did the same. Afterward, they rated how much pain they believed each child was in. Despite the identical reaction in each video, the adults attributed more pain to a boy who pricked his finger rather than a girl. The researchers attribute this conclusion to culturally ingrained myths such as "girls being more emotional." Too often, pain in women is overlooked or minimized due to implicit bias. This is just one of many examples of how implicit bias negatively affects different groups of people.

Many people, like myself, believe we won't fall for these biases. However, closer thought raises the question: How would we even know if we couldn't consciously prevent implicit bias? As it turns out, our brain has an innate ability to group individuals as an "in group" (people like us) or "outgroup" (people who differ from us).[1] Recent research has studied the brain networks attributed to in-group bias and prejudice. The model proposes that these biases are observed in various brain regions, with both high and low processing stages. The primary response is in the amygdala, which is involved in the experience of emotions. The frontal cortex is involved in higher-level processing. Overall, researchers concluded that in-group bias involves key and overlapping brain regions and cannot be separated. The frontal cortex manages our performance of judgment, motor functions, and personality and has a critical role in implicit bias. The act of "encoding" different people activates our frontal cortex and leads to implicit stereotyping, thus causing a domino effect that intensifies implicit bias. Additionally, it is much easier to stereotype and group individuals when you are under pressure. This creates a higher likelihood for implicit bias to impact one's opinions and decision-making, which can be "life-or-death" in healthcare if biases impact patient care and treatment. While many of us believe we won't fall trapped by these biases, it is inevitable. Bias is ingrained in our minds and our society.

In April 2021, the Centers for Disease Control and Prevention (CDC) declared racism a public health threat.[2] Numerous studies conducted by the National Academy of Medicine conclude that providers have a lower likelihood to give adequate treatments to people of color when compared to white patients, even after normalizing external factors like class, access to health insurance, and healthcare services. One study of 400 hospitals in the United States showed that black patients received cheaper, older, and more conservative treatments than white patients. For post-surgery care, Black patients are more likely to be discharged earlier than white patients, and at a time when discharge is too early.[2]

On top of this, CDC data shows that the COVID-19 pandemic hit communities of color the hardest. In response, the CDC created a plan to address the impact of racism in the healthcare system which includes more studies on how racism affects health, making new investments into minority communities, and expanding internal agency efforts.

The Takeover of Artificial Intelligence

Although artificial intelligence (AI) has revolutionized the healthcare field, it can worsen implicit bias in the healthcare system. AI and medical models for imaging put forth new

methods for diagnosis fundamentally powered by the large datasets they use. AI creates a quicker approach to diagnosing and providing algorithms that radiologists can use, thus leading to the speculation that AI will replace radiologists.[3] With the increasing dependency and use of AI, there is a concern about these "algorithms" perpetuating implicit bias and further facilitating unequal access in the healthcare system. While these models are useful for medical imaging, it is challenging–almost impossible– to create an AI model with data that represents an entire population. In a type of AI algorithm called supervised learning, models are trained with labeled datasets, which allow the models to grow more accurate over time by checking their predictions against the labels. For medical imaging and diagnostics, machine learning programs can be trained to examine medical images or be aware of certain markers for illness. Underrepresentation in datasets means that AI models are like you and me: they have bias. This bias can lead to differential medical treatment, and failure to identify these sources of bias can further aggravate healthcare inequalities. Medical imaging can propagate biases in many different steps, from making the model to deploying it to using it on the correct demographic.

The Medical Imaging Data and Resource Center (MIDRC), supported by the National

Institutes of Health, aims to develop imaging data commons and produce resources faster to accelerate clinical use of AI models while accounting for equity and trust. This committee tracks the diversity of data used to create these models and identifies 29 sources of bias in developing and implementing medical imaging techniques. These biases were grouped into 5 prevalent areas: data collection, data preparation, model development, model evaluation, and model deployment.[4]

Data collection is fundamental to gathering data relevant to one's project. This is a key step that leads to bias in AI models– after all, it is one of the first steps in creating a model, and if the data collection is biased, then a "domino effect" will occur and lead to more bias in the model. The accuracy of the model and results produced by the system depends on a training set: data that trains the model during testing to investigate whether the model is built correctly or not. If the model fits against its training data, but not against a predefined test dataset, then "overfitting" occurs and it cannot generalize well to new data. If the model cannot generalize efficiently to new data, then it will not be able to complete the prediction tasks it was built for.[5] These models are built on thousands of data points, and it is nearly impossible to accurately represent all demographics. Societal and institutional biases make it harder for underrepresented groups to participate in these studies. The exclusion effect becomes even more concerning when patients with a particular condition or a higher likelihood of a specific condition are not represented in these AI models.

Is there a solution?

As we rely more on AI models in medicine, how are underrepresented populations going to be included? In the case of data collection, being knowledgeable about this problem and taking steps to ensure that the sampling population provides representation for diverse demographics is key. For exclusion bias– when specific population groups are excluded from the data collection– making sure that the training sample represents the population that the AI model intends to predict outcomes for and examining inclusion and exclusion criteria is essential. If we can mitigate AI model bias at the first step, then there is a smaller likelihood that this will be propagated or amplified in the later stages of creating an AI model.[6]

While we actively take steps to decrease bias in medical technology, one has to ask: if implicit bias is a defining feature of the human brain, can we ever completely be rid of implicit bias– especially in the technologies we create? Even if we account for implicit bias in the algorithms for AI models, and have almost perfect data collection for our intended sampling group, it is impossible to account for all implicit bias. The American Bar Association says eliminating implicit bias is only possible if people recognize and understand their bias and why they have it.

This is easier said than done. To recognize bias, one has to actively be looking for it or someone has to point it out. While, if you are devoted, you can change your individual bias, it is very hard to collectively, as a society, be rid of all implicit bias. However, that does not mean we can simply accept implicit bias as a natural state and disregard the consequences of

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perpetuating our biases. These beliefs negatively affect different communities. It is important to collectively keep our biases in check, especially when our biases have the ability to influence medical technology such as AI and ML models that will use their algorithms to diagnose and treat all different groups of people. The future of healthcare and medical technology is in our hands- or more accurately, our data.

A Glance into the Future

Along with AI models, neurotechnology is immensely successful in diagnosing and treating various neurological disorders, including the improvement of speech in paralyzed individuals and diagnostics using brain-computer interfaces: a direct communication pathway between the brain's electrical activity and an external device. Every day, there are groundbreaking findings made with the support of neurotechnology. At UCSF, a brain-computer interface with machine-learning algorithms recently enabled a paralyzed individual to mentally "spell" letters with high accuracy and create real sentences. Deep-brain stimulation is a neurosurgical procedure that places a neurostimulator, which sends electrical impulses, through implanted electrodes to specific areas of the brain. Deep-brain stimulations can treat diseases such as Parkinson's, stroke, and Alzheimer's disease.[7] With these monumental breakthroughs, scientists must keep their implicit biases in check and create equal access to these treatments and diagnostic tools. Neurotechnology and AI can further divide the healthcare system, but if we mind our bias and actively break the disparity in healthcare, they can create equal access and treatment in medicine.

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Mind Your Brainwaves

By: Jeremy Manwaring

Humans have used the natural world for centuries to augment themselves in various ways. We believed the world could fundamentally change and provide for us, given we understood it enough. There have been countless examples of cultures around the world using the fruits of nature to help themselves grow, from using medicinal herbs to become spiritually elevated, to religious objects thought to banish bad spirits. Before the digital age, many cultures used what was available to them to utilize electricity's effects on our minds. In Ancient Greece, Plato and Aristotle used electrical torpedo fish discharge to cure ailments such as headache, gout and prolapsed anus. Similarly, in the 11th century, Ibn-Sidah, a Persian physician, placed torpedo fish in front of patients' eyebrows to cure them of epilepsy.[1]

Now, we stand at a precipice in the 21st century, hurtling towards an era where the fusion of computer science, electrical engineering, mechanical engineering, and cognitive neurosci-

ence empowers us to venture beyond the realm of rituals and into a new age of understanding how we can modify ourselves. We can now surgically or non-surgically modulate the electrical neuronic impulses of the human brain to treat various disorders and scan brainwaves to decode information locked in complex patterns of electrical activity, entering a novel realm of neuromodulation. As this technology grows, the benefits and implications will reveal themselves with time. Recent advances also promise a future where these neuromodulating devices can be implanted and used from home.

What is Neuromodulation?

Neuromodulation is a technique in which fixed-frequency electrical currents are applied to the brain to target the corresponding brain regions for symptom or disorder relief. Currently, two platforms exist to induce changes in neuronal communication with neuromodulation: invasive and non-invasive techniques.

Invasive techniques include Deep Brain Stimulation (DBS), a surgical procedure that uses implanted electrodes to send electrical signals to brain areas usually responsible for bodily movements. This is a highly invasive procedure involving a wire, electrodes, and the removal of the top layers of the scalp for implementation. Non-invasive techniques include Repetitive Transcranial Magnetic Stimulation (rTMS). This in-office procedure uses an electromagnetic coil placed on the scalp to send magnetic pulses to nerve cells in regions of the brain that control mood and emotion. In a year-long study where scientists observed the long-term effects of rTMS in a year-long follow-up study, a response rate of 67.7% and remission rate of 45.1% were observed for rTMS in patients with Depressive Symptomatology,[2] highlighting the effectiveness of DBS using rTMS.

These tools are used for various clinical purposes, including but not limited to emotional regulation, cognitive impairment therapies, chronic illnesses, epilepsy, and movement disorders. Many of these treatments are done in-office and have become highly unaffordable and inaccessible. The average cost for rTMS (Repetitive Transcranial Magnetic Stimulation) treatment is $200-$300 per session, with a total treatment course ranging between $6,000 to $11,000. In the United States, Deep Brain Stimulation (DBS) surgery, including the implanted device, hospital fees, and anesthesia, can range from $35,000 to $100,000.[3] Insurance may cover these costs but can remain outstanding and inaccessible to the general public. These technologies exist to treat conditions that affect a large population but are still not widely used due to the sheer amount of effort and money required to do treatment with neuromodulation. This makes treatments for cognitive impairments and mood disorders limited to medication and other therapies that may be less targeted and effective compared to neuromodulation.

[Doctors operating on a patient using invasive methods]

Introducing At Home Neuro-Devices!

Recently, some biotechnology start-ups have seen a lucrative opportunity through neuromodulation technology with the potential to treat patients from the comforts of their homes. Minimally-invasive neurotechnology can transform the ways we can treat psychiatric and psychological disorders, as long-term treatments usually done in hospitals or clinics can be done in the home environment without multiple in-office visits, circuitous provider referrals, and hefty medical bills.

The neuromodulation market is pulsing with innovation, with projections of the global neuromodulation market reaching USD $10.4 billion by 2027 from USD 6.0 billion in 2022. Many contenders within the neurotechnology sector, including Medtronic PLC as a global frontrunner, offer a spectrum of neuromodulation, spinal, and orthopedic solutions. Others include Boston Scientific Corporation, for its array of spinal cord stimulators and deep brain stimulation systems, alongside Abbott Laboratories, with its robust neurology and neuromodulation portfolio. Another company near the frontier of transcranial direct current stimulation (tDCS) and transcranial magnetic stimulation (TMS) research is Soterix Medical.[4]

Motif Neurotech, a neurotechnology company, has created a real prospect for at-home minimally-invasive neurotechnology, which can be used to alleviate symptoms of depression. Motif Neurotech is focused on developing bioelectronic systems for treating treatment-resistant depression. Their technology involves a pea-sized brain stimulator designed for humans, which can be implanted in a 20-minute procedure, aiming to provide a minimally invasive solution for mental health disorders. The company has secured over $50M in federal funding and collectively has a team with over 50 years of medtech experience. Their tiny device is similar to transcranial magnetic stimulation, requiring a less invasive implantation procedure than other standard procedures. The company collaborated with researchers at Rice University and the Baylor University College of Medicine to provide an alternative to traditional neuromodulation systems. In other systems used in offices today, various failure points are associated with moderately invasive techniques, such as fractures of the device, unintended migration to other parts of the brain, overheating, and battery failures.[5] Having a medically approved device in the palm

[Motif Minimally Invasive At-Home Neuromodulation Device]

(Motif Neurotech)

of your hand, being minimally invasive, and being used at home opens up the ability to drastically lower the cost of neuromodulation therapy and make it more accessible to the patients it can help the most. However, this opens up a Pandora's box of potential implications and consequences of these devices for privacy.

The Uncertain Future of At-Home Neuromodulation

In a future where we can easily have small implants to modulate our emotions, what are the potential implications of neurotechnology and biotechnology companies expanding this field of therapy into other sensory systems? With neurotechnology, we can change how we perceive reality by targeting areas of the brain responsible for taste, sight, touch, and memory. The ethicality of these devices must be discussed; the way that data is handled, privacy is protected, and these technologies become distributed are all within the scope of the conversation. The concerns of cognitive autonomy and mental independence are highlighted in a world where neuromodulation is regularly used; with the commercialization of neurotechnology and biomedicine, we also stand at the concern of how much private capital should be involved with our neurobiology when so little is known about the long-term ramifications of changing it. However, the hype around neuromodulation means that the rapid research and development of these devices are the highest priorities for companies we remain on the bridge between discovery and innovation. In terms of navigating privacy in the space of federal law, government intervention is needed to oversee policies and business practices in accordance with existing medical and smart devices, a question of how much power is left to these corporations at the end of the day is a different story, left waiting to unfold.

As we navigate the next frontier of neurotechnology, it may be some time before we can effortlessly alter our emotions with a simple swipe on a smartphone. Until that day arrives, we will continue to use new tools to explore to augment our minds as we stand on the brink of unprecedented technological advances. Humanity will always carry forward the legacy of innovation rooted in nature, seeking to refine and amplify the power of the mind. Just as early cultures used electrical torpedo fish to harness the potential of nature's forces, modern neurotechnology represents the next step in our journey, promising new ways to enhance our mental and emotional landscapes while deepening our understanding of the complexities of our brains.

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MIND Your Passwords: Get Out of my Brain!

By: Amanjot Bains

A marvel of ultra-high computational prowess, adept at producing substantial results while consuming minimal power. This extraordinary entity accumulates weeks and months' worth of data on a daily basis—information stemming from inquiries, memories, and responses. It's a seemingly endless whirlwind, deciphering continuous streams of data, novel concepts, and expanding memory repositories. Then– it plunges into darkness. The information painstakingly gathered and stored disappears. It's not a computer that has fallen victim to hacking this time; it's your brain.

In the evolving world of technology, the realm of neuroscience has begun to venture into uncharted territory, unravelling the mysteries of the most intimate cognitive asset. Alongside these mysteries, come the questions and concerns of unlocking the privacy of that asset. Standing on the precipice of a new era, the collection and storage of brain data has become essential for various applications, being driven forward by rapid progress in nanotechnology. This era promises to push towards advancements in knowledge about the brain by utilizing electroencephalograms (EEGs), functional magnetic resonance imaging (fMRI) scans, and brain-computer interface (BCI) data. But the question does arise: who's brain will provide this knowledge, and at what cost?

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The foundation of our personal autonomy is privacy, and when it comes to the private thoughts we have, protection is absolutely necessary. The collection and storage of brain data require a strict framework to ensure the confidentiality and security of this information in this era of data-driven technology. EEGs, which track brainwave patterns, and fMRI scans, which record detailed changes in neural activity, are both common ways in which brain data enters the digital world, raising questions about who has access to it and how it is stored. The protection of brain data necessitates the same rigorous regulations as those required to ensure the privacy of medical records, such as under the Health Insurance Portability and Accountability Act (HIPAA).

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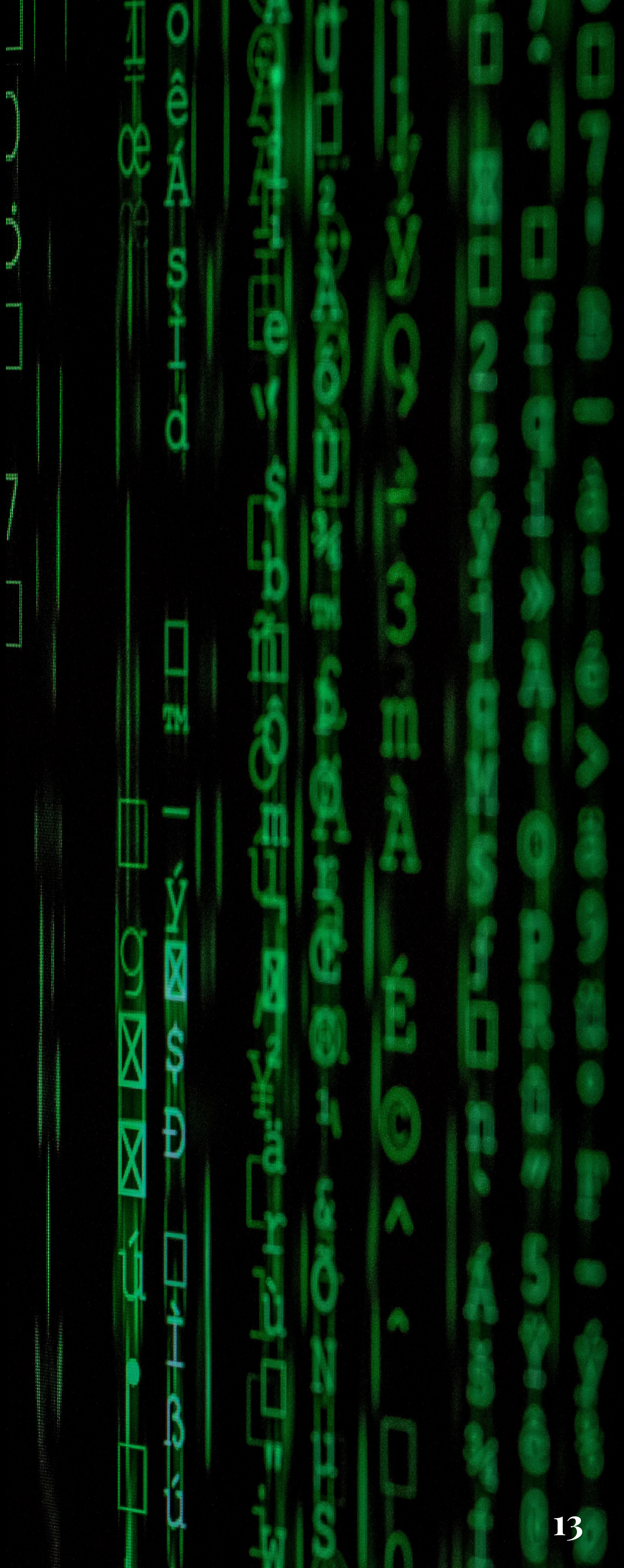
Diving into the brain raises questions about how and which specific parts of the brain are accessed, while the even more complex intricacies of ownership, consent, and the potential for discrimination arise. Going forward, safeguards must be established to ensure that there aren't threats of data breaches and hacking, especially of our most sensitive information. The focus during the past few decades has been on further development of neural data collection technologies, improving their accuracy, functionality, and ease of use. With this, the more invasive the technology is, the greater threat it poses if its data were to be wrongfully acquired[1]. On the other hand, not enough efforts have been made to improve the security of these systems and the data they hold.

The common attacks that these systems face are attacks via record multiplicity (ARM), preimage attacks, hill-climbing attacks and second attacks, and brute force attacks which usually access the data directly from their storage locations[2]. While all of these methods of hacking these systems are the ones utilized, ARM is the one most often attempted. It is a privacy attack where an assailant uses multiple compromised templates that define the infrastructure and arrangement of a project,with or without associated information such as the parameters and algorithms, to recover the original biometric template. The biometric materials can be anything, including but not limited to age, gender, cognitive ability, mental status, fingerprints, and health information. Biometric data is unique to each individual and cannot be easily changed, making it valuable to hackers and even more of a reason for better protection. With this information, hackers have endless options for how they choose to use this compromised, personal information.

It is crucial to comprehend the checks & balances,as well as the legal frameworks, that offer some semblance of guidelines in the complex world of brain data technology[3]. Although in a somewhat disjointed fashion, numerous jurisdictions have established laws and regulations that control the gathering and use of brain data. These rules frequently apply at the federal, legal, and administrative levels. In order to ensure the ethical collection and handling of brain data, research institutions and healthcare facilities typically follow institutional review board (IRBs) guidelines. Contrarily, legal coverage is provided by data protection and privacy laws, which vary from one region to another, with the country of Chile leading the way for including digital rights and protecting "mental integrity" with regards to the advancing world of neurotechnologies[4].

Currently, the U.S. The Food and Drug Administration (FDA) sits at the intersection, responsible for deciding what entities successfully ensure the 'safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation'[5]. Recently, Neuralink — an American neurotechnology company developing implantable brain-computer interfaces founded by billionaire Elon Musk — failed to pass the FDA's standards to initially move into clinical trials on human subjects[6]. Neuralink has the ambitious goal, of using BCIs to allow the paralyzed to walk, the blind to see, and create the ability to store and rewatch memories, among other, equally large goals. Some of the safety concerns identified by FDA were the device's small threads carrying electrodes which could migrate to various regions of the brain causing tissue damage/ inflammation, the device's lithium battery damaging brain tissue, the device's small size making it difficult to remove, and other relevant concerns including overheating. Moreover, the agency is under investigation by the U.S. Department of



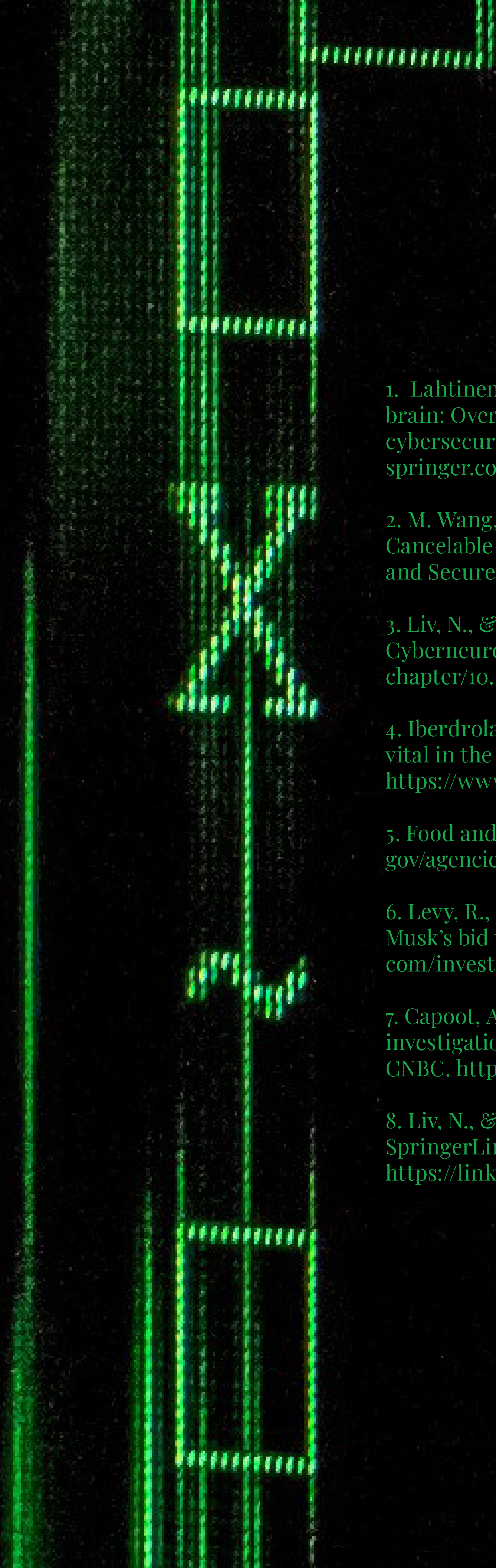
Transportation over potentially packing and delivering implants removed from the brains of primates for running trials, which may have carried infectious diseases[7]. The FDA's checking of Neuralink is an example of how similar agencies could regulate data usage as these companies advance forward through of human trials.

Beyond the legal and regulatory aspects, the ethical issues surrounding the security of brain data are of utmost significance. Brain data has a wide range of potential uses, including neuroenhancement, medical diagnosis, and the possibility of forever changing lives–for the better or worse. These abilities raise ethical concerns about what can be done with such detailed knowledge of our brains, and whether achievingthe goals of neurotechnology can do more harm than good. Given that informed consent is now a crucial component in the responsible use of brain data and most clinical practices, one ethical consideration is what information is disclosed — both to large clinical corporations and for of free use. There are a lot of unanswered questions in the field of brain security, ranging from potential risks of malicious misuse of technology to the long-term negative implications of neuroenhancement. In order to establish a comprehensive framework that respects the boundaries of cognitive privacy while maximizing the potential of brain data for the greater good, it is imperative that we address these ethical concerns as we navigate this uncharted territory.

Looking ahead, we find ourselves at a crossroads, unsure of whether we are moving toward increased privacy or worsening security flaws for brain data. The future is characterized by the convergence of numerous technologies, including the increasing involvement of artificial intelligence's (AI) and machine learning (ML) in the analysis and interpretation of brain data and clinical trials involving neural technologies[8]. These developments could lead to new understandings of the human mind, but they also present fresh security risks. Existing datasets abound with useful information as computational biology and data mining techniques advance, making them appealing targets for both research and potential exploitation. It is still unclear whether these developments will result in greater privacy or higher risks.

There are many complex legal, moral, and technological issues in the field of brain data security. It is crucial to strike the right balance between utilizing neurotechnology's potential and protecting people's privacy. Establishing a strong framework that respects the limits of cognitive privacy, guards against abuse, and evolves with the state of neurotechnology is crucial as we navigate this uncharted territory. Emerging technologies, regulatory developments, and ethical considerations will undoubtedly shape the future of brain data security, and it is our collective responsibility to make sure that it moves us toward a more secure and privacy-respecting future.

So the question stands, can the brain be hacked? As the saying goes, "never say never" but with the right steps and regulations in place, we can sure make obtaining this data a lot more difficult for bad actors.



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Graphic: Anoushka Shah

Mind Your Circuitry!

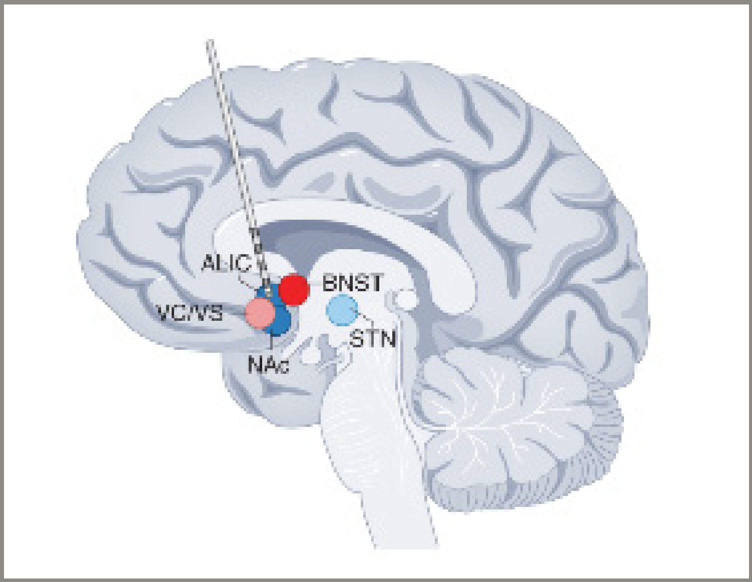
By: Jasmine Lopez

Until I was 10 years old, I broke into tears whenever I could not get in bed at exactly 8:00 PM. I had to wake up for school at 6:00 AM and needed exactly an hour to get ready, so sleeping at 8:00PM would guarantee a perfect 10 hours of rest. If my family arrived home from a gathering any later than that, I was flooded with distress and dread– filled with the anxiety that the following day's structure and organization would be ruined by a disrupted night of sleep.

As first-worldly and miniscule as this problem is, it was one of many health anxieties that I had growing up, which manifested as the tendencies of Obsessive Compulsive Disorder (OCD). However, I was never diagnosed with OCD, but rather with Generalized Anxiety Disorder (GAD) when I was thirteen; it was not until the age of 17 that I realized many of my symptoms had the hallmark signs of those of OCD–ritualistic, repetitive, and compulsive. Despite never being diagnosed, I owe my GAD coping journey to learning more about OCD.

OCD affects roughly 2-3% of the population, or 1 in 40 adults, 50% of which have debilitating symptoms. Treatment for OCD and related disorders (such as body dysmorphic disorder (BDD) and Tourette's Syndrome (TS)) can range from cognitive-behavioral therapy to antidepressant medications, but about 30-40% of people on these treatments do not respond well. In fact, 10% of patients still struggle severely after being treated with these conventional methods.

In efforts to remedy this gap, deep brain stimulation (DBS) has become one of the most effective invasive neurotechnologies to treat OCD, alongside other non-invasive techniques. DBS involves the insertion of an electrode into the brain, which is connected to a neurostimulator on the chest via subcutaneous wires. The neurostimulator is a pacemaker-like device which sends electrical signals to the electrode, stimulating the structures it is connected to deep in the brain.



An animated representation of deep brain structures which are commonly connected to the tiny electrode (Nature Medicine, 2022)

Finding these targeted brain regions involves neuroimaging using functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) scans.

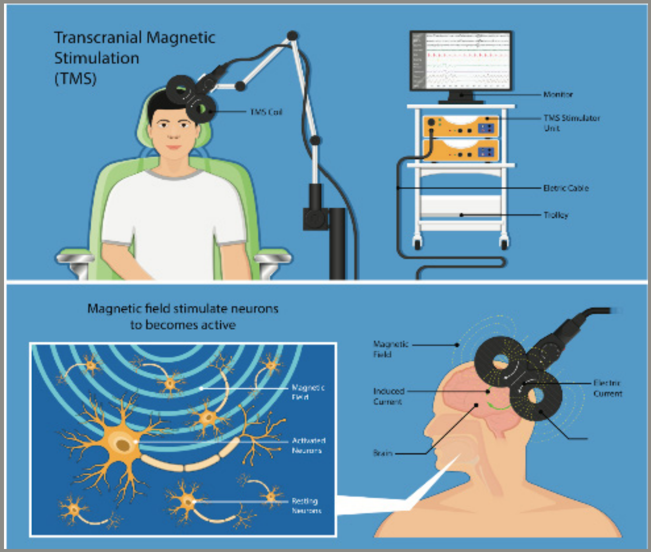
Although DBS for OCD is under-researched, the treatment is more developed for conditions such as Parkinson's. The most updated research has shown that 60% of OCD patients recover from debilitating symptoms after the procedure. Below is an account from "Mr. A", the first participant in a study "DBS for severe and treatment-refractory OCD" at the Australian and New Zealand Clinical Trial Center:

"When he [the doctor] turned the DBS] on ..., [Mr A] felt something different in his mind at that particular time and when the doctor went to switch it off, [Mr A] said, 'Please don't. It's the best I've ever felt,'."

According to the narrative case study, "Identity Challenges and 'burden of normality' after DBS for severe OCD," Mr. A's life once consisted of constant "checking" (frequent revision of rituals, such as repeatedly going back to see if you locked the door) that was so severe it prevented successful relationships and academic/professional life; almost immediately after DBS, Mr. A was able to flow through his day-to-day without his mind getting stuck as often on irrational anxieties (i.e. washing his hands repeatedly) to an extent beyond the comprehension of a non-OCD brain. Mr. A was then able to shift his focus from these compulsory behaviors to finding his life callings and passions once more.

It seems too good to be true– so what is a digestible explanation for what DBS is even doing on a physiological level to the brain of a person with OCD, given the information we have today? We'll start off by introducing the cortico-striato-thalamo-cortical (CSTC) circuit, which is a circuit in the brain that plays a crucial role in motor control, cognition and emotion. Most importantly in our context, the CSTC circuit is involved in flexible thinking and adaptive behavior. Through neuroimaging and circuit-based models, neuroscientists have come to believe OCD, on a neurological level, involves the disruption of the CSTC circuit and the potential for neurotransmitters to get "stuck" in spots of the circuit. Although much of OCD can be learned behaviorally through different environments and upbringings, severe OCD typically involves this nature of neurological dysfunction. Neuroscientists speculate DBS modulates the flow of the CSTC circuit in the brain; however, the exact mechanisms remain unknown.

Despite this, we actually don't have to get deep into your brain for neurotechnology to facilitate OCD treatment. Transcranial Magnetic Stimulation (TMS) is a non-invasive OCD treatment that involves the generation of a magnetic field by a wire coil which travels through the brain and sends electrical signals to targeted regions.



Graphic of Transcranial Magnetic Stimulation (TMS) and its mechanisms (Utah Therapy Works, 2023)

Formatting/Design: Hannah Corr

45% of OCD patients have found relief of symptoms through this treatment, and some return for "maintenance" treatments less frequently after their initial bout of treatment (five times a week for four to six weeks). Besides TMS, Transcranial Direct Current Stimulation (tDCS) and Transcranial Alternating Current Stimulation (tACS) are other non-invasive neurotechnologies involving the use of electrical currents on the scalp; tDCS utilizes lower electrical currents and tACS administers oscillating currents as opposed to stagnant ones.

Currently, neuroscientists are working on understanding the complexities of how exactly DBS, TMS, tDCS, and tACS work to produce the beneficial effects they have so far, but, for now, it is reassuring to see the array of options available for those who did not experience relief after extensive cognitive behavioral therapy and the simultaneous usage of Selective Serotonin Reuptake Inhibitors (SSRIs). Luckily for me, my world no longer shatters if I'm not able to go to bed at 8:00 PM (that would be unfortunate now that I'm in college). From my own experience, the form of psychotherapy that saved my sanity was Eye Movement Desensitization and Reprocessing (EMDR), a practice that involves the reprocessing of trauma in association with bilateral stimulation (stimulation that moves in a left-to-right pattern). This bilateral stimulation could be facilitated as auditory stimulation, eye movement, or, in my case, hand tapping. Throughout this process, your therapist guides you through traumatic memories that were never digested in a healthy environment, and resurfaces them so you can re-experience and re-interpret them in a safe space. This, in tandem with the bilateral stimulation, allows your brain to form new neural pathways and essentially rebuild how you interpreted that situation in a more positive light.

Although cognitive-behavioral therapy followed by SSRI's are always the primary recommendations for initial OCD treatment (alongside lifestyle changes), there is hope for individuals who still struggle severely despite these treatments. The primary goal of this article may be to bring awareness and excitement towards neurotechnological treatments for severe OCD– but what is just as important is acknowledging the micro-behaviors that many of us hold onto as a result of past trauma, and remove stigma from pursuing milder forms of treatment, like EMDR, for such tendencies. In an increasingly connected yet demanding world, we live in contradiction as we are encouraged to care for our mental health while working countless hours. Because of that, it is our job to stand up for our well-being, be open to treatment within reason, and spread the possibility of new alternative procedures within our communities. The more we do so, the more we can incentivize and influence healthcare systems to make these therapies more accessible to broader communities.

MIND YOUR ATTITUDE

Sculpting Well-Being through Body, Mind, and MUSE

By: Beatrice Lowman

Anyone who has used a long walk, vigorous work-out, or intense study session to diffuse strong emotions knows just how intertwined our emotional state is with our physical body and mental capabilities. However, in a world where the pursuit of physical health and cognitive prowess often takes center stage, the importance of mental well-being is frequently overlooked. While many are familiar with the idea that exercise and a balanced diet can positively impact mental health, a crucial yet underestimated aspect is how mental states can manifest into tangible physical changes. Further, our emotional states significantly influence cognitive flexibility, shaping our ability to navigate life's challenges. How can we actively nurture our mental health to positively impact our overall well-being? Amidst this exploration, revolutionary technology – the MUSE EEG-guided meditation headband – emerges as a potential game-changer, offering a user-friendly entry point to meditation.

BODY: *Understanding the Interplay between Mental States and Physical Health*

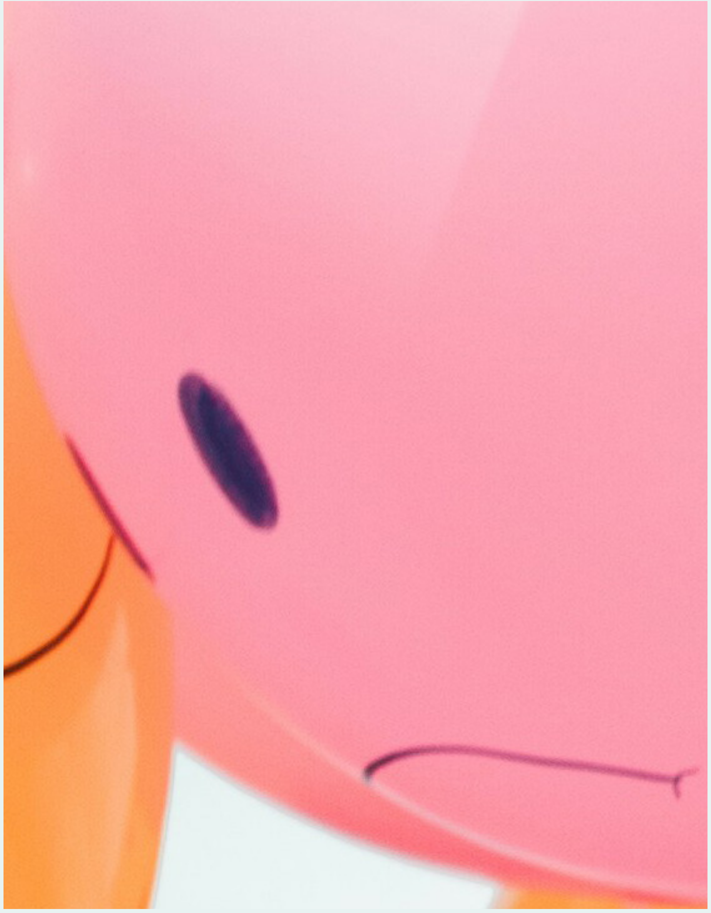
One key determinant of physical well-being is our relationship with stress, which is facilitated by hormones (chemical messengers in the bloodstream). Cortisol is a hormone released by our adrenal glands as a part of the body's stress response[1]. Our cortisol levels spike when we are in high-stress situations, which signals our bodies to suppress inflammation and nonessential functions like metabolism in addition to releasing glucose, or sugar[1]. This has many evolutionary implications – if one were suddenly attacked by a bear, they would benefit from temporarily improved immunity resulting from limited inflammation. Furthermore, the halting of metabolism and provision of additional glucose allows for maximizing fast energy, which might be critical for their survival. In this sense, cortisol plays a central role in our response to threatening situations[2]. The problem arises when we develop chronic, long-term stress, causing our bodies to release cortisol frequently over long periods of time. Studies reveal that consistently high levels of cortisol compromise the immune system, leaving us vulnerable to illnesses. This is frequently seen in college students during exam season when sickness floods the dormitories[3]. These negative effects on long-term health can be further exacerbated by poor emotional states. Individuals who report themselves as generally happy have smaller responses to stressors, and have lower levels of cortisol output throughout the day. Depressed individuals or those who report a negative mindset, however, have large spikes in response to stress and have consistently more output of cortisol, leading to an increase in short-term and long-term health problems[4]. Negative emotional states can also cause heart problems, diabetes, and even early death in some situations. A study by Andrew Steptoe ties depression and other negative affective states to, "premature mortality and increased risk of coronary heart disease, type 2 diabetes, and disability."[4] Mental health deficits including long-term stress, depression, and a general negative mindset can increase one's risk of numerous physical health issues. Therefore, while it may seem counterintuitive, mental health is an essential component of one's physical well-being.

MIND: *Navigating the Impact of Emotional States on Mental Acuity*

Our mental state affects many facets of our health – not only physical but also cognitive ability. Positive mindsets broaden our mental capacities, while negative mindsets narrow them. This can be explained through evolutionary implications, as negative mental states often occur when we are in life-threatening situations where our bodies prioritize quick action and high alertness to broad, creative thought. Positive mental states naturally occur when we are in safe environments, where it is most advantageous for us to explore and push creativity and problem-solving. Even when these emotional states are artificially induced, they still have the same effect on our cognitive capacities. In a study by Alice Isen's research group, participants watched a comedy film or received bags of candy to induce a positive mindset. This led to improved performance on creative problem-solving tasks compared to the control group, likely enabled by broadened mindsets. As one might expect, the narrowed mental capacities associated with negative mindsets are disadvantageous to academic performance. Multiple mood disorders including anxiety and depression are linked to lower GPAs throughout college and higher rates of dropping out. In essence, the impact of emotional states on cognitive abilities is far-reaching, affecting everything from creative reasoning to academic performance. The profound connection between mental and cognitive realms further emphasizes the imperative of nurturing positive mindsets.

MUSE: *Exploring Solutions through EEG-Guided Meditation Technology*

So far, we have established the critical effects that mental health can have on both physical health and cognitive flexibility - but what can we do about it? The answer, luckily, is that our mental health is malleable, and there are tools we can use to improve it. Meditation has been practiced for centuries as a method of maintaining inner peace, and today's technology may make the mental rewards of meditation even more attainable for the average person. One of these technologies is called MUSE, a headband device designed to guide users through meditation by using data from their brain waves. Meditation is traditionally a practice in which



one sits still and attempts to maintain a "still mind" by avoiding drifting thoughts. The benefits are extensive, with regular meditation lowering perceived stress and improving overall mental health. The MUSE headband tracks EEG signals from the user's brain, detecting changes in focus and using audio cues to guide the user back when they become distracted. By prompting the user to stay in a deep meditative state, the product aims to make meditation easier and more effective.

The MUSE headband has proven to be successful. One study asked adults to use EEG-guided meditation practice in 42 10-minute sessions over the span of six weeks, which resulted in improved attention, well-being, and greater body awareness and calm. Another study found that elementary children who regularly used the MUSE headband for four weeks had improved cognitive functioning. Regular meditation facilitated by the MUSE headband can lead to relatively quick emotional and cognitive improvements. It is important to note that these benefits can also be attained through

traditional meditation. Further research should be conducted to compare the results of EEG-guided meditation to self-taught and instructed forms of meditation. The revolutionary aspect of the headband is that it may make meditation easier, especially for those with difficulty staying focused for long periods of time such as young children. Furthermore, it may eliminate the need for instruction, enabling users to be more independent in their mental health journeys. This technology has large implications for mental health, as it requires no expertise, very little time, and minimal effort, and yet has significant results.

As with any revolutionary technology, there are caveats to the use of EEG-guided meditation as a primary method of improving mental health. First and foremost, the headband is expensive - with the newer models priced over three hundred dollars. The unaffordable reality of this technology has the potential to worsen existing disparities in mental health treatment. Part of the beauty of meditation is its inherent accessibility due to the traditional non-materialistic emphasis of the practice, which the MUSE headband does not follow. Nevertheless, it is plausible that the benefits offered by this technology justify the price tag, especially when compared to common household items such as televisions which can be similarly costly yet potentially detrimental to one's health.

The MUSE headband also raises concerns about overreliance on technology. Consider a hypothetical situation in which a user finds great success with the headband and continues to use it long-term. After many months they might become adjusted to the audio signals, working seamlessly with the device and staying deep in a meditative state almost without effort. However, without the headband, they may find this deep meditative state very difficult to reach. In fact, they may be unable to maintain elevated mental and cognitive states without constant access to the headband. Such extreme reliance on technology is concerning when it comes to such intimate matters as our own mental and emotional health. Meditation with MUSE may be easier, but it may not be advisable as a sole or primary source of mental stability.

Holistic Health: *The End Goal*

Mental health, physical health, and cognitive ability are deeply intertwined parts of a unified system that encompasses the overall health and well-being of each individual. Our capitalist culture so heavily emphasizes outer presentation and performance that we often pour effort and time into maintaining our physical health and pushing our cognitive abilities, all while neglecting our emotional health. However, when one considers how deeply mental health affects every aspect of our well-being, it becomes intuitive to take an inward-out approach: start prioritizing mental health, and let the benefits seep into one's physical and cognitive well-being.

Meditation, if used correctly, can be life-changing. It can lower stress, improve mental health, and consequently improve physical health and cognitive flexibility. The MUSE EEG-guided meditation headband offers an innovative and user-friendly introduction to meditation for beginners. Centering on the user's mental health and long-term well-being, the headband is a refreshing product in a culture that constantly pushes consumable, addicting, and harmful technology to the masses. Despite some noteworthy drawbacks, the headband has the potential to increase cultural emphasis on mental health and make self-treatment more accessible. In just weeks, the effects of EEG-guided meditation could be noticeable for an individual, and will hopefully serve as a gateway to a lifetime of prioritizing mental health and using regular practices to improve upon it.

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Formatting/Design: Hannah Corr

MIND YOUR TONGUE

By: Siri Tantry

Have you ever wondered where the phrase 'mind your tongue' originated from? We all know it means to be quiet , or to be aware of our words and language, but why is it 'mind your tongue'? Who came up with this phrase? Why not say something else? Why not mind your pharynx? After hours of research, the only thing I was able to learn was that the phrase originated from the latin phrase "Favete linguis!" which directly translates to: "facilitate [the rituals acts] with your tongues." However, that isn't really relevant to my question of why we use mind in the phrase – so while I slowly come to terms with the notion that I may never know the reason for why the word mind was used, whoever used it really knew how to effectively play-on-words. Perhaps I have lost you at this point – but the phrase "mind your tongue" beautifully shows the connection of the mind to our tongue in just three words. It's quite a no-brainer (pun not intended) that our minds are connected to our tongues: How else would we use words to express our thoughts? In this article, however, we're going to go on a deep dive to understand the physical connection between our tongue and the brain, how it allows for complex speech, and the possibilities this connection can lead to in the medical technology field.

Formatting/Design: Hannah Corr

Tongue + Brain = Hypoglossal

The hypoglossal nerve is the 12th cranial nerve that originates from the bottom-most part of the brain, called the medulla, to the tongue. The purpose of this nerve is to help us with general tongue movement[1]. So you can thank the hypoglossal nerve for your ability to talk, swallow, and eat food! Though everyone knows that our body parts are all interconnected with one another, the role our tongue plays in our body and lives is often overlooked. For instance, stimulating the tongue can help increase the healing of certain diseases and help improve neurological disorders. All of this is possible because of the direct connection the tongue has with the brainstem, which is extremely important for fundamental bodily functions including breathing and even basic mood regulation[2]. Even more significantly, the tongue can be seen as a possible pathway to induce neuroplasticity, allowing the brain to reorganize and form new synaptic connections in the context of learning. Given how imperative of a role the tongue plays through its direct communication line with the brain, it's easy to see how this information can be applied to help people with complex disorders with a neurological basis, such as multiple sclerosis and blindness[3,4].

Electroceuticals: What are they?

Before really talking about technology used to stimulate and change the brain, it is necessary to have a better understanding of the principle behind stimulating nerve tissue. The term "electroceuticals" is broadly used for medical devices that provide neurostimulation for therapy. Though not always, most of these technologies tend to be implants that can be surgically implanted. Though the term electroceuticals seems lofty, many of these electroceutical devices are things that I am sure you have heard of and seen; for example, pacemakers and defibrillators are all examples of electroceuticals. When it comes to the electroceuticals subgroup of implants, some current examples include cochlear implants, spinal cord stimulators, retinal implants, and deep brain stimulation devices.

Now, I'm sure your interest must be piqued on how this great technology works, so let's take a dive into how electroceuticals become a form of neurotechnology. Electroceuticals have two levels; the first is anatomical and the second is signaling. Anatomical technology refers to the physical device that targets the nerves and brain areas associated with a disease for intervention. Signaling technology refers to the replication of the exact action potential patterns, which are the electrical pulses neurons use to communicate, that are associated with a healthy brain. However, it becomes extremely hard to develop electroceutical neurotechnology and bring its uses to mainstream when most of this technology is invasive and may require head surgery. It is in such cases we turn to the use of tongue stimulation as an alternate pathway to reach the brain.

For example, electrically stimulating the tongue of patients with multiple sclerosis improves their gait by 20%[5]. Multiple sclerosis is an autoimmune disease that causes the body to inappropriately attack the signaling ability of neurons, including those involved in movement. Stimulating the tongue activates the nerves on the tip of the tongue that are directly connected to the brain stem; these electrical pulses help activate the neural network for balance, which can shore up the circuitry weakened by multiple sclerosis. In fact, tongue stimulation[6] is being used to explore treatments for patients with other degenerative diseases and conditions such as vision loss, stroke damage, and Parkinson's[7].

What is the world doing now?

It is increasingly clear that there is a future in stimulating the tongue to treat diseases; it's no surprise that there are companies dedicated to commercializing this new class of electroceuticals to treat a variety of different diseases. One such company making headway into this treatment area includes Helius Medical Technologies[8], based out of Pennsylvania, who are developing a first-in-class "Portable Neuromodulation Stimulator" (PoNS)[9] device and therapy. The PoNS device is a mouthpiece and controller that delivers mild-stimulation to the tongue surface. These impulses then trigger a flow of stimulatory electric potential that targets the brain structures (forebrain and cerebellum) that control motor function, which then allows for the brain pathways to be activated and improve function. To dive deeper into this technology, PoNS helps improve the gait deficiency that is caused by MS (multiple sclerosis). Gait control is a process that requires activation of nearly the entire nervous system and muscular system - hence the brain- stem signals from PoNS go to the limbic system, the brainstem, cerebral cortex, and the spinal cord. Specifically, PoNS therapy exerts neuromodulation effects by the translingual stimulation (allowing for activation mechanisms involved in neuromodulation signaling pathways from the brainstem to the cerebral cortex) of the lingual nerve and chorda tympani which have direct connections to the brainstem[10].

Currently, Helius Technologies has made headway with clinical trials with their PoNS therapy, testing its effectiveness for gait improvement in patients that have mild to moderate MS and traumatic brain injury. At the same time, they have received "breakthrough" designation by the FDA for PoNS treatment of gait deficit of MS and stroke. Moreover, PoNS has now been authorized as a medical device commercially available in the US, Canada, and has been authorized for use as an adjunct to a therapeutic exercise program (not commercially available) in Australia[8].

Helius is not alone in this growing market- similar products include the VitalStim Therapy, developed by the Chattanooga Company, which is a painless non-invasive therapy to treat dysphagia (a swallowing disorder which makes it difficult to move food from the mouth to the stomach)[11]. In this therapy, external stimulation is applied to the front of the neck to help restore swallowing function in patients with dysphagia. Small electrical currents to stimulate the swallowing muscles allows the patients to work on positions and swallowing mechanisms.

The Future of Electroceuticals in Neurotechnology

While effective, invasive technology exists, bringing it to mainstream use can be both difficult and dangerous. Stimulating the tongue in a noninvasive manner, however, can have similar therapeutic effects when it comes to treating diseases and managing symptoms. The neurostimulation devices explored in this article are not only making headway with tremendous progress in helping patients, but provide safer and more accessible solutions that don't deal with surgery or implantations. As we watch all this technology make news, it is no secret that the future holds exciting possibilities in therapy and medicine. Who would've thought electrical stimulations to the tongue could open up a new avenue of motor functions and therapy in neurological disorders and motor disorders? Times are exciting and ever-developing, so let's wait out the ride, and until then keep minding our tongue!

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Mind Your Business: Fighting the unrelenting urge to always self-serve.

by: Jade Harrell

I'm not entirely sure when the first time I was told to "mind my own business" was, as the desire to know everything, seemed to burn in my veins and slither its way onto others even as a tiny child. Of course, this habit would generally not be well received, since most people like to keep things private from a prying, non-conformist (one might even call annoying) five-year-old with no respect for personal boundaries. Hence, I was told to "mind my own business" quite young. Maybe the first time I was told this was with my parents, or it could have been when I was at school with my peers. When I reflect back to these times, who I bothered with my questions doesn't intrigue me very much actually; rather, it is the motivation of this action which appears to have remained constant in all these scenarios that does intrigue me. When people tell others to "mind their own business," it is usually because they find the curiosity of others to be an intrusion, or an attack. They say "mind your own business" because they think it is their business which they are keeping from you, and that your business has nothing to do with them. They believe that when you attempt to peer into their life for a moment, it is because of some motivation outside of yourself, a motivation ultimately regarding them, and therefore you should step back, go away, and "mind your own business." Mind only yourself.

However, I find all of these presumptions quite funny because I know that at five years old, I really couldn't care less about the people I was interrogating information from. The motivation to understand others and find out juicy little details in their life was entirely driven by my innately selfish curiosity, thus making me feel it was my business. How could something not be my business if I was in control of where I channel my curiosity, and my business is what I control? Much to the dismay of my older, more-powerful-than-I victims at the time, saying "mind your own business" did not work to drive me away (sorry about that). But now that I am older and much more socially aware of my behavior, I find it incredibly fascinating how my nature at that age was to force my will onto others without caring about how it would make them feel. I also know that curiosity and nosiness is a hallmark behavior of many naive children, unaware of social customs. So I ask the question: Are we all inherently selfish, and have we just developed complex ways of hiding it?

You MUST be inherently selfish.

Similar to my train of thought, most psychologists and philosophers have assumed that we all must be inherently selfish. All humans are animals, therefore we must fall under Darwin's principles of evolution: the life we see in the world around us is adapted to enhance survival in the face of an environment that poses inherent dangers to one's survival. In order to enhance your own survival, you must act selfishly, either by taking resources away from others or saving yourself instead of someone else in the event of a disaster or disturbance. The term psychological egoism describes this phenomenon in humans: everything we do, any action or feeling or thought, even inadvertently, is done for the sake of one's own welfare and is out of self-interest. This assumption is fairly unsurprising. In history and in our daily interactions with people, most events and decisions can be traced back to one person trying to please or benefit themself one way or another.

Yet, there is much opposition to this concept as it is often seen that, as humans, we also tend to help each other. We do not see in us the same brute, unforgiving selfishness that we see occur in many animals. Instead, we have compassion for one another and at times do things that would appear out of our own self-interest and directly self-sacrificing to benefit other people. The idea that we do things out of selflessness and for the good of others is called altruism3. While altruism is often used as evidence against egoism, there are many components to it that would make it appear as though "genuine" altruism does not exist, and it is only a byproduct of egoism. Darwin's assertion of a never-ending struggle to survive was used to prove natural selection and evolution, where the fittest of the population "survive" through their offspring into new generations. Under this idea, it would make sense that humans developed an evolutionary trait of prosocial behavior, like being altruistic to your family members and friends. Having a support circle increases your chance of survival and ensures the survival of your offspring when you provide for them back. This behavior can also extend to members outside of your "tribe" – perhaps, if you do something good and self-sacrificing for someone outside of your tribe, that person and their tribe is more likely to help you if you are in need.3 These frame altruism as an ultimately selfish thing, as altruism is an evolved trait to help yourself, under the guise of "helping others first."

One could argue in favor of altruism and say that sometimes, people do good things for others at the expense of one's survival, or without the thought of a reward in return. When one gives money to a homeless person who unfortunately may never succeed in climbing up the social ladder, there is no tangible gain in return for your kindness. If there is no gain in return for your kindness, but in fact, only a loss of something (in this case money) – then it must have been out of genuine selflessness. However, this also falls into the abyss of egoism as it can also be said that the "gain" or reward here is an internal reward of self-pleasure. When someone gives money to a homeless person, it is personally rewarding because it makes the person feel as though they are doing the right thing, thus making them feel like a good person and helping their overall self-image. If they did not help them, then it would make them feel like a bad person. It can also be suggested that they are helping the homeless person because seeing that person in their impoverished state makes them sad as a result of empathy; something that can even lead to physical discomfort. So in an attempt to alleviate the negative emotions they feel, they help the homeless person. We are trained by the social world around us that we will be rewarded for helping someone and punished (either by our own negative feelings or social ostracization) for not helping someone, encouraging us to be altruistic. Again, these would all make the altruistic act a selfish thing as it is only to make oneself feel better, under the guise of charity, as a result of the evolved traits we have (empathy and prosociality).

As I hope you have noticed, it seems as though egoism is a catch-all explanation for all behavior. No matter the altruistic act, it can somehow be tied back to a self-interested desire. This is similar to the nature of skepticism, as all things can somehow be doubted or questioned. However, this leads to a problem of circular logic: because all things can be doubted or questioned, it makes perpetual doubting or questioning obsolete. If it is always an option, I do not always need to choose it. Similarly, if it is always an option and I do not always need to choose it, then it is likely to not always be "right." Overthinking does not always lead you to the truth. While it is possible that selfishness

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and egoism is our inherent nature, and it probably is true, it is not beneficial to spend time thinking about it excessively outside of general self awareness (much to the dismay of my cynicism). It has also been proven that generally, egoism fails to predict behavior, making it fairly irrelevant.

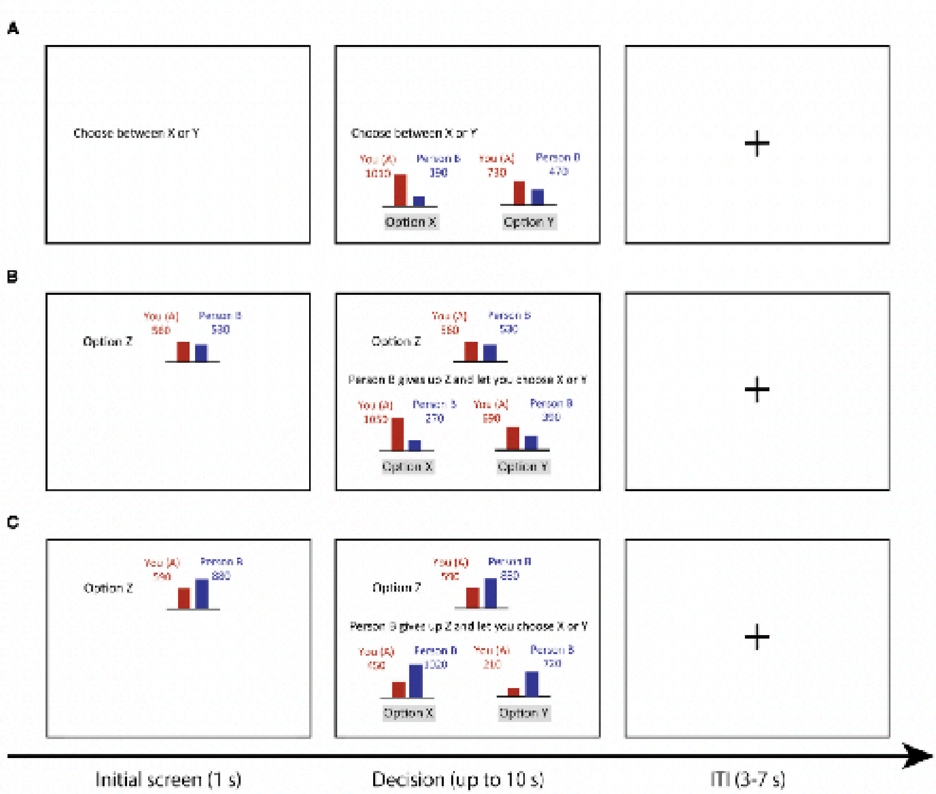
A series of experiments conducted by Daniel Batson tested the various egoist loopholes mentioned earlier which show this failure. To test if it was true that people acted altruistically to avoid feeling bad as a result of high empathy, Batson gave people ranking high on an empathy index (empaths) the option to help the individual in need while also telling them that someone else had volunteered to help already. The subjects chose to help more often than not.
In another experiment, he tested the social ostracization hypothesis by giving individuals the option to help or assuring them that if they did not help, no one would know. Again, subjects consistently chose to help. There were many other experiments he conducted in similar fashion, producing the same results. Does this prove altruism?
In a final "defense" to egoism, it is important to note that these experimental designs can be argued with, too. Just because the subjects are told that someone else will help the individual in need does not mean that the subjects trust that piece of information, or that they trust the other person more than themselves to do the helping. It is a common phenomenon that people believe they can do tasks better than others because they are blind to what is outside themself. Therefore, it is just as likely that these people who were told someone else would help simply thought they would be better at doing it. Further, in an even more selfish possibility, they could have helped because they wanted to be the one to experience the personal reward of helping, disregarding the other person altogether. For the social ostracization test, the subjects could have felt guilty for not helping even if no one would know, making the personal reward mechanism a confounding factor to the experiment.

I am not necessarily trying to say egoism is unilaterally correct when I showcase how it can come up in altruistic acts. Instead, the back and forth-ness of egoism and altruism shows that both must exist simultaneously. Batson's approach to altruism is not successful because he was attempting to disprove something that cannot be disproved, like skepticism or spirituality or the subconscious. If altruism exists, egoism can exist as a counter argument if posed in direct opposition to altruism. However, egoism in this way also cannot make altruism redundant. Altruism, as seen in Batson's experiments and our daily lives, is much more abundant in human behavior as opposed to brute selfishness. Therefore altruism exists, but on a different dimension to egoism. If egoism is a theory, then altruism must be a practice – they are not ideas which can debunk one another, but rather, exist in harmony.

Altruism and Egoism in the Brain.

In the study of altruism and prosocial behavior, it has been shown that altruism is not well predicted by typical psychosocial measures, such as socioeconomic status and race. When something is not well predicted by social constructs, it may be better predicted by biology; thus altruism and prosociality has been well studied neurologically in order to investigate the potential mechanisms at play. For the sake of simplicity, when determining neurological correlates for behaviors classified into "altruistic" and "egoistic" categories, we can measure altruism on a spectrum in order to see its extent in human behavior, and measure that in opposition to selfish behavior. As already mentioned, altruism is highly correlated with empathy – and by extension, it is highly correlated with perspective taking and theory of mind[7],. In order to have empathy for another person, one must understand the context of their feelings, their perspectives, and how the other person might be processing a situation. The first step in mapping out altruism and prosocial behavior neurologically is to see if the same places in the brain are activated as when one's empathy and cognitive perspective taking are being used.

The temporoparietal junction (TPJ) is heavily associated with understanding others' perspectives, so it was theorized that the TPJ may be responsible for the difference in levels of



altruism between people. A study was conducted in which individuals were given a binary choice between giving someone more money, or giving themselves more money, while being able to see how much money each person had currently before making the choice. The study found that, typically, people chose the otion to give more money if it lessened a disparity between the two. People generally did not give the other person more money than themself.

Those who participated in the study had the gray matter volume of their TPJ measured via voxel-based morphometry, and it was seen that those who were charitable had more gray matter volume in their TPJ. The results of this study confirmed the presence of biological differences between people who were less or more altruistic; that, mechanistically, altruism is tied to empathy; its presence is more pronounced when there exists a perceived disparity between two peoples; and it is also tied to pay-offs (i.e. “I will not help you if there is too much cost of doing so”). These results suggest that altruism is a physically manifested trait that could be selected for under the framework of evolution, as it tends to bring equal wealth within a community while not putting oneself at a disadvantage (reducing one’s chance at survival).

Another neurological correlation of altruism is within the anterior insula and the amygdala. The anterior insula is implicated in the empathy of pain, as activation is seen both when experiencing pain oneself and when witnessing pain. This duality between first person experience and third person witness suggests that when we feel empathy, we do attempt to feel the pain others are feeling within ourselves – we put ourselves in their shoes. At the same time, it is seen that activation of the anterior insula also predicts whether or not we will act generously towards someone when we are moved by empathy, associating the anterior insula in how we behave altruistically[10].

Additionally, the right amygdala volume is larger in individuals who have larger social communities and act more altruistically overall[10]. The correlation of the amygdala in prosociality is especially interesting because of what the amygdala is particularly known for – regulating and producing a fear response in individuals. However, we see that the amygdala is activated during the reading of social cues and facial expressions as well, suggesting that perhaps during social interaction one is simultaneously measuring for potential danger.

Oxytocin, a hormone which functions as a neurotransmitter, is also heavily implicated in prosocial behavior and altruism. It is a hormone released during childbirth, nursing, and in building trust between romantic partners/close friends and between the mother and child. When given oxytocin nasally, it has been shown to increase feelings of trust, empathy, and reduce outgroup bias to people in a room. Given the connection between childbirth and other prosocial behavior with oxytocin, this pushes the idea that prosocial behavior is related to the parental care commitment in humans, which further pushes that prosocial behavior is reinforced biochemically by evolution.

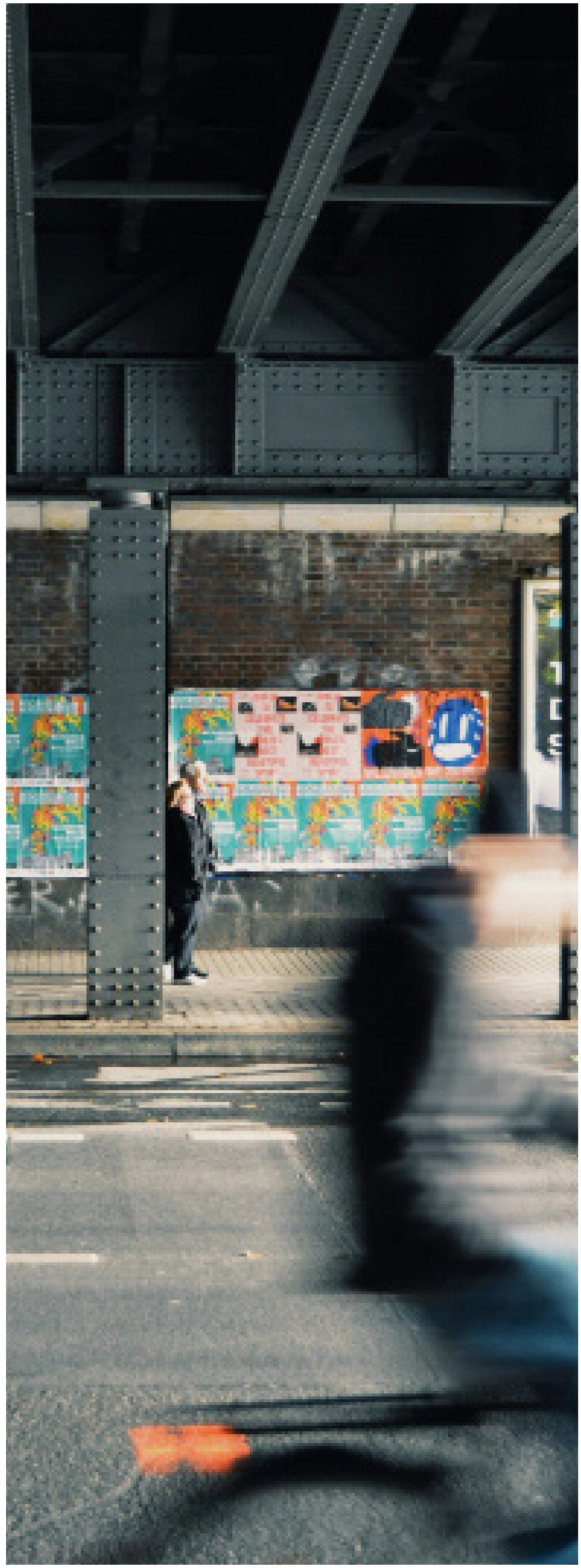
In the last edition of MIND, I unpacked the neuropsychological knowledge behind the disorders of psychopathy and sociopathy. Interestingly, parts of the neurological makeup of psychopaths is also related to that of altruists – but in reverse. While the amygdala is shrunken in psychopaths, the amygdala is oversized in altruists. While oxytocin levels are a main force in driving prosocial behavior, oxytocin levels are extremely low in psychopaths[11], . Psychologically, psychopaths have low empathy, do not help others unless it is to benefit themselves, and can be directly harmful to people physically or emotionally. In addition, psychopaths typically are raised in extremely physically or verbally abusive households, were neglected as very young children, or otherwise lacked affection and attention[12]. Considering the role of oxytocin in child development – and the subsequent prosociality that is formed – it would make sense that psychopaths, which were lacking childhood support, did not develop the same level of prosociality or altruism that is seen in everyday people or in overzealous altruists. We can again put this pattern in a nihilistic evolutionary framework: children who lacked sufficient parental care are “unfit” in society, somehow missing the evolutionary traits needed to be successful. Although this is possible, it is, of course, necessary to be careful of “social

Darwinism" – as social behavior is much more difficult to directly correlate with survival.

Has the growth of technology produced more egocentric or prosocial behavior?

Hopefully this information has put into perspective how altruism and egoism (our evolutionary self-serving drive to survive) work together in order to produce the mutualistic society that humans have created for themselves. Yet, when I think of the world in its current state, I definitely do not view it as the happy, mutualistic society as I should after I've put together this argument. I, and many others, see an overexploitation of resources and people, perpetual arguing between uncompromising extremists in politics, and a lack of nuance in our social relations with people. I see constant visions of an unhappy, destructive world glaring through my painfully bright computer screen as I do my silly little research on these topics – and, in my dissociative state, I wonder once more: has hyperconnectivity to the world increased or decreased the mutualism that should be occurring in an "evolved" society? Am I not seeing this harmony because I was born in the age of "big-tech?" Or, am I simply a pessimistic brat and technology has actually enhanced complex thought and education beyond that of the 1950s, 1800s, and so on? The answer appears to be just as nuanced as I wish my TikTok feed was.

The issue with answering a question about the Internet like this is that the Internet is a massive domain. On one hand, you have the Dark Web, which is extremely antisocial (circulating child porn and gathering hitmen for violent crimes) – but on the other hand you have political rights movements succeeding as a result of more people interacting with your petition. Then, there are gray areas like online chat rooms and texting, which can go either way. Prosociality, empathy, and altruism depends on how someone uses the Internet.



When attempting to answer this question on my own, I thought back to the TV show Black Mirror, which uses absurd futuristic scenarios to dive into the potential dangers of letting technology get too powerful within society. In a couple of episodes, the idea of a real-life "blocking" feature is toyed with a bit. The feature, as illustrated in the show, did not strike me as any more harmful than how blocking already proceeds over social media. By blocking and filtering out content on social media as it is, I have already observed a degradation in the capacity for nuance and empathy towards groups outside of the user's interests. Algorithms on, for example, TikTok, are exceptional at feeding its users only content that they want to see and filtering out the rest. While this is great if your motivation is engagement and money (as TikTok's motivation is), this can become incredibly dangerous on a societal level as it consistently keeps people from being exposed to different perspectives and activities. Adolescent teens are using TikTok for hours each week, taking up a large chunk of time spent naturally learning. If theory of mind development is slowed during this critical time, it can be detrimental to the growth of empathy in these age groups, possibly damaging prosociality. While I am only theorizing here about the harm that this could have on people's empathy development, this pattern is already happening to various insulated groups on the Internet. For example, the alt-right fascist groups commonly seen on platforms like 4chan and the ever-growing population of 'incels' on Reddit, whose capacity for empathy seemingly has been terribly damaged when compared to individuals not frequenting these online spaces.

Another avenue to be explored was the effect of online communities, such as Discord servers, on the development of prosocial behavior. For those unaware, Discord servers are large chat rooms that people can join for online discussion on common interests (one might join a few Discord servers for a video game, for example, and then leave the server in a month or so – whenever they grow bored of it). In my own experience of frequenting servers, I have found that they often function as their own complex social groups, depending on the amount of people participating in them. Each user has their own personality which shines in the servers (personalities which arguably can be different from their personalities in real life), and everyone knows everyone. Communication in the servers between different members can be daily to hourly – creating a glorified, constantly active friend group. The impact of the server can be either positive or negative to the individuals participating, and thus harm or hinder prosocial behavior. For example, having one mean member on a server can make the socializing experience difficult for everyone.

In line with my analysis of Discord servers, research studies show that Internet use predicts a decline in prosociality and empathy. For example, in a study with nursing students, those who were addicted to their phones tended to feel personal distress as opposed to empathy when witnessing suffering in others14. In another experiment where two groups of avid technology users were subjected to an overnight camp, one where technology was banned and another where it was not, it was found that the group who was banned from technology use had improved emotion recognition compared to those who were not. Another similar experiment where two participants were made to have a conversation with each other, it was shown that presence of a cell phone lessened trust in the conversation partner, worsened perceived relationship quality, and lessened perceived empathy from their partner15.

However, besides phone addictions, these studies were done on otherwise healthy samples. When focusing on individuals who have social anxiety, are neurodivergent to some degree, or who have lacked social experience in another way, it was instead found that increased Internet use and the use of online chat rooms enhanced sociability/prosocial behavior. The thinking behind this is that, perhaps with the lack of physical contact, the intimidation factor of socializing is removed for many of these groups. Similarly, those who are on the spectrum for autism and have difficulty reading non-verbal social cues are able to communicate easier online as digital socialization is purely verbal. When reflecting on my previous analysis of Discord communities, I must note that in the times I have seen servers succeed as tight-knit social groups, the member population typically had many neurodivergent or socially anxious individuals.

In addition, it has also been found empirically that texting improves sociality/prosocial behavior when the texting partner is someone you are already close with in- person15. Texting simply acts as an accelerator to an existing relationship, and can fill in gaps of communication when people do not always have the time to meet in person. However, I do want to consider how this may be impacting people adversely as well. While texting can healthily enhance a pre-existing relationship, I believe that it also opens up for codependency and unhealthy communication. Firstly, with the possibility of constant communication that texting provides, it makes rejection much more difficult to face. A read receipt tells you each time someone has read your message without responding – a little receipt which causes much grief and heartbreak within my generation. People can get ignored much easier, leading to the infamous "ghosting" that occurs when someone stops texting you suddenly. These things are often a mere byproduct of the vastness of online communication, but being consistently rejected in very frequent ways like this can cause hypersensitivity to communication. People can become overaware and insecure of their relationships with others because they get left on read or their call was missed. While this may be beneficial in the sense that people now "know who their real friends are" and can spend more time deepening those few relationships, this also opens up people to social feelings they were never supposed to experience. When I talk with an acquaintance in class, deep down I know they are just an acquaintance and I enjoy our brief conversations as they occur. But when I text that person later and they leave my messages on read, I am forced to confront the fact that we are not close friends, causing unnecessary resentment and difficult feelings.

This rejection can cause a strange equilibrium between the altruistic and egocentric axis. When I am hurt by the rejection, I may want to pull inward and return back to my natural, selfish state – "Well if they don't want to talk to me, then I don't care about them. I don't care about anyone. I'll live by myself forever." Or, one might swing in the opposite direction and behave in a seemingly self-sacrificing way – "They either meant to leave me on read or they didn't mean to leave me on read. I'll keep reaching out because I will not let it bother me and reaching out is the

right thing to do" (assuming that the reason for reaching out is something important, like a class project). But even in this altruistic scenario, one cannot say that it is healthy to voluntarily subject yourself to repeated rejection and hurt.

Technology makes connection to other people much more immediate and consistent than something in person, pointing to how technology acts as an accelerator of all things social. While it does not appear to pull everyone in just one direction of "altruistic" or "egoistic," depending on the way it is used by the individual, it does pose the risk of pushing someone to the end of either spectrum. The internet is only becoming more expansive every day, reaching new people all the time, and for more time, thus making this risk much more concerning. One cannot deny the utility of the internet, so it would be ridiculous to try and keep it from advancing. But, it may be worth the consideration of future researchers to investigate how much and what kinds of internet use is healthy for people socially, and to take such research seriously, – lest we leave it unregulated (as we have been) and create an overgrowing population of inept extremists. On a brighter note, though, this research can also help to bring more altruism and prosocial behavior among people and communities who are struggling.

Conclusion

Something that I struggle with a lot when researching these topics is taking up a moral stance or action plan. So easy is it for me to say, "Well, this is just the way things are." and perpetuate my never-ending, self-satisfying cynicism. If there's always something bad happening, then I can justify always feeling bad, too – remaining in my comfortable cell of misery. Besides, it's much too difficult to actually do anything about any of this.

To an extent, my cynicism is right. What we are left with (no pun intended) after synthesizing these ideas is a systemic issue:

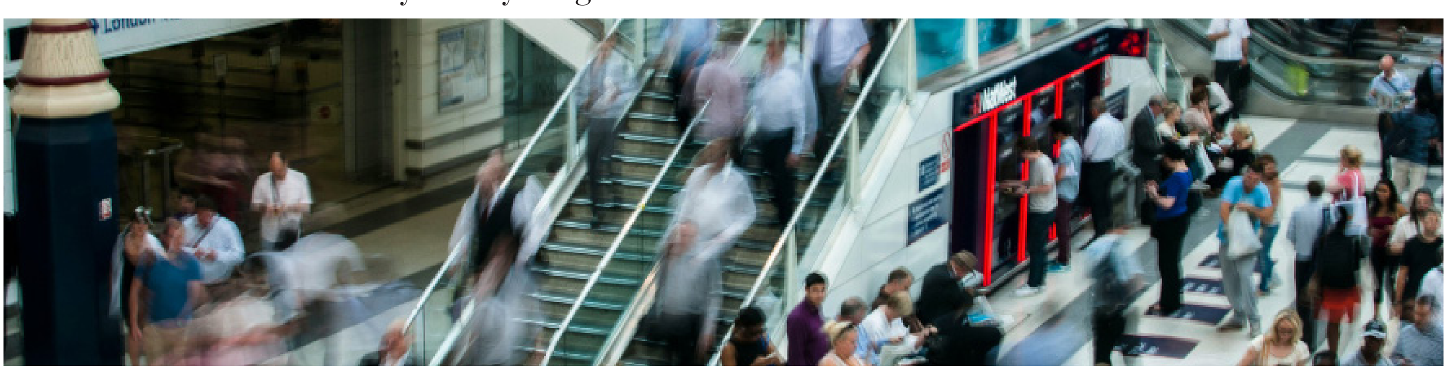
Egocentric behavior predominates if altruistic behavior is not socialized into the individual
⤜ egocentrism or altruism is reinforced biochemically in the brain, perpetuating the behavior
⤜ use of the internet reinforces and accelerates the behavior
⤜ (and while more research needs to be done on this) behavior produced by the internet is most likely neurologically reinforced
⤜ perpetuating the behavior
⤜ perpetuating the behavior
⤜ perpetuating the behavior...

Where can we even break through on this feedback loop to stop it? Completely alter our brain chemistry?

Put all babies in a lab after birth and force a specific
kind of socialization? Destroy the Internet?

There's ethical problems with the first two ideas, and even if we destroy the Internet now, someone can just reproduce it again.

Another thing we must consider before attempting to "take action" is whether or not any of these things are actually bad. Sure, having highly egocentric people is harmful to other people. The egocentric person can hurt someone's



feelings, do something scandalous in the economy, and once reinforced enough biochemically they can rank within the psychopathy spectrum and do awful things to many members of society. But if it is true that egoism is our inherent state, who are we to say that human nature is "bad?" The most we can say, really, is that egoism is unproductive to mutualism. The morality of this is subjective here, and I cannot make a confident stance against it when, as a psychology researcher, I simultaneously value natural human behavior. But this is also very external locus of control of me. If we go down this rabbit hole any further, essentially what it will lead to is "anything that is ever happening is acceptable and should not be changed because it is natural," an idea eerily similar to the notion of fate – something that I somehow don't believe in either (maybe I just don't believe in anything).

Before we do anything to alter the consequences of the future, it is important to ask ourselves what we truly believe in, and in what ways how the event occurring actually defies this. I'm taking the time to remind you of this because I believe that many people throw themselves at changing something because of the social pressure of meeting others' standards of morality. However, this only ends up facilitating an environment where instead of doing what one actually feels is right, productive, etc., they do something which they think will put them in a better social standing with others. This behavior is egoism disguised as altruism, fueling a collection of self-protecting individuals whose actions can quickly become contradictory to what they truly believe in.

I believe in promoting complex thought, nuance, and creating a society which engages through these elements as I believe it will lead to less individual suffering and the expansion of our people. I also believe in examining the way in which the current world works, as we can use it to contrast with what we desire it to be, and for the sake of learning in and of itself. The system for which I have discussed in this long, long article would be defying these values as increased egoism can harm individuals, decreased sociality can hinder mutualistic interactions, and the internet accelerating these processes can heighten the antagonism – all of which, in my opinion, will lead to more individual suffering. So I believe that this system is "bad," and I would hope that this is a compelling argument for you, too.

Because we know how these processes occur, we can do something to insert ourselves to stop it. The feedback loop chart from previously is actually evidence for this, not against. Because repeated exposure reinforces ideas in the brain, by reducing exposure to antagonistic systems we can prevent these things from perpetuating. We can begin to resolve this problem by more effectively implementing regulation on content consumption over the internet (not like the easily-ignored time "reminders" that TikTok, caring about our lives so much, has recently implemented. Additionally, we can take greater care to ensure proper socialization of children through social programs and better education (for example, adding emotional regulation and communication skills into the classroom at an early age), and by spreading awareness about these processes to the public so they are more concerned with internet use and socialization. For any of this to work, we must also give people the resources in order to accomplish these things, such as a better standard of living.

Perhaps this call to action is even worse than my cynicism from earlier, as bringing "a better standard of living" opens up another massive systemic issue that we must somehow solve first, while simultaneously solving this one. It's a paradox. However, a complete reestablishment of the system proves necessary time and time again if we want to reduce the suffering of individuals. People cannot absorb the information I am providing in this article until they are secure in themselves and their survival. How could someone, who is burdened by the task of finding immediate shelter, food, or medical care lest they die or starve today, care about the state of their mind or others' minds 10 years from now? Or whether they are acting in an abstract "egoistic" manner? What is the likelihood that someone in that situation even has access to education in order to be able to understand this? Before we can promote the kind of world and the quality of minds and emotional relationships that I wish to see one day, we must allow for the capacity for mutualism to even occur. Without this, it is in my belief that we will not evolve much further.

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Contributers

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Shobhin Logani is a Junior studying Molecular and Cell Biology and Data Science at UC Berkeley. He is interested in exploring the relationship between electrical and biochemical nature of the brain. He is also passionate about commercializing research to create accessible therapies, and recently interned at a neurological diagnostics startup. He has enjoyed his first semester as Publications lead, and is hoping to pursue a career in the biotechnology industry.

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Aileen is a sophomore at UC Berkeley double majoring in MCB and Business Administration. She's interested in driving for more accessible language in technical STEM fields. She believes that subjects like neuroscience – however technical – will always have room for more fun and playful writing. Aileen was inspired to join publications and learn about neuroscience by one of her favorite authors, Sam Kean, and continues to explore ways that she can recruit her friends, family and peers to become neuroscience nerds.

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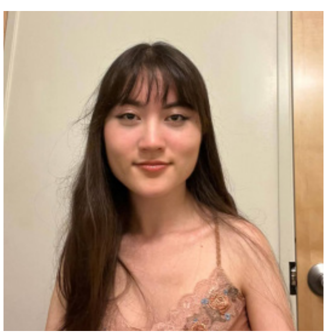
Tess is a freshman at UC Berkeley double majoring in Molecular and Cell Biology and Psychology, and has been a writer for Neurotech@Berkeley for two semesters. She is passionate about neurobiology and cognitive behavioral psychology, and hopes to pursue medical school after undergrad. Tess researches direction selectivity in the retina within the Feller lab. Outside of academics, Tess enjoys hiking, exploring new cafes, and going to concerts!



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Jade is a freshman at UC Berkeley double majoring in Molecular and Cell Biology and Psychology, and has been writing for Neurotech@Berkeley for one semester now. Always being interested in the physical sciences and why people act the way they do, Jade found her happy place in studying how chemistry in the brain shapes behavior. Specifically, she is interested in how we create abstraction, develop beliefs through emotion and experience, and potential blind spots in cognitive awareness. When not writing for Neurotech, Jade is probably still writing – but instead maybe a new short story or poem, or a long rant to a friend about the problems with human nature. After graduation, she hopes to become a researcher in her neuroscience interests mentioned earlier!

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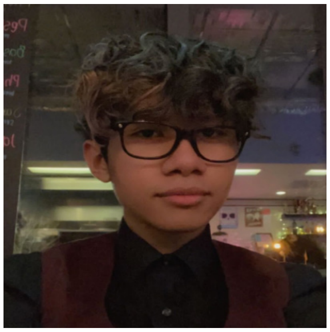
Siri Tantry is a Freshman studying Microbial Biology at the University of California, Berkeley. She is extremely passionate about neuroscience and wants to further her studies in neurodevelopmental diseases. In her free-time is typically volunteering with children on the autism spectrum, reading, singing, dancing, recording voice narrations for storytelling Youtube Channel, recording/writing episodes for her podcast, or emceeing for events around the Bay Area.

Contributers



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As a Junior at UC Berkeley, Jasmine has been actively involved in her fields of Cognitive Science and Psychology through research on emotion perception at the Whitney Lab for Perception and Action. At the lab, she has engaged in the collection and analysis of eye tracking data and will be continuing with EEG (electroencephalography) data during Spring 2024. Jasmine had the pleasure of contributing to the insightful articles in the MIND magazine for the first time this semester and will be continuing in the following semester. Outside her fields, she enjoys uplifting other Latine and first generation students through her work at Stiles Hall!

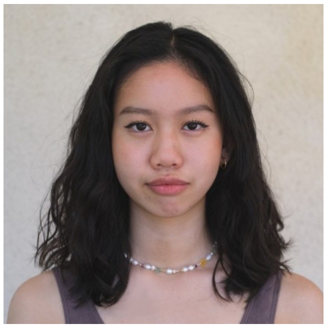
Beatrice Lowman | Author

Beatrice is a sophomore studying Cognitive Science and Data Science at UC Berkeley. She is passionate about the intersection between technology and human well-being, and hopes to pursue the ethical implementation of AI in her career. After enjoying her first semester writing for MIND, Beatrice is looking forward to continuing with Neurotech at Berkeley as an author and contributor to software and web development projects. Outside of Neurotech, her interests include music, feminism, and nature!

Hannah Corr | Design

Hannah Corr is a sophomore studying Molecular and Cell Biology and Psychology at UC Berkeley. She is interested in pursuing a career in the medical field and using her passion for neuroscience to study developmental disorders in children. In her free time, she enjoys her position as an undergraduate researcher in the Colala and Kidd Lab, rock climbing, baking, and making music.

Contributers



Emma Cao | Design

Emma Cao is a first year student studying Data Science and Cognitive Science. This is her first semester as a part of the design team at Neurotech@Berkeley. She is also pursuing the Certificate in Design Innovation from the Jacobs Institute to explore her passions in graphic design, web design, and UX design. In her free time, she enjoys baking, oil painting, and figure drawing.

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