mind

Issue 7: Dark Side of the Mind | Spring 2022

Cover by Haya Halabieh

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Formatting by Megan Lui

Letter From the Editors

Dear Reader,

Spring 2022 was a semester of continued change and growth for Neurotech@Berkeley's Publications Division. Last semester, we felt our first respite from the pandemic, with the emergence of hybrid classes and in-person meetings. This semester brought a new, rejuvenated energy to campus – one that hasn't been felt since 2019. Along with fully in-person classes came club dinners, retreats, and banquets. Publications welcomed several new members, relaunched our Neurotalk podcast, and added thousands of followers to our Medium page. This semester has all led to what you are reading right now: MIND, Issue 7: The Dark Side of the Mind.

At the beginning of each term, during one of our first division meetings, each writer gets a chance to suggest a theme for the magazine (with mind puns highly encouraged). Each time, the Pink Floyd inspired theme gets written on the board, but outvoted – until now. Inside this issue you will find pieces on topics ranging from the dark side of biomedical science to the dark side of beauty and artificial intelligence. We hope these articles will not only stretch your conception of the boundaries of neuroscience and technology, but will kindle your interests into a different side of the mind.

It has been our pleasure to serve as division leads this semester and a privilege to learn every week from our passionate writers, podcasters, and designers. We would like to take this time to truly thank them and you, the reader. Thank you for continuing to support our articles and goals to create an accessible, free space to teach and learn all there is to know about the brain, mind, and technology.

Without further ado, we are proud to present The Dark Side of the Mind…

Sincerely,
Annabel Davis & Jacob Marks

“topics ranging from the dark side of biomedical science to the dark side of beauty and artificial intelligence”

The Brain in the Jar

By Oce Bohra

The Disembodied Brain

In A Wrinkle of Time, two siblings Meg and Charles hurtle through time and space to rescue their father from the clutches of evil. Evil, in one instance, materializes in the form of IT, a giant disembodied brain that uses hypnosis to control the inhabitants of a faraway planet. In the story's climax, the children flee IT's crumbling lair as the brain "pulses and quivers, seizes and commands" (D'Egle). When I watched the movie as a child, that scene left me both spellbound and disturbed.

The disembodied brain, the brain in a jar, the brain isolated from a body are tropes littered throughout cinema over the last century or so - and understandably so. This phenomena repeatedly arises in cult classics like Star Trek and Dr. Who, as well as dozens of smaller science fiction films like The Man with Two Brains, in which a neuroscientist falls in love with a telepathic brain kept in a jar. It permeates children's media - in the animated TV series Teenage Mutant Ninja Turtles, an evil supervillain named Krang takes the form of a tentacled brain within an android body.

Until recently, the disembodied brain existed solely within the boundaries of fiction - it was fear-inducing but ultimately as unrealistic as vampires, ghosts, and Frankenstein. Brains were seen as scary, posited UC San Diego neuroscience professor Alysson Muotri in an interview with KPBS, because "We don't fully understand how [they] work… We see that massive, mushy tissue and is that it? How come it creates everything that we know? How come it creates who we are?"

Rapid progress in the fields of neuroscience and genetics over the last few decades is changing that. Scientists have begun growing rudimentary brain-like structures in the lab called brain organoids. This process revolutionizes our understanding of the brain and gives rare insight into the pathology of neurodevelopmental and neurodegenerative disorders. It also opens the door to a new host of ethical questions and forces us to reexamine our definitions of sentience and consciousness.

What are brain organoids?

Due to ethical concerns, our current understanding of the human brain largely rests on studies of post-mortem brain tissue, rodent and primate animal models, or two dimensional cell cultures. These methods are lacking - animal brains have stark differences to human brains, and 2D cell cultures tend to be overly simplistic and error-prone. They fail to capture the intricacies of human neurodevelopment and neurological dysfunction. In recent years, scientists have begun to model human brain organogenesis in vitro in order to better model the conditions of the human body.

Brain organoids are three-dimensional in vitro cell structures that are grown from human induced pluripotent stem cells (iPSCs) and embryonic stem cells. These stem cells differentiate into multiple types of neural cells that self-assemble into a "mini-brain" structure that mimics part of the brain's architecture and function. These organoids average the size of a pea, and within them, neurons form connections and create complex electrical and chemical signaling pathways. Specific brain structures and systems can be reproduced and stimulated, making organoids an ideal model to investigate the dynamic process of brain development and the roots and pathology of neurological diseases.

Organoids and Neurological Disorders

In 2013, the first neurodevelopmental disorder was modeled with brain organoids. Researchers from the Austrian Academy of Science derived an organoid from the iPCS of a patient with microcephaly - a disease characterized by a markedly reduced brain and head size. A set of gene mutations involved in microcephaly were identified; however, mouse models with these mutations were not able to replicate the reduction in brain size seen in human patients. Using human organoids, researchers were able replicate this brain reduction and pinpoint one of the root causes of the disease. They reprogrammed fibroblasts with mutations in the CDK5 Regulatory Subunit Associated Protein 2 (CDK5RAP2) from microcephaly patients in order to build a human organoid model. With this model, they could trace microcephaly-associated cellular abnormalities to loss of function in CDK5RAP2. These organoids had reduced neuroepitheilian regions and radial glia stem cells and exhibited premature neuronal differentiation - these phenomena cumulatively led to smaller brain size. This work was groundbreaking, and since then, organoid models have become a fixture at a number of biomedical labs.

At UC San Diego, "organs-in-a-dish" were used to produce the first direct experimental proof that the Zika virus causes birth defects and discover that HIV drugs could be repurposed to treat the autoimmune Aicardi-Goutieres Syndrome. At the Salk Institute for Biological Studies, researchers studied early cortical development in patients with ASD and macrocephaly (increased brain size); iPSC forebrain organoids revealed an increased production of inhibitory GABAergic neurons caused by the increased expression of transcription factor FOXG1, which was then identified as a potential therapeutic target (Mariani 2015). At Harvard Medical School, scientists tackled Alzheimer's disease, a neurodegenerative disease that affects over 40 million people worldwide. Alzheimer's disease organoids exhibited high levels of abnormally folded amyloid-β (Aβ) peptide deposition and hyperphosphorylated tau protein; these symptoms could decrease upon treatment with β- or γ-secretase inhibitors, they discovered.

Brain organoids are being applied to study a range of other phenomena - from neuroinflammation, to Parkinson's, to brain tumors. This method has opened the gates to personalized medicine in psychiatry - organoids developed with a patient's cells can help gear a highly specific therapeutic intervention. These structures also enable the discovery of new drugs and the exploration of the mechanisms behind neurological disorders.

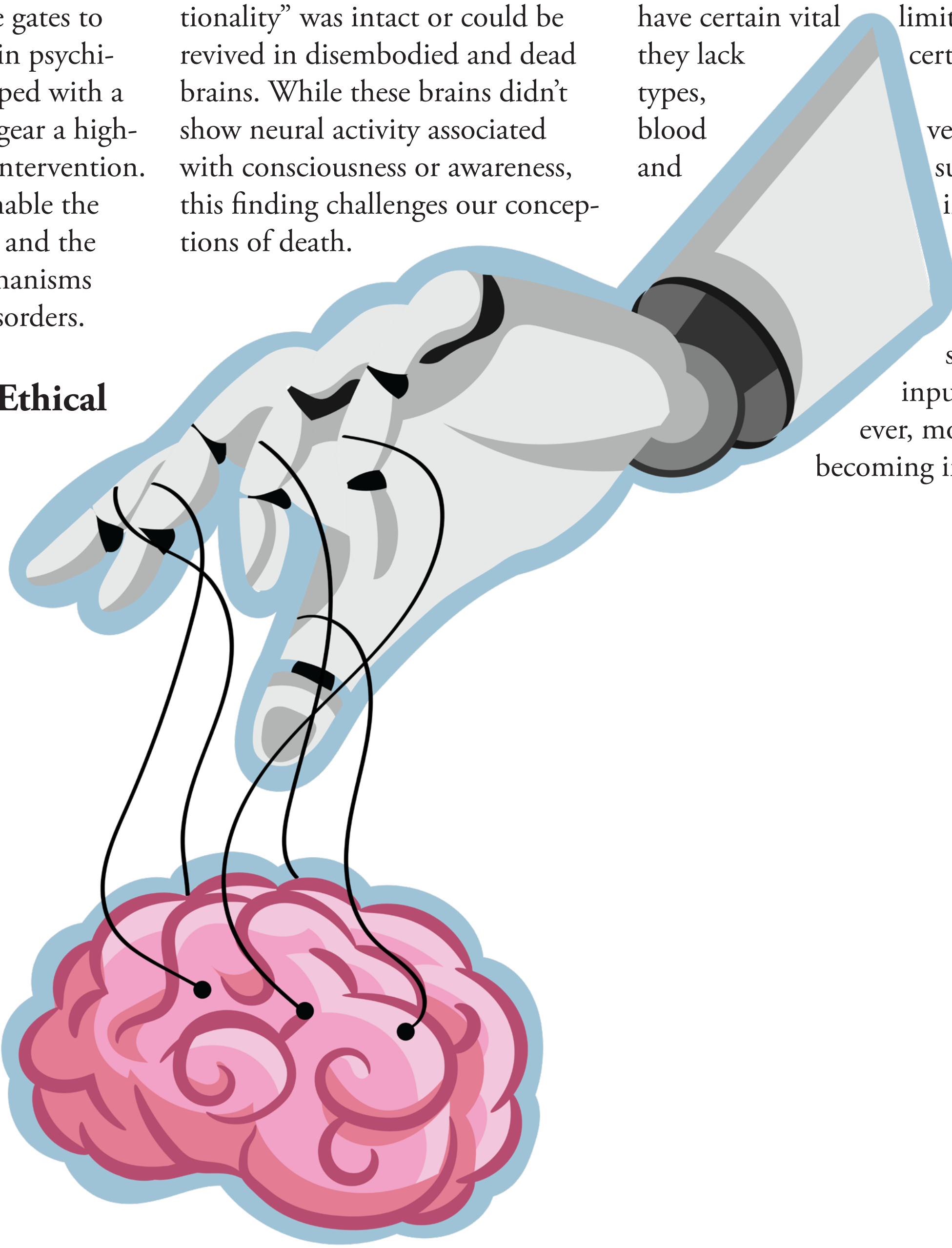
Controversy and Ethical Concerns

In recent years, a series of experiments have pushed brain research closer and closer to what was, previously, indisputably considered science fiction.

In 2019, researchers at Yale University devised a dialysis machine for brains called BrainEx: the system restored cellular function in 32 dead pig brains by enabling the brains to intake glucose and oxygen. Cellular death was previously considered irreversible, and this finding showed that certain "neuronal, glial, and vascular cell functionality" was intact or could be revived in disembodied and dead brains. While these brains didn't show neural activity associated with consciousness or awareness, this finding challenges our conceptions of death.

Senior neuroscientist for the experiment Nenad Sestan discusses the difficulty of working with human brain tissue questions in his article for Nature: "If researchers could create brain tissue in the laboratory that might appear to have conscious experiences or subjective phenomenal states, would that tissue deserve any of the protections routinely given to human or animal research subjects?"

Brain organoids today are far from conscious or sentient, and they have certain vital limitations: they lack certain cell types, blood vessels, and supporting tissue and receive minimal sensory input. However, models are becoming increas-



ingly sophisticated at an astounding rate. The more organoids resemble in vivo brains, the more pertinent the question becomes. And, in order to truly understand and model expressly human conditions like schizophrenia or depression, some neuroscientists, including Muotri, argue consciousness must be created in organoids.

Muotri's team has already met controversy. They've recorded brain waves in nine-month-old brain organoids; these electrical patterns are similar enough to preterm babies' electroencephalography (EEG) patterns that a machine learning algorithm can't distinguish between them.

The Pasca Lab at Stanford is building a three-way cortico-motor assembloid - a combined cortical organoid, a spinal cord organoid and a muscle grown in vitro. Researchers in Germany have built an organoid with rudimentary eye-like structures sensitive to light. Several labs have inserted human organoids into rats' brains, where they've become functionally connected with the rat.

These organoids are already beginning to integrate and absorb sensory information. They can build complex connections and operate in tandem with other organ structures. Consciousness - or a version of it - seems to be a matter of time away.

Many, many ethical questions and concerns are at play. Most importantly, how do we measure sentience and consciousness? Will scientists arrive at a widely accepted definition? How will researchers recognize if their models meet these thresholds? What are the boundaries involved in inserting human neural tissue into animals? Will ethical guidelines surrounding organoids adapt as they become more complex? How will organoids be ethically disposed of? What level of informed consent are stem cell donors entitled to?

What makes organoids powerful - the use of human tissue and human stem cells - is also what makes the method ripe for ethical concerns. Ethicists have more questions than answers, and for now, the world of brain organoids holds both untapped promise and trouble.

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By Emily Moberly

Locked Out of Now

Humans are the only known animals whose minds are not confined to time or space. While you might physically be sitting at your desk, your mind can be reliving any moment in your life or visualizing any version of your future self, independent from what is happening in the moment. Our minds act as our own personal time machines. However, the capability to mentally be in a different moment than the one you are physically in is a cognitive achievement that comes at a high psychological cost.[1] Harvard psychologists, Matthew A. Killingsworth and Daniel T. Gilbert, say "A human mind is a wandering mind, and a wandering mind is an unhappy mind."[2] Through looking at the lens of future and past thoughts, we'll find just how expensive this psychological cost is and the neuroscience behind why we potentially sabotage our happiness.

What are thoughts?

Many people understand how thoughts work in the terms of receiving and returning a signal. For example, a soccer ball is flying at us and our visual systems send a signal to the brain which detects the object and communicates with our motor areas for us to duck. Except, what about when there isn't a ball flying at us, when we aren't solving a math problem before us, or are not glued to a screen? We still are thinking, so where are these thoughts coming from? This stimulus-independent thought or "mind wandering" is something we are constantly doing and makes up much of our internal experience.

In the soccer ball example, the added layer of complexity is that before you even walked up to the field, you likely had a stored representation of the game of soccer that you were building upon. It probably wasn't a complete surprise because of the brain's ongoing updates of the current environmental situation. While the model of a soccer game is complex, it pales in comparison to the complexity of our model of society and how to interact with other complex human beings. Our brains are enclosed in a dark and soundproof shell, yet are constantly constructing an elaborate model of the external world. To succeed in a complex world requires a complex model which requires constant updating of our mental representations.

Future: Intrusive Thoughts and Anxiety

The issue is the brain does not create an accurate model of the external world, it creates a useful one. One that helped us survive, even at a cost of happiness. Because unfortunately, happiness is a weak evolutionary force. Some biologists, such as Richard Dawkins go as far as to say that "We are survival machines — robot vehicles blindly programmed to preserve the selfish molecules

[1]Li, Paul. Introduction to Cognitive Science; University of California Berkeley, 10 Mar. 2022. Lecture.

[2] Killingsworth, Matthew A., and Daniel T. Gilbert. "A Wandering Mind Is an Unhappy Mind BREVIA." Harvard University, 12 November 2010, https://wjh-www.harvard.edu/~dtg/KILLINGSWORTH%20&%20GILBERT%20(2010).pdf. Accessed 19 April 2022.

known as genes."[3] His book *The Selfish Gene* forces us to question how much genes care about the well-being of us, their temporary hosts, as long as we successfully pass down their material to the next generation.

So what did selfish genes claim to be evolutionarily advantageous? A model of the world with an infatuation with the negative. It is better to feel paranoid rather than safe in an unpredictable world. The neurotic ancestors who were anxious about everything were the ones who survived longer and passed on their genes because they weren't killed by predators or starved to death during an unusually long winter. Nowadays, in an urban world with infinitely more stimulation, our brain is constantly having to scan for new forms of danger. Most of this scanning happens subconsciously but occasionally, a potential threat evokes a strong enough emotional response for it to rise into our awareness.

The number of potential threats is unlimited given there are no confinements to time and space when our mind is a time machine. Have you ever been waiting at the train station and randomly had the thought pop up of what would happen if you just leaped onto the tracks– or even worse shoved the lady in front of you onto the tracks? You would likely never admit it due to the abhorrent nature of the thought, but in an anonymous survey by the Anxiety and Depression Association of America, it was found at least 6 million Americans are affected by these sorts of intrusive thoughts.[4]

This is a prime example of the dark side of our ability to produce counterfactuals or those 'what if' statements. Our minds are intrigued by breaking boundaries of human decency and the norms of society, just as they are with space and time.

Many people have likely heard "you are not your thoughts" before, but it can be hard to experience an unwanted thought and not worry about what it means. Unfortunately, fighting the thought or attaching fear and shame to the thought only gives it more power. In a study by Harvard University, participants were told to think about anything, except a "white bear," and, as expected, all of the participants thought of a white bear at least once per minute. The social psychologist leading the study, Dr. Wegner, found evidence that when we try not thinking of something one part of our brain does exactly that – it "avoids" the thought. However, another part of our brain "checks in" over and over again to make sure we're still avoiding it– immediately bringing said thought back into our thoughts.[5] This leads to fascinating questions. If we aren't our

[3]Dawkins, Richard, 1941-. The Selfish Gene. Oxford ; New York :Oxford University Press, 1989.

[4]"Unwanted Intrusive Thoughts." Anxiety and Depression Association of America, ADAA, 26 April 2018, https://adaa.org/learn-from-us/from-the-experts/blog-posts/consumer/unwanted-intrusive-thoughts.

thoughts, then who are we? How is it that one portion of our brain can actively be avoiding the thought and another checking in on it? Does this imply we are both the thinker AND the observer of the thinker? If you thought I was going to give insight on any of these questions, I will not, but perhaps these questions can be food for thought at 3 a.m. the next time your ever-active brain decides it doesn't want to sleep.

Clearly our ability to visualize the future does more than agitate our peace of mind. Despite it being rainy and cold today you are able to pack sunscreen and sunglasses for your vacation to the Bahamas. We are able to dream of a better world and a better future that we can take small steps toward today. There are many amazing things humans can do with our ability to live in the future, but not when it robs us of our lives today.

Past: Repetitive Thoughts and the Default Mode Network

The reason we can think about the future is through using our memory and models of the past. We are collectors of experience. And these experiences can teleport us into possible futures, as well as allow us to dwell in our past. We become lost in the past when our minds relive not only emotionally charged moments, but also ingrained thought patterns. Donald Hebb studied thought patterns in depth with research on the Aplysia Californica sea slug and the process of forming, strengthening, and solidifying neural pathways based on experiences.[6] But besides the catchy phrase–"neurons that wire together fire together"–what else can we take from Hebb's research?

Humans are creatures of habits and neural pathways are the basis of habits, so as certain connections are used more frequently, they become stronger and faster. This is incredibly useful when it comes to building new positive routines or from an energy efficiency standpoint. Imagine if at 50 years old you had to consciously focus on how to coordinate your movements to put on your pants like a 6-year-old might. Where the structure of neural pathways isn't so useful, however, is when well-worn pathways allow for us to be on "autopilot" throughout our day because of our tendency to follow the path of least resistance. Like most processes in our body, our mind, when not consciously being fed something to think about, acts according to the law of least effort to preserve mental energy. According to the research of Dr. Fred Luskin of Stanford University, an adult human being has approximately 60,000 thoughts per day—and up to 90% of these can be repetitive. [7] Conserving mental energy through repetitive thoughts

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[5]Bilodeau, Kelly. "Managing intrusive thoughts." Harvard Health, 1 October 2021, https://www.health.harvard.edu/mind-and-mood/managing-intrusive-thoughts. Accessed 19 April 2022.

[6]Hebb, D. (1949). The organization of behavior: A neuropsychological theory. New York: John Wiley and Sons.

[7]Stanford University [@Stanford] "According to Prof. Luskin, we have over 60,000 thoughts a day with 90% being repetitive – how to change and find peace: http://bit.ly/HXiJ4r" Twitter. 5, Apr. 2012

isn't inherently unhealthy as it is the reality of adulthood to have some extent of cyclicity in work and everyday schedules. But, what is all this noise?

Neuroscientists have long known that even when our brain is not consciously attentive to something, it remains incredibly active. An increase in interest in where this activity comes from has led to the discovery of what is called the default mode network. The default mode network is the ruler of all mind wandering. Within a fraction of a second of switching your attention off an external task your default mode network switches into a higher state of activity. As you are reading, you may be thinking about all the laundry on your sofa or the conversation you had at work, and in mind-wandering the brain disengages from the visual information of the text and turns its attention inwards. This explains why we lose track of what we are reading when our mind wanders: Meichao Zhang described that "recalling personal memories activates certain brain areas which are functionally decoupled from the regions involved in processing external information" – such as the words on a page.[8] These brain areas aren't completely understood, but we know from fMRI research that they include the anterior medial prefrontal cortex, posterior cingulate cortex, and angular gyrus.[9] Moreover, imaging done by Nathan Spreng, who conducted four separate neuroimaging studies on autobiographical memory, navigation, theory of mind, and default mode (resting awake state), showed that brain activity in these domains demonstrated a high degree of correspondence.[10] This supports the mental time travel hypothesis with specifically the default mode network acting as our time machine. When our brains are not actively involved in another task, the time machine navigates us with the aid of our memory to free-ranging mental activity.

The default mode network allows us to be emotionally intelligent, social, and conscious creatures as well as to plan and self-reflect. But now that we have a basic mechanistic understanding of this network, let's dive into the downfalls. Improper functioning of the default mode network is associated with a wide range of mental disorders, including the attention lapses and task errors in people with ADHD, the psychosis from aberrant connectivity of internal and external signals in people with schizophrenia, and the rumination from higher connectivity in people with major depressive disorder. Lots of research is still required in these areas to create causal connections and developmental understandings, but hopefully, there will be answers to how we can support those with disorders or those who are merely held back by their mind-wandering thoughts.

[8]Zhang M, Bernhardt BC, Wang X, Varga D, Krieger-Redwood K, Royer J, Rodríguez-Cruces R, Vos de Wael R, Margulies DS, Smallwood J, Jefferies E. Perceptual coupling and decoupling of the default mode network during mind-wandering and reading. Elife. 2022 Mar 21;11:e74011. doi: 10.7554/eLife.74011. PMID: 35311643; PMCID: PMC8937216.

[9]Heekeren, Hauke R. "The default mode network and social understanding of others: what do brain connectivity studies tell us." Frontiers, 24 February 2014, https://www.frontiersin.org/articles/10.3389/fnhum.2014.00074/full. Accessed 24 April 2022.

standings, but hopefully, there will be answers to how we can support those with disorders or those who are merely held back by their mind-wandering thoughts.

Present (or Lack Thereof)

As mentioned, Killingsworth and Gilbert's research proved, "A human mind is a wandering mind, and a wandering mind is an unhappy mind." But how did it do so? In 2010, they conducted a study with 2,250 subjects, checking with them at random times (via a phone app) to record what they were doing at that moment and what their mind was focused on. They determined that the test subjects had wandering minds 47 percent of our time. That means that half of our lives we aren't even presently focused on what's right in front of us.

How does this make us unhappy? If mentally re-living a happy time from the past could make you feel happier in the present, why don't we all continually relive our happiest moments? There's no shame in reminiscing about your achievements and good times but permanently depending on your senior prom or high school football season to bring you joy won't work.
In fact, the five most prevalent activities participants in this study claimed to be most present during, were unsurprisingly the five activities that brought them the most happiness. Sex was at the top of this list, followed by exercise, conversion with friends, what participants considered 'playing,' and listening to music.[11] Activities that scored low on the presentness scale such as work, household chores, grooming, listening to the news, and rest were mainly activities people claimed made them most unhappy.

The second half of activities are facts of life just as much as hopefully the first list is. What's most important from this study, however, is that what people were thinking was a better predictor of their happiness than what they were doing. Our capacity to think any thought is a gift for thriving in today's society, being a self-aware and conscious person, and opening the door for limitless creativity, but also is a curse that steals our minds from our physical and present bodies. So be present, there is a lot of joy that can be found when you live in the moment. And if your default mode network took over when reading that last sentence, read it again.

[10]Spreng RN, Mar RA, Kim AS. The common neural basis of autobiographical memory, prospection, navigation, theory of mind, and the default mode: a quantitative meta-analysis. J Cogn Neurosci. 2009 Mar;21(3):489-510. doi: 10.1162/jocn.2008.21029. PMID: 18510452.

[11]Tseng, J., Poppenk, J. Brain meta-state transitions demarcate thoughts across task contexts exposing the mental noise of trait neuroticism. Nat Commun 11, 3480 (2020). https://doi.org/10.1038/s41467-020-17255-9

The Wicked Seductress

By Mary Shahinyan

Obsession, when not directed towards something positive, is unhealthy. By obsessing over something, one may lose sight of everything outside of the subject of obsession and become all too consumed by it. Obsession over beauty is, unfortunately, something many have struggled with throughout history. From unhealthy beauty standards and unrealistic expectations of what society deems "appealing" to trying to recreate something naturally beautiful, artificially. Obsession over beauty has driven people to become insecure and, in extreme cases, has driven some to the brink of insanity. Furthermore, the lengths to which individuals will go to meet societal beauty standards have impacted how they view and treat themselves and others. From face editing filters and body modifications on social media to taking the beauty that exists both in and around us for granted, obsession with beauty has proven harmful. The pervasiveness of beauty in our daily lives leads us to ponder: how does the brain process what beauty is and decipher between what is beautiful and what is not?

Recognizing Beauty

When looking at something or someone truly beautiful, people will often report feeling awestruck and overcome with emotions. Many scientists have debated the regions of the brain that recognize and respond to beauty. We know that the brain uses certain cognitive domains for facial recognition and evaluation of attractiveness; these regions include the occipital and temporal areas of the cortex, the inferior occipital gyri, and the fusiform gyrus (Yarosh 2019). These domains are responsible for processing and recognizing facial features. When we see people, our brains analyze and respond to their facial features based on which ones are similar and which ones are not. The favored facial features stimulate reward systems in the brain "such as the amygdala, cingulate and insular cortices" (Yarosh 2019). These brain regions are home to emotions that motivate our behavior and action. When the brain processes facial features such as the symmetry of the face, bone structure, eye color, and all other traits that an individual can be identified by, the reward system is activated. The activation of the reward system causes dopamine to be activated in the ventral tegmental area of the midbrain. The physiological response to what the brain is processing allows us to then label those features as "attractive" or "beautiful." However, the way we decipher attractiveness is not only subjective to the individual but also differs between biological sexes due to reproductive differences and evolutionary pressures.

When looking at phenotypes for a mate, in evolutionary terms, males and females have different preferences. However, determining attractiveness is similar across both sexes. A person can prefer brunette individuals over blonde-haired individuals, but still be able to assess whether a person is attractive or not despite their specific preference. Beyond similarities between sexes, a "meta-analysis, covering 919 studies and over 150,000 observers, reported that people agree, both within and across cultures, who is attractive and who is not" (Yarosh 2019). This study tells us that although trends regarding what is beautiful are constantly changing throughout history, baseline attractiveness stays consistent. The consistency in assessing attractiveness that various groups arguably have different preferences "strongly suggests that judgments of physical attractiveness are hardwired in human genetics" (Yarosh 2019). There is something in our genetics, influenced by evolutionary pressures, that fixes what we deem favorable to observe. We can often agree on beauty and attractiveness. In fact, our preferences can be observed as early as six months old when infants can be seen looking "longer at faces judged by adults as attractive and less time looking at faces that were judged as not attractive" (Yarosh 2019).

Although the human brain has neurobiological tools to assess beauty and decide on attractiveness, the brain remains susceptible to deception and fixation. Given that our beauty assessment is genetically hardwired to better the survival of their genes and reproduction, it is understandable that humans pay so much attention to aesthetics. Therefore, not only are there selective pressures on attractiveness, but also on our ability to detect attractiveness. When the deciding factors between what is and is not attractive are reinforced among others in society can often create a more significant emphasis on aesthetics and thus strengthen the importance of perceived beauty.

Each instance of beauty is unique in its way. Because of this, it is challenging to recreate beauty in the same way or experience something beautiful in the same way. Therefore, the desire to attain or re-experience beauty can quickly lead to feelings of frustration and inadequacy. These frustrations are currently dominantly present on social media; from TikTok to Instagram, the filters people use to modify their faces and bodies in both pictures and videos have created a digitalized beauty that cannot be recreated in real life. These false images of what beauty should look like (a certain body type, certain hairstyle and color, face structure, eye color, and so on) have led many individuals to feel insecure about their appearance.

Chasing Beauty

When we see something beautiful, we admire it, stare, and want to be in its presence. Once we are entranced, we then want to attain such beauty. The desire to attain and marvel at beauty has manifested in museums. We love looking at beautiful things so much that we have built an entire industry around cultivating artwork and displaying it. Being entranced by beauty portrays a person's admiration for it and, thus, one's desire to attain it. However, not one instance of experiencing beauty can be replicated or re-lived perfectly, for each instance is unique.

This desire to replicate and "perfect" beauty has crept into our daily lives. Social media, for one, plays a significant role in impacting societal standards of what is considered beautiful. Although "beauty of a face is not the same as the beauty of a painting," many individuals cannot distinguish; digitized "paintings" of faces on social media have blurred the lines between facial beauty in real life and an artistically edited one on an online platform. This "editing of beauty" to mimic painting qualities has led to unrealistic beauty standards in real life that many try to attain. We edit facial body features, but it has also led us to edit our surroundings in pictures. For example, if the sunset colors that we took a picture with are not as bright and colorful as we wanted them to be, we will increase the vibrance and color tones of the image to fit our standard of beauty. Although "beauty is plural, diverse, embedded in the particulars of its medium," many individuals still fall into the cycle of obsessing over the societal standard of what is "beautiful" during their generation. In some individuals, this can lead to eating disorders, body dysmorphia, and feelings of not being enough, when in reality, all of these individuals are beautiful in their own ways. These feelings can harm an individual's appreciation of themself and appreciation of the beauty around them. This is the dark side of beauty.

So why do people constantly chase beauty?

The simple answer is dopamine reward. Like any commonly known and studied addiction, humans can also become addicted to beauty. This addition to beauty relays back to the reward system mentioned earlier. The following steps describe what a person goes through on a neurological and psychological level when seeing or experiencing beauty.

1) The body receives sensory stimuli.
2) Dopamine is activated in the ventral tegmental area of the midbrain.
3) The dopamine produced can then travel to different brain parts via different dopamine pathways.
4) In the case of the mesolimbic reward pathway, dopamine will arrive at the nucleus accumbens and activate it.
5) Dopamine levels then increase further and tell the amygdala and hippocampus that a reward has been presented (something good has happened from these sensory stimuli. Time to feel an elevation in your mood!)
6) This feeling, however, is very fleeting and leaves the brain wanting more, want ing to feel that again.

That feeling of wanting more, wanting to experience a sensation again, is a driving force in many addiction battles. Beauty gives us natural dopamine boosts and makes life often feel more colorful, enjoyable, and grand… however, as with most things, there is a flip side, a dark side: a side of beauty that leaves us constantly with a need to feel again. The feeling that may drive us to chase after beauty in a way that holds us back from truly experiencing and realizing it at the moment.

The Dark Side of Beauty

For many, the idea that beauty has a dark side can seem extreme and unbelievable. Isn't beauty, goodness, purity, happiness? Perhaps that positive outlook on beauty is something that we fabricate. Perhaps, the reality is that beauty can be dangerous. Take the ocean, for instance. People marvel at its beauty and have become so fascinated with the ocean that they will drive for hours to sit in the sand and stare at it. This infatuation with the ocean can be misleading, for the ocean can be quite powerful and savage. The term "'true beauty' [as] characterized by volatility, danger, and boundlessness, all characteristics associated with the sublime" (Rankin, 2019). The "true beauty" in this instance is the ocean itself. Rankins' description of "true beauty" perfectly describes the ocean, for it also is volatile, dangerous, and boundless. Many lives have been lost to the ocean due to its untamable power. Despite this danger, most remain fascinated and unalarmed. This fascination presents itself in poetry and art, where oceans are depicted as overwhelming bodies of water that creep up and draw us in. When we sit in the sand and admire the stunning shades of blue and green from afar, the ocean calls out to us. It first tempts us to dip our toes in the shallow ends of its shores and then slowly pulls us inward as the waves crash and recede.

The beauty of the ocean can serve as a creative take on how beauty standards often pull us into dangerous habits. When we admire beauty from afar (i.e., admiring beauty on social media platforms that can be far removed from our lives), we get slowly pulled into the virtual realm of beauty and try to replicate what we see in our real lives. As we try to get closer and closer to being as beautiful as what we see online, we may be misled and develop insecurities and unhealthy habits. Science can explain the reason why we fall into these habits from an evolutionary perspective, given that "human physical characteristics and their perception by the brain are under pressure by natural selection to optimize reproductive success" and that "the neuroscience of beauty is best understood by considering the evolutionary pressures to maximize reproductive fitness" (Conway and Rehding, 2013). However, evolutionary pressures alone are not sufficient to describe human behavior concerning beauty for "attractiveness is part of our status ranking among our same-sex peers, and we actively deceive others and ourselves about our personal appearance" (Conway and Rehding, 2013). We have even gone so far as to modify our bodies to states beyond recognition and create whole fields and sectors of beauty to market.

Obsession with beauty has overtaken various types of industries, including neurotechnology. Artificial intelligence algorithms are being used for many face editing filters and apps that people use today. AI technology recognizes an individual's face by mapping out the facial features (similar to how the human eye recognizes and maps others' facial features) and then edits them accordingly. If you want eyeshadow, fuller lips, more defined cheekbones, and a "cut jawline," then the AI technology on face editing apps will come to your rescue. However, posting and advertising these edited images as "real" and "natural" beauty can be harmful, especially for easily influenced youth on social media.

In Conclusion

Destigmatizing beauty as this pure and ironically "beautiful" concept is an important and necessary conversation to have. The fixation that people throughout history have had on looking pretty, wearing pretty clothes, being in pretty places, and so on has the capacity to be detrimental to an individual's mental and physical health. The obsession that people have about being as good looking as the influencers on social media, wanting to be dressed in the most lavish clothing, or to be traveling the world to all of the beautiful places not only strips individuals who browse social media apps of reality but also impacts their perception of their physical appearance and lifestyles. When people constantly see other people's lives filled with endless fortune, love, and allure, their willingness to accept the existence and benefit of imperfection decreases. That person then wants to belong, identified as one of those influencers "who seem to have their life together, never age, and sparkle like a Hollywood star." The hypercritical lens that that person then places on imperfection can lead to a hypercritical lens of the self. This hypercritical lens can be problematic because "while the desire to look 'good' is natural, the problem arises when one begins to evaluate self-worth through physical appearance" (Choudhury, 2021). Furthermore, a compulsion toward being beautiful or surrounding yourself with beautiful people, things, and places can be hazardous because "when certain benefits, incentives, and decisions are skewed by external appearances, they will surely disturb the social order" (Choudhury, 2021). The compulsion to make decisions based on the aesthetics around the decision may result in a faulty judgment and lack of attention to all other components that should be factored into the decision-making process. It is essential to assess how the ever-advancing field of technology can continue to impact beauty standards. As neurotechnology and the world of social media both advance, our perception of beauty should also include the unique and imperfect aspects of what makes us and our surroundings admirable and valuable. The dark side of beauty, the side that leads to feelings of doubt and criticism, plays with and twists our admiration for aesthetics into a possibly unmanageable unhealthy obsession like a wicked seductress.

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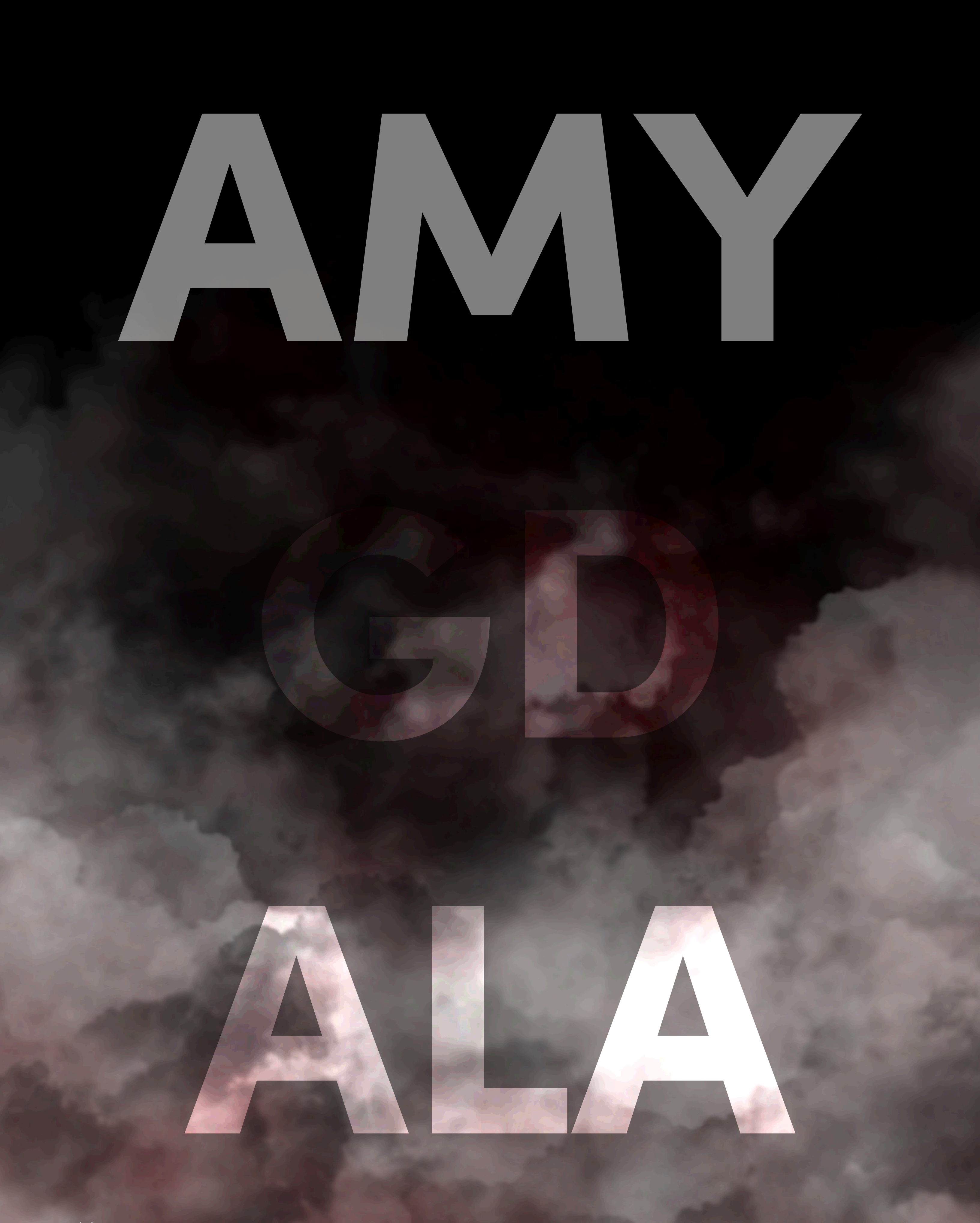

Artwork by Megan Lui

The Prince of Our Mind: The Amygdala

By Meltem Su

Is it better to be feared or loved?

Though this question has been argued by society for centuries, Niccolò Machiavelli simply stated that "it is better to be feared." While he certainly did not end the debate for political theorists, he impassioned neurobiologists.

Why did Machiavelli conclude that it is better to be feared and can science back his claim up?

The Amygdala

Fear is an emotion and state that is controlled by a collection of nuclei in our brain called the amygdala. Though this almond-shaped organ (found on the right and the left side of the brain) constitutes a very small portion of our brain, it is an all-encapsulating part of our lives. In almost every human action there is a sense of fear — fear of injury, fear of loss, fear of knowledge, fear of the unknown, and more.

The amygdala is a high-sensing structure. It can receive input from smell, taste, noise, and touch. This capability to respond to many aspects of sensation allows organisms to protect themselves from potentially harmful and dangerous situations. The amygdala can also help organisms remember past experiences due to its unique position near the medial temporal memory system. This ability to form an association with past experiences allows organisms to learn what to do and what not to do.

When the amygdala is activated, our bodies respond physically, chemically, and physiologically. Physically, humans can respond by freezing or jolting. Chemically, humans can release stress hormones. Physiologically, both our blood pressure and heart rate increase. These intense responses are all stimulated by just the 10 nuclei composing the amygdala(Sah, P).

So what exactly is fear?

Fear is a complex emotion and it oftentimes is difficult to define. Why is it that someone can watch horror movies at 2 AM while others can get scared by even the thought of a clown? Or why do students say they are 'scared' for their neurobiology final?

Fear was, is, and will be the center of many philosophical thoughts either directly or indirectly. It seems nobody has found the answer yet. Many thinkers have defined fear in a sense that was relevant for their time or in their life. Aristotle talks about fear as a way of defining courage. Many cultures teach to fear all bad omens, hence the protecting evil eye. Even biology innately teaches us fear with warning coloration of bright colored animals. Fear is best defined in specific contexts and aspects of human life.

In neuroscientific and biological terms, fear is initiated in the brain, in the amygdala, which triggers a response that leads to physiological changes such as increased breathing, heart rate, and blood pressure, and depression of the gastrointestinal system. Then higher level processing regions, namely the hippocampus (which aids in memory formation and learning) and prefrontal cortex (which aids in reasoning), are both activated to help us elucidate the recognized threat. Our body then either reacts to the threat or slowly enters a relaxation phase if the perceived threat is not truly dangerous. Finally, our brain helps us learn from fear and remember whether the perceived threat is something to be feared the next time there is a cue (Smithsonian Magazine).

However, using the amygdala 24/7 is not practical. While fear may play a significant role in daily behavior, humans avoid amygdala hijacking (the takeover of the amygdala in a state of fear) due to the frontal lobe which is responsible for reasoned thoughts and rationality in such situations. This important function prevents constant chaos in our minds (Holland).

Fear is Everywhere

Political theory is based on fear. Many are familiar with the Machiavelli debate on whether it is better to be feared than loved. But, he was not the only one that had his philosophy based on fear. Hobbes also based his theory on fear and he stated that the origin of fear in humanity arises in supreme power and that this power uses that fear to rule (Jakonen).

Society is based on fear. Why is it that so many irrational things are allowed in our everyday society? In our current society, so many crimes go unpunished without much questioning. Is staying away from the herd mentality fear-inducing? In the Roman era when gladiators battled each other and looked to the audience for approval to kill an opponent, is the gladiator's guilt reduced when more people show approval for it? When a group of viewers point their thumbs, rather than a single individual, does the crime split into smaller fractions, overall reducing or even eliminating the feeling of crime?

While fear originally evolved to be beneficial to early humans by protecting and creating alertness in more harsh living conditions, has it turned into the sovereignty of our brains?

The Psychology of Fear

Fear is either unlearned or learned. Humans are born with natural fears such as the fear of separation, loud noises, and falling off heights. In fact, by studying newborns' behavior in different scenarios, these are the only three fears that scientists have proven that humans are born with (Kounang)! Everything else that you fear today is due to your environment.

Humans' "learned fears" are due to a plethora of factors. In fact, Pavlovian conditioning is one of the biggest methods by which organisms learn to fear. This works through cue stimulation and memory of past experiences. Adverse results from particular stimuli create fear in our minds. Similarly, stimuli creating positive experiences are remembered well and received leniently in our minds.

This Pavlovian conditioning is the reason why so many phobias exist in our world today. Though some of these phobias aren't necessarily dangerous, such as xanthophobia (the fear of the color yellow), this creates diversity in fear (Coss). However, the benefit of this 'fear' diversity has allowed humans to learn from ancestors about potential threats to our livelihoods to prevent them and to increase the likelihood of longer and healthier lives.

The Final Verdict

So … was Machiavelli correct that it is better to be feared than loved? Some will argue strictly love, some will argue strictly fear. But in truth, it is difficult to just credit one of these two emotions to explain the success of a ruler. Teachers, in a way, are rulers of their classrooms but choose to rule with love and compassion. Contrarily, a landlord rules their property with fear and threat of eviction. At the end of the day, both are rulers. But sometimes teachers rule with fear and maintain a classroom and landlords rule with kindness towards their tenants and still maintain their property.
Our amygdala helps us respond to dangerous situations. But how much fear can a ruler really instill without creating the fear into a state of constant anxiety leading to hatred? The amygdala releases stress hormones and increases blood pressure among other symptoms of fear. Can a human healthily survive in this physiological mode? Just by understanding the physiology behind fear, we can already see that the ruled population will turn towards the feeling of hatred more than the feeling of love.

All in all, the answer is that Machiavelli was wrong. Maintaining the thin line between fear and love is what creates a respected ruler.

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The Dark Side of the Moon

By Sameer Rajesh

A curious fact about the Moon is that it is tidally locked—that is, its rotational speed about its own axis is equal to the orbital speed it has going around the Earth. As a consequence of this, almost all the time the Moon shows the same face to the Earth. If you were to keep looking at the Moon through a telescope every night, you would see the same features in the same positions.

The Moon is, of course, not flat, so it stands to reason that there is a side we don't ever get to see—a side that has been titled by popular culture "the dark side of the moon."

The name is a misnomer, though. No part of the moon is ever dark—each face of the Moon is illuminated at different times by the sun. Really, the term "dark" speaks more to the fact that we don't know what's back there.

Borrowing the language of Pink Floyd, let's begin a journey into the dark side of the mind.

Stories From Neurophysiology

The tale of electrophysiology (studying electrical activity in cells, tissues, and organisms) begins in the home of Luigi Galvani, an 18th-century Italian physicist who discovered he could make frog legs twitch when he applied electrical sparks to them. Almost two centuries later, technology had progressed to a point where scientists could use tools such as microelectrodes to study the electrical behavior of single cells. Pioneering studies in the 50s and 60s led to the development of the field of clinical neurophysiology, whose main goal is to make precise recordings of the electrical activity of neurons in humans.

Neurophysiology as a technique has rapidly advanced to the forefront amongst neuroscientific tools to investigate the nervous system. It requires no direct contact with neurons and can detect the firing of action potentials—the electrical impulses which travel down neurons to propagate information.

In 1968, early neurophysiologist David Robinson did a series of theoretical calculations and made experimental observations that resulted in the conclusion that neurophysiology was detecting far fewer neurons than should be present in different brain regions. He noted that this discrepancy should be "a very disturbing question to users of microelectrodes." Over the following decades, more research supported his conclusion—there was a large, in fact, a dominant, population of neurons that were fairly silent—either inactive or unable to be detected with microelectrodes. In effect, they were "dark," just like the far side of the moon, to us.

How do we model a mostly quiet brain?

Before answering that question, it's important to get our feet wet with some basic concepts in information theory. Neural encoding is thought to exist on a sort of spectrum between two extremal limits of encoding capacity. The first of these is the "local coding" framework, an idea that accounts for the very low activity of most neurons. This framework imagines the brain as a keyboard, with each neuron specifying a single concept or item. It is often affectionately referred to as a "grandmother" strategy, so named because it implies the existence of a cell in your brain that fires only when thoughts, perceptions, and actions related to your grandmother occur.

This does well in explaining the idea that most neurons are quiet most of the time—you aren't always thinking about your grandmother (though, maybe you should be). But a significant drawback is that this scheme only allows you to represent as many items, ideas, and concepts as you have neurons, which poses significant challenges for learning and memory. If there are only a finite number of neurons in the brain, you would have a very limited capacity for the storage of information.

The other extreme limit of neural encoding is the dense coding framework. It argues that every neuron is involved in encoding information to some degree. From a simple calculation, if every neuron has either an active or inactive state (in much the same way a "bit" in the language of computer science can be either a 1 or 0), then the total number of concepts you could represent in the brain would be on the order of

$2^{\text{number of neurons}}$. The number of atoms in the universe is around 2^{265}, while your brain has close to 100 billion neurons, allowing for a total storage capacity of 2^{100} billion—these numbers are vastly, vastly, different. This astronomical figure far exceeds any reasonable expectation of what we can hope to store, and does not explain how we can activate multiple neural pathways simultaneously. Furthermore, maintaining a network of that size is energetically completely unfeasible, and would produce activity levels that far exceed the observations of largely dormant neurons.

Evidently, human brains don't function at either of these limits, and a proposed compromise is the sparse coding framework. In this regime, the number of neurons that fire during certain neural pathways is limited—in essence, it doesn't allow the large-scale activation of dense coding networks. On the other hand, it does allow for the activation of multiple neurons in encoding and processing a stimulus, giving it an edge over local coding networks.

In the sparse coding framework, we can recover the fact that many neurons that are specific to certain neural pathways only spike rarely, when those pathways are activated. But it is a little bit more difficult to understand why some neurons are much, much louder than the rest—they seem to fire very frequently. There are some guesses as to where this discrepancy might arise from, but for the most part, it is still an active area of research.

Okay, but what do the quiet neurons really do?

There are a number of different theories as to what the low activity neurons are actually doing. Some speculation exists that they might be involved in refining general stimuli into specific perceptions—for example, deciding what exactly a particular visual stimulus is from a general triggering of the visual neural pathway. There is some evidence also that these quiet neurons may play some information processing role that we haven't yet uncovered, or that they are latent, unused neurons that can become integrated into other neural pathways should the need arise.

Despite insights from the worlds of information theory and neurophysiology, our overall guesses are inconclusive. For now, the dark side of the brain remains dark. But questions about how we think about electrical activity possess real probative value, especially when we look at clinical indications of abnormal electrical activity in the brain. For example, can we understand epileptic disorders in a new light once we uncover the role of quiet neurons and the variations in encoding strategies and neuronal activity in different regions of the brain? It's an idea that is far enough in the future to say we're not there now, but not so far to say it's out of reach.

Misnomers and Hope

Astronomers are generally unhappy that the side of the moon we don't get to see is called the "dark" side of the moon—it is, for long periods of time, illuminated by sunlight. We just aren't in the right position to see it.

I think there's an interesting parallel to be drawn to the dark side of the mind alluded to thus far. Perhaps we haven't been looking in just the right places, and maybe there are better tools to answer the questions we have. Still, advances in neuroscience and electrophysiology give me hope that we may soon uncover a few of the most elusive features of our brains.

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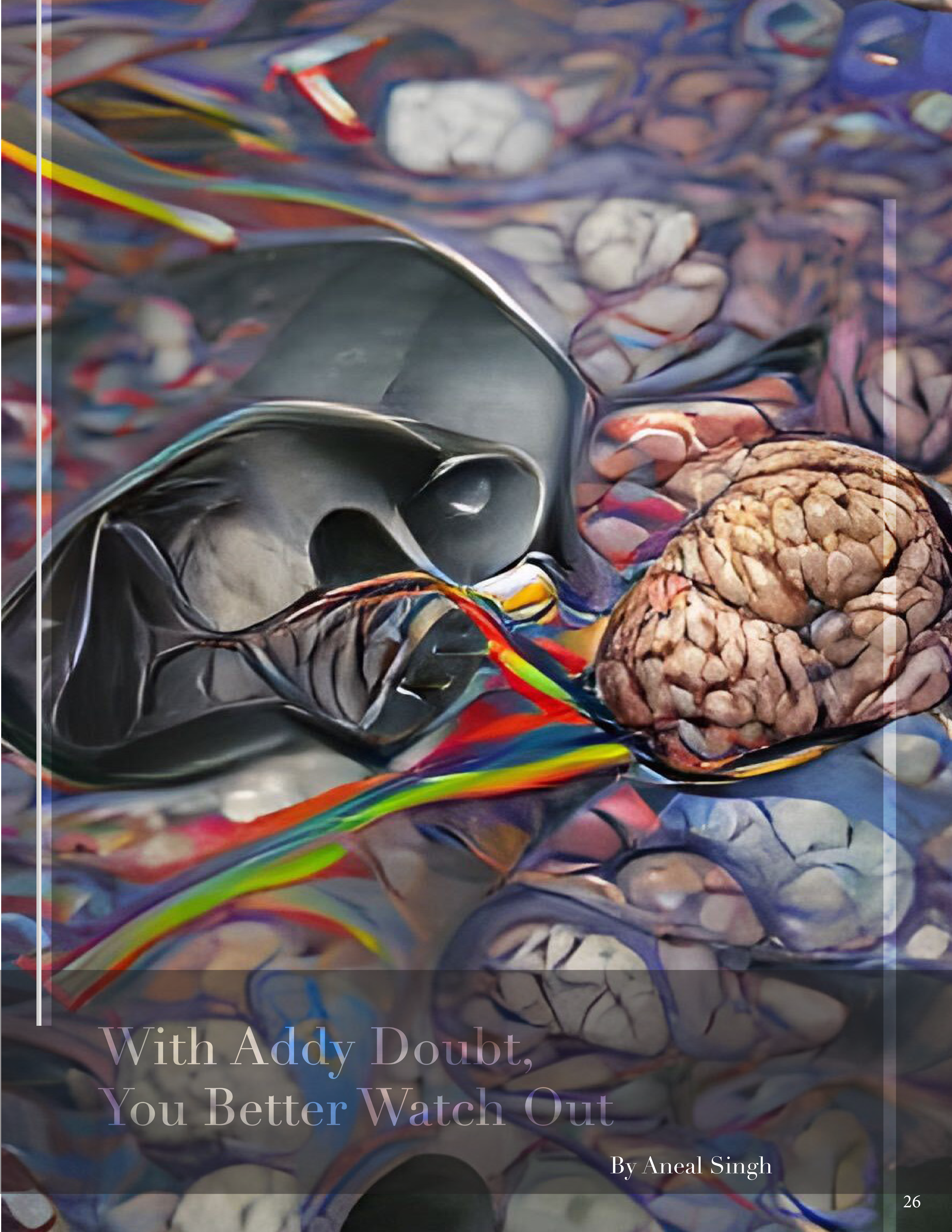


With Addy Doubt, You Better Watch Out

By Aneal Singh

"YOU'RE GOING TO KILL HIM!" Like many fathers who endure the pain of seeing their child addicted, Rick Fee yelled furiously at his son's doctor out of concern over an Adderall overprescription. The Fee's were convinced that their son Richard, 24 years old, did not have ADHD as a child or college graduate. Despite violent, delusional activity and time spent in a psychiatric hospital, Richard could still convince professionals for one more 90-day dosage. Two weeks after his medications ran out, he hung himself in his bedroom closet.

The story of Richard Fee highlights the concerning normalization of excessive Adderall intake for young adults. From 2006 to 2011, a John Hopkins meta-analysis reported that non-medical use of Adderall for adults ages 18 - 25 rose 67%, and emergency room visits went up 156%. As more data continually emerges about the abusive cycle that young adults involve themselves with, the search for a solution for Adderall addiction becomes direr.

How Adderall Affects the Brain

Compared to other pharmaceuticals that have consumed the scene for decades, Adderall was introduced to markets in 2001 as a slow-release capsule. Adderall, also known as amphetamine-dextroamphetamine, is a prescribed medication primarily used to treat attention deficit hyperactivity disorder (ADHD) and narcolepsy. Adderall is a stimulant that contains three parts dextroamphetamine and one part levoamphetamine. It increases the neurotransmitter norepinephrine, known as the "stress hormone," and dopamine, which is responsible for pleasurable sensations such as motivation. When the simultaneous stimulation of the central and peripheral nervous systems occurs, Adderall users become more alert, and tasks that require staying focused for an extended period become easier, crowning it as the "study drug."

Stimulants are considered the first-line treatment for ADHD in the U.S. As a result, close to 50 million prescriptions of stimulants like Adderall got dispensed in 2011. ADHD is one of the most common childhood neurological disorders (among 10% of children), and diagnoses have climbed more than 30% in the past eight years.

Side Effects and Abuse

A person can rapidly move from recreational use to abuse to addiction due to Adderall's addictive potential with the potent stimulant amphetamine. The known side effects of Adderall include: sleep disruption, increased risk for mental health problems (including depression and bipolar disorder), and aggressive or hostile behavior. Adderall abuse will cause a person to build a tolerance to the drug. Furthermore, to experience the desired Adderall high, a person will have to consume more. When the abuse stops, withdrawal is likely to occur with the potential experience of suicidal thoughts, mania, panic, or nightmares. For extended periods of Adderall intake, the medication will disrupt the dopaminergic system, which is crucial for mood regulation. Neurotoxicity is the ability of a substance to disturb the functioning of the nervous system or brain. There are many types of neurotoxic substances. In this case, Adderall causes the brain to remove dopamine receptors to elevated drug levels, leading to various disorders. Adderall floods the brain with dopamine to elevated levels the user cannot naturally produce. As many will start using Adderall for the high or "benefit of studying," they unknowingly sign a deal that enables long-term, permanent effects on their cognitive performance.

Spread to College Campuses

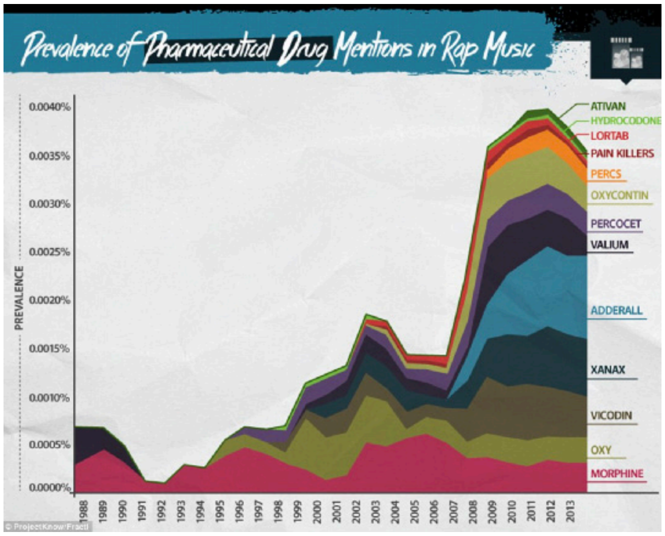
Whether students have heard talk of the drug on campus or have used it themselves, Adderall is prevalent in the realm of academics. Students claim the drug helps them focus when they stay up late studying, making it one of the most popular drugs used today on college campuses. The impact that Adderall has on studying helps explain why the most extensive age range of people abusing the drug without a medical need includes 18-to-25-year-old young adults: the prime age for a college student.

Across the U.S., nearly one in six college students now say they have used stimulants like Adderall, Ritalin, or Dexedrine, according to a national 2018 study by Ohio State University. Of the surveyed population, 21% use it for non-academic purposes. Similarly, an investigation at a Midwest college demonstrated that the following students have experimented with Adderall, Ritalin, or Dexedrine, according to a national 2018 study by Ohio State University. Of the surveyed population, 21% use it for non-academic purposes. Similarly, an investigation at a Midwest college demonstrated that the following students have experimented with Adderall as a study aid: 51% of seniors, 31% of juniors, 16% of sophomores, and 19% of first-year students. The trend seems to be that as students slowly integrate into the adult world with more workload, they come to a point where they need to rely on something other than themselves. Interestingly, the study also found that in terms of physical performance, there were no significant differences between athletes and non-athletes; recreationally, there was no difference between "Greek" and "non-Greek" students.

Furthermore, the study "Tweaking and Tweeting" took a unique approach to monitor a real-life avenue for Adderall intake, focusing on public-facing Twitter status messages containing the term "Adderall" from November 2011 to May 2012. The tweets that students with GPS data at universities posted were examined for the mention of the use and side effects of Adderall and other commonly abused substances. Results found that tweets peaked–213,663 tweets from 132,099 unique users–during traditional college and university final exam periods, most commonly in northeast and south regions of the United States. The study concluded that Twitter posts confirm the use of Adderall as a study aid among college students and possibly contribute to normative behavior regarding its abuse.

Music

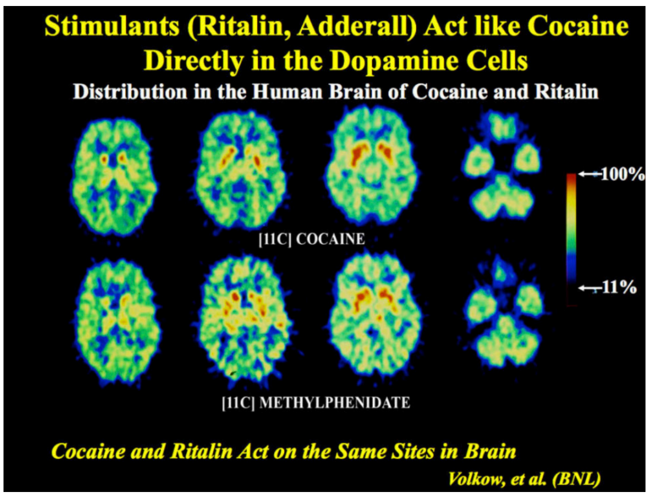
Trends have clearly shown to normalize the recreational, non-prescribed use of Adderall, and the future still has more concerns with its popularity in the Drug Slang in Hip Hop Project. Rap songs rarely mentioned pharmaceutical drugs during the 1990s, but over the 20 past years—and particularly since 2007—their prevalence has spread through analyzing published lyrics on the website Genius. Morphine and Oxycodone were the main pharmaceutical drugs mentioned in rap music before the mid-1990s. Since then, other prescription medications have become notorious for appearing in hip-hop songs, including Adderall and Xanax. Rappers such as Danny Brown, lyricist of 'Adderall Admiral,' have explained that they take Adderall to help them work. Furthermore, they have claimed that the drug helps counterbalance the often lazing effects of marijuana, reinforcing the notion to younger and older generations that taking this substance has now become a way of life. The 2021 study "A High Note: Drug Misuse in Popular Rap Musics" supports conclusions made by the Drug Slang Project as they reported the scary reality that 72% of sample-sized rap songs contain references to one or more substances. Yearly trends indicated that alcohol lyrics were declining and prescriptions were rising. The song lyrics' messages about substances allow music to reach the ears of younger populations without digital media, sparking even more, worry for generations to come.



Normalization Through Media: The Different Perceptions of Substances

Whether through the songs we hear on the radio or the tweets we vent to the world, Adderall has become normalized. Sister drugs such as Ritalin are used at the same rate as Adderall in universities (16%). Yet, it is interesting to note how one substance for increasing "academic performance" is in a better light than Mr. Escobar's similarly performing cocaine. After someone swallows methylphenidate (Ritalin), it enters the bloodstream and eventually finds the brain, where it blocks dopamine transporters and increases attention signaling. Again, cocaine acts the same way. But the two drugs differ significantly: methylphenidate takes about an hour to raise dopamine levels, whereas cocaine hits the brain in seconds. Accordingly, studies supported by the National Institute on Drug Abuse found that users of Ritalin and similar drugs “showed the highest percentage of cocaine abuse.” Because a tolerance builds up, abuse of Ritalin can lead users to consume stronger and more potent drugs to achieve the same high.

Reflecting on this course, what was once a simple inquiry of taking Ritalin to get the extra edge on a final can lead to a simple rabbit hole towards cocaine; only the public perception of the two drugs mainly differ if one will take it or not. Since cocaine is an illegal “street drug” and has a far worse media portrayal than Adderall, many steer away from it initially; However, once one tries the more socially acceptable drug, they risk reopening themselves up to the opportunity of trying other substances.



The Future

When put into perspective, we can now see how scary the misuse of Adderall and similar substances is. Especially in college, competing against the professor or class, one can easily slip by with an addiction. As no one is holding their hands compared to previous years, students are especially vulnerable and may do whatever it takes to succeed. Moreover, the future holds an even scarier reality. While the global prevalence of ADHD has remained stable, there was a 123% increase in diagnosis for U.S. adults between 2007 and 2016. Even more startling, adult women had a 344% increase in the prescription filling rate of ADHD medications between 2003 and 2015. Compared to countries such as Japan, China, or those Europe, the U.S. is between 500 - 1000% higher! Therefore, many such as Dr. James O’Keefe state, “We need to track this closely and be really careful about doses, who’s getting it, and how long they’re taking it.” Professionals at Johns Hopkins suggest that to prevent “doctor shopping,”--whereby patients get multiple prescriptions from different physicians, sometimes with the intent of selling or distributing pills–Adderall prescriptions are put into a database and monitored similarly to the painkillers crisis. While the future is scary with the increasing market control and normalization of Adderall, the next time you see someone take it “just for fun,” remember that it is a potentially dangerous key to the dark side of the mind.

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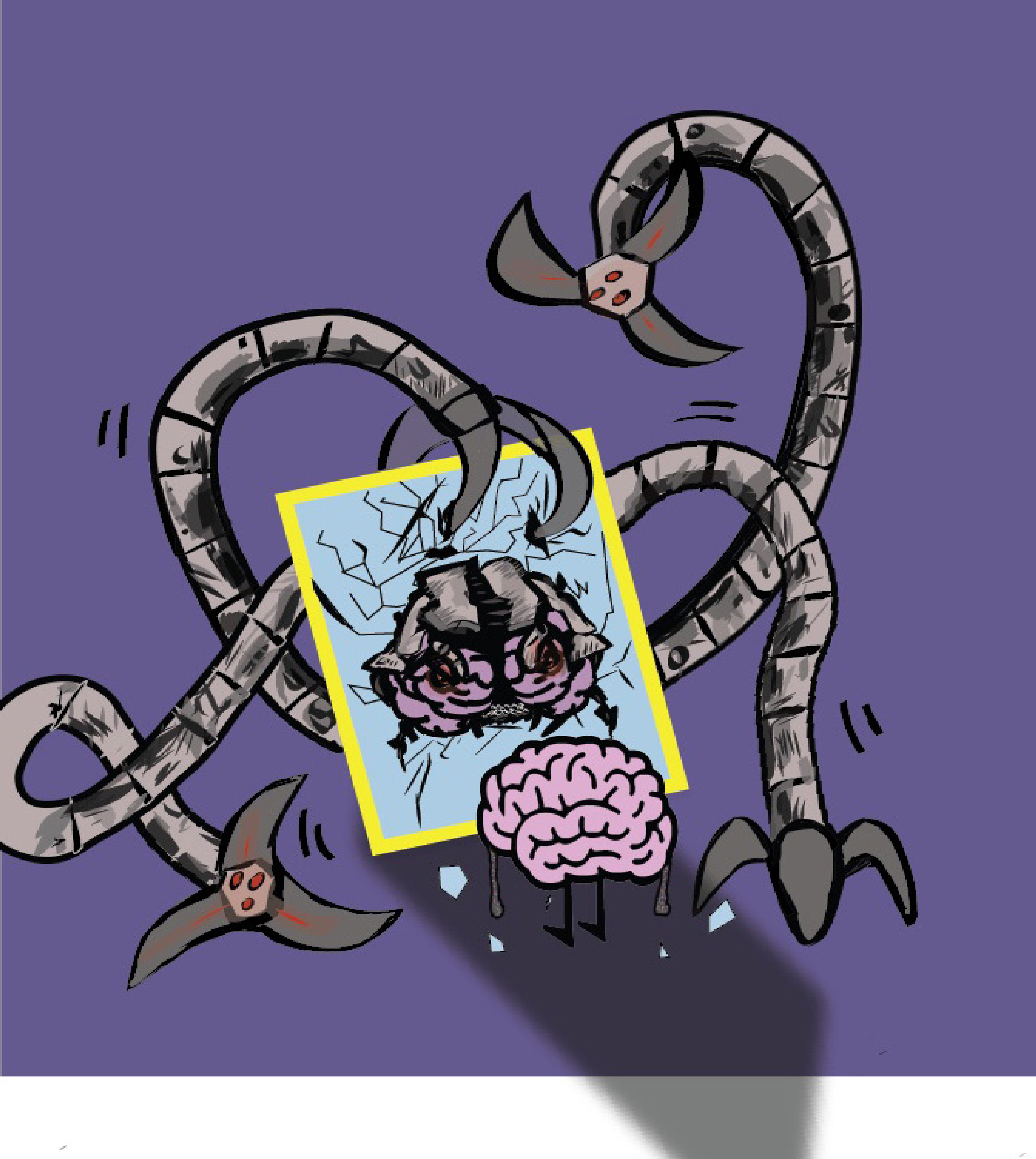


FEATURING...

Your Brain on Technology: Ceribell and EEG with Dr. Josef Parvizi

Interview by Shobhin Logani, Waleed Latif, and Hana Massab

Preamble

Welcome to Neurotalk! Neurotalk is a podcast run by a dedicated group of members in Neurotech@Berkeley, with the goal of presenting information about current events in the field in a digestible way and breaking down misconceptions in the public discourse. Our theme this semester was "Your Mind on ____.", where we explored how the brain interacts with different external forces in the context of neurotechnology. This article is an edited transcript of our first themed episode: "Your Brain on Technology: Ceribell and EEG with Dr. Josef Parvizi." In it, we have an enlightening conversation with Dr. Parvizi, the founder of the start-up Ceribell which uses an innovative rapid-response EEG system to aid in seizure detection and screening. If you want to listen to the full episode or see where to find future episodes, search "Neurotalk" on Spotify!

Introduction to Ceribell and Dr. Parvizi

Welcome back everyone. This is Hana, Shobhin and Waleed, and today we bring you Neurotalk's first themed episode: Your Brain on Technology. Combining the brain's functions with technology and computer science is at the core of neurotechnology, and we are lucky enough to have an expert here today to dive into these ideas.

Dr. Josef Parvizi

MD PhD, Professor of Neurology and Neurological Sciences, Stanford University Medical Center

Our guest today is Dr. Josef Parvizi, professor of neurology and neurological sciences at Stanford University School of Medicine. He is a principal investigator in the Laboratory of Cognitive and Behavioral Neuroscience, where his lab seeks to understand how the anatomical and the physiological basis for human behavior and cognitive experiences are affected in patients with neurological disorders, using three methods: intracranial electroencephalography, functional MRI, and intracranial electrical stimulation. He is also notable for starting the Human Intracranial Cognitive Electrophysiology Program at Stanford. Now if that's not impressive enough for you, he is also the inventor of Ceribell, a biotech company that creates a widely accessible, cost-effective FDA-cleared, portable EEG system. Their device aims to improve both the diagnosis and treatment of patients at risk of seizures in real time.

Ceribell uses novel AI algorithms and cloud technology that can enable their EEG device to detect and more precisely monitor seizures without the need of EEG technologists, or a specialist interpreter. Dr. Parvizi, we are honored to welcome you to Neurotalk.

[Dr. Parvizi] Thank you. I'm honored to be there.

[Hosts] Yeah. So before we get started talking about Ceribell and medical technology, I wanted to start just by asking you, you know, you're an extremely accomplished researcher and entrepreneur. Could you just tell us more about your career trajectory, specifically [about] crossing that gap between academia and industry as well as, like, what experiences led to a research interest in brain physiology and EEG.

[Dr. Parvizi] Well, thank you so much for your compliment. I am an epileptologist, I'm an MD Ph.D., [and] I'm a physician scientist. I went into this field combining science with clinical practice, and my research is primarily motivated by finding solutions for unmet needs in the practice of medicine and also largely speaking in the field of cognitive neuroscience. We have understood that we can't really help patients with brain problems if we actually don't know how the brain works.

So some of the basic science work that my lab is performing these days is rooted in the question of how the brain works, but the overarching goal is to find out how we can use this knowledge to serve patients who are suffering. So the code word here is really "alleviate suffering" in the realm of neurological problems.

The Musical Origins of Ceribell EEG

So, your question is really how this whole thing started.

[Hosts] Yes.

[Dr. Parvizi] So of course, we have we have our best intentions. We have our motivation, we have our goals, but many times in life-- I hope young undergrads understand-- that life is not how you entirely plan it. Many times, you have to be open to serendipity and things that happen totally unplanned.

It actually started truly in an unplanned way. I was very busy with research in the lab doing some other stuff, but then one day I was in a concert by Kronos Quartet, our Bay Area native amazing quartet. And I was listening to what they had put together-- the performance is called "Sun Rings". For those of you who haven't heard it, please do-- they got Grammy award for it. What they had done was kind of combine their beautiful artistic work with engineered sounds from NASA, and these are usually signals captured by Voyager spacecraft plasma wave sensors that are needed for NASA to know if Voyager is in the solar system, because plasma waves are generated by solar, kind of atomic explosions, et cetera. What I understand is that it basically these ones and zeros captured by plasma wave sensors of a Voyager spacecraft were turned into sound that you can actually hear. And it's incredible. It's [an] amazing experience because you think that there's just vacuum out there, but now they're playing the sound of space. So, I was there and I was thinking, oh gosh, I mean, we have a universe of our own in our head. Maybe we should really turn the brainwaves into sound and understand.

So, I asked one of my colleagues, expert Chris Chafe, to help me. He's a professor in the music department here [at Stanford] It's great to be in a place where you can just knock on the next door and they do crazy stuff. And for those critiques who think that taxpayers' money is being used for stuff that is completely useless, this guy actually took some taxpayers' money and converted [the] growth of tomatoes to sound to CO_2 sensors. He recorded from CO_2 sensors in a greenhouse and he correlated it with the growth of tomatoes there, because if the tomatoes are growing faster, then they are using CO_2 faster, et cetera. So that was his algorithm. It's actually not a joke, it's very difficult. Germans and others had tried for decades to sonify brainwaves.

But they could only do it by compacting the brainwaves by 60 times or 120 times because the brainwaves oscillate at a much slower range than your ears can hear. And if you do that, you're really losing the real time of the information. So, I'm in that concert, [and] the idea comes to me that we should really do sonification of the brainwaves and see how they sound.

And then I'm lucky that I'm in a place that I have crazy colleagues, intelligent people, professors who can help me as just a simple clinician. I asked him and then he says, "Oh yeah, I'm actually stuck in a snow storm in Canada. I have nothing to do, but we have great Wi-Fi here so I'm just working. I'm bored. Please help me." And that's like amazing feedback to get on your email, to prove that he's bold. And he wants to work with you. So I sent him some EEG's but this time I said, well, this gentleman is going to convert it. How do I know what he's doing? So maybe I should just convert normal brainwaves plus seizure brainwaves. So at least I know. And I knew exactly at which time the seizures begin. So I caught it like 50% before [and] 50% after the onset of seizures. And then a couple of days later, he replied back and says, "[the] weather is still very bad, so it allowed me to work on your project. And here it is, listen to this. It's amazing. I want to collaborate with you."

I said, wow, he already is interested! Must be really interesting. I was in my office and I still remember that day. I played the sound and at the time that I know halfway [through the sound], the seizure will come like a few seconds before the seizure that I had seen with my own eyes.

My ears could tell me, oh, shoot, something is happening. This really crazy sound of seizure I could hear [was] so intuitive and so amazing. I said, okay, we have a task at hand, so we are going to turn this into a device. We are going to give it to every doctor. They go to the bedside and put it over the head of their comatose patients to see if there they are comatose because they have so-called subclinical silent seizures which [are] known as non-convulsive status epilepticus. That was the origin. Serendipity. It's not like I was smart. I was calculated. I sat down and thought day and night how to invent a system. I come up with this method [and] I say, okay, Chris, let's create a device that will allow easy access to brainwave information.

And that is where I think students need to think carefully, because if you're really thinking about coming up with your startup or a solution, you have to make sure that you are providing a whole solution to an unmet need. You can't go 90%. You can't go 80%. It's almost like a chemical reaction. If one substrate is missing, if one enzyme is missing, good luck. You're going to basically be left alone in the Death Valley, you have to like fire your engineers after five years. So you need to have a very complete solution.

Also, you have to be very respectful to people who have been before you. It's not like you are the only genius in this world. Even Einstein didn't come with his theory of relativity out of zero. You know, there's always something in the background that enables these great thinkers to come up with a solution. So, I did some research in terms of what exactly has been available.

What happened was that I discovered that a lot of people before me have tried this sonification, and the sonification has not worked because it has kind of lost its value of real time.

Checkmark. Okay. With Dr. Chafe's help, we can make it real time. Fine. But what else is missing? Well, we need to have some sort of some sort of hardware to get the signal acquired.

So, what do you do? Of course, you start thinking about the state-of-the-art or what is so fancy and of course, dry electrodes came to my mind.

We tried dry electrodes vs. wet electrodes. For those of you who are unfamiliar, the brain produces some sort of electrical potential. And if you want to harness them, you need to have at least sensors that can do them: electrodes. And for that, you need at least two electrodes to get one minus the other, get the kind of electrical potentials, the voltage recorded.

Here's the problem. Sometimes many of [the scientists] try to come up with a solution that is fancy and glittering, and I'm like, wow, this guy is really on top of it by coming up with things that are fancy, but they are not bulletproof. It's okay to go two steps back. It's not too fancy, but it's at least robust.

And that is where we actually failed for a couple of years. We tried to be fancy-- while we are inventing this from Stanford. Come on, we can't just go with gel and wet electrodes. We need to go with dry electrodes that are fancy. The problem with dry electrodes is that you put these two metals over your head and trying to harness the voltage, but the medium is very unstable. You only have a physical contact with the head through the sensors that are dry. If you use a gel, which is the wet system, you have these electrolytes around your electrodes, and it is through this medium that you harness the volt. If your electrode moves a little bit, since the gel is still there, you don't lose the signal.

As your electrodes move within the jail, you'll be fine, but we didn't know that. So we put [in] a lot of effort to do this crazy dry electrode system. And we do have some companies that are doing fancy marketing and saying, whoa, we are the best we have dry electrodes-- yeah. Good luck. It's never going to be bulletproof because when things are done by non-experts, you know, you can go in and do a nice demo in front of people and show and impress people. But if you give a device [to] some people who [are] not very well-trained, meaning everybody in the hospital-- nurses, doctors—[they're] just doing a signal.

So we failed in our dry electrode system. Not that so we couldn't get voltage, but it wasn't bulletproof and it wasn't dummy proof. [And] when you say that it's bulletproof, it's just in terms of who can use it. Bulletproof means that is safe to be used in unknown situations, assuming that there are so many unknown parameters and also some users that are not going to follow your instruction, booklet. You [need to] know are they going to fail or are they going to be able to do it? It has to be so intuitive and so resistant to noise and resistant to the unknown parameters. You know, that's what I mean.

[Hosts] I just wanted to note how that is super important when you're talking about like clinical stuff that's going to be applied in a clinical setting, like you said.

[Dr. Parvizi] We might get into this later about accessibility, but it has to be able to [be] used by people who aren't trained and [who aren't] experts in the underlying technology. And it has to be like universally applicable. You can't just come up with a device or with a solution that only operates in the hands of trained people. You're just going to be very limited. That's not the solution.
[Hosts] You also mentioned the proprietary aspect of it was the sonification of those seizure waves. And you said it was very 'intuitive' to hear those seizure waves. I was just curious, is it intuitive for a clinician to be able to hear those seizure waves and hear it in advance before you see it? I mean, there has to be some like baseline

right of understanding to be able to realize that there's a seizure.

[Dr. Parvizi] So you don't know much about seizures, you don't know much about much about [the] clinical interpretation of EEG, but I tell you that patients can remain in their ICU bed in an altered mental state. They are nearly comatose or they are extremely altered, confabulating, delirious, not coherent, because their brain is in a seizure state. It means, unfortunately, [that] tons of neuronal populations have gotten locked into this oscillatory synchronous wave form.

Imagine, like, you are in Times Square and everybody's chanting very loudly, the same thing, the same slogan. Do you think you can have a nice, intelligent conversation with your friend? No, it's just overriding everything else.

Defining EEG and The Unmet Need

The unmet need is as follows, which we haven't covered. So about 90 years ago, Hunsberger wanted to capture brainwaves because he was a psychiatrist and he profoundly believe [in] doing telepathy and transferring brainwaves across individuals, equal transfer, mental, whatever. It's 90 years ago, I don't understand. But he came up with a way of capturing these brainwaves. Of course, he couldn't capture them on [the head]. He went to people who had skull bone defects or he took poor dogs and took the skull bone away and then put the sensors over the brain. He captured the brainwaves, it got published. Nobody cared until prominent neuroscientists basically verified his findings and published it in reputable journals. And everybody started talking about electrical philosophy. It kept going in various waves-- everybody was using it in a haphazard way. Some people were putting two electrons, some people eight. Those days were very, very depressing days. You didn't have amplifiers, so you couldn't actually get too much signal, I mean, you [couldn't] do what we are doing today. You can [now] easily acquire simultaneous information from hundreds of sensors. But [in] those days they couldn't, they had technical problems.

The maximum they could use were very few electrodes.

[Hosts] Before we continue, I think EEG is something we're going to keep referencing throughout the episode, and I just wanted to provide kind of a working definition. It's a term that I think not a lot of people are super familiar with, It's a little scary sounding, you know, electroencephalography. So, in kind of a more digestible understanding, it really just involves measuring the combined electrical activity from neurons, which are the cells in the brain that essentially allow it to do the amazing things it does.

When a neuron fires it pushes electrical signals that allow them to work together. [Because] those signals are electrical so they can produce wave patterns that can be captured, which are what most people consider brain-waves. Do, do you have anything to add to that that you think would aid someone who's unfamiliar with EEG [and their] understanding of why it's so important to the medical field?

[Dr. Parvizi] Right. So think about the head. So there are 86 billion neurons. Each neuron, as you said, works with electricity and I've created some sort of a field and you can actually see how the field is going up and down, et cetera. You don't want everything to go up and down at the same time.

That means too much synchronicity. That's the Times Square where everybody is screaming the same chant, right? So EEG is very important because many times patients can be completely altered. They are not them-selves. And it is happening because their brain has gone into this up and down, up and down together type of a state-- which is a seizure state. Many times these up and down states correlates with convulsions because your muscles are also going basically back and forth, kind of up and down in the brain, [and] the muscle also con-vulses. That's why many people think seizures are easy to see because patient has fallen on the ground and is convulsing.

But the sad truth is that [the] majority of seizures are so-called non convulsive especially in sick people in the intensive care unit. That's really, really sad. You can't identify these seizures unless you have an objective way [to do so], like an EEG.

So what happens? What's the unmet need? Let's talk a little bit about that. If you are a Berkeley undergrad, and you want to come over the solution, you need to identi-fy the unmet need. At my time, 10 years ago, when we came up with the solution, [the unmet need] was that nobody could get EEG without hiring an EEG tech [or] without buying these bulky machine.

Each of them [is like] you're buying one Ferrari one, one rig, [and] the hospitals can afford many Ferraris by the way in the United States. So you buy these bulky de-vices, you hire [an] EEG tech. If you want an EEG-- if let's say you're an emergency doctor and [the] patient has been just hauled in with an ambulance [and] has been having shaking or some sort of weird abnormal behavior-- you want to know what's going on in their head. The first thing you do is a CAT scan [to see if] there's some sort of a bleed or abnormal structure. Still, it doesn't sometimes explain why the patient is severely altered. Then, if you really want to know what's going on inside the brain, you order EEG.

What's going to happen.

You need to pay someone and that someone has to pay someone. And that someone else is a tech who's living at Fremont because techs are unfortunately poorly paid. They can't afford Atherton or Menlo Park Right, right by the hospital. (I'm talking from a Stanford-centric point of view).

What happens is that [the techs] are living in the suburbs and you're calling them at 2:00 AM. This tech has to wake up, put the scrubs on, come to the hospital, go in and get this 'Ferrari' from the closet, walk to the patient's bedside and start gluing electrodes one by one. It takes 40 minutes to set this up, but that's not the end of the game.

You have to wait for a neurologist to have access to that data and good luck with all these firewalls and everything. This tech has to cut short the recording after 15 minutes and export it into [a] hospital server and then call in neurology. And [the] neurologist may not answer the first page. You need to call them three times for them to answer. And then when they answer, this neurologist has to rub his or her eyes and then start staring at the computer to see what to do. And guess what? The neurologist has to call back the ordering physician, the emergency doctor, by that time. The neurologist calls the emergency doctor. It might be like 8:00 AM and that doctor has already left.

It's a very tragic situation as a result. If you are an emergency doctor, what would you do? If you have high suspicion that the patient is seizing, what would you do? Sit there and wait for all of this to unfold? No, we intubate and treat the patient with anti-seizure medication.
You shower the patient's brain with all sorts of anti-seizure medications in case, but that could be dangerous for them, couldn't it? It has all sorts of side effects. Let me ask you another question. You have one hundred patients like this. What percent of cases do you think [you] are truly seeking? You have high suspicion on all of them, how likely is that you will win all the 'lotteries'. You bet extremely low, right? So about 5% to 10% of the times you will be okay. But 90% of the time you will be wrong. What did you do? You just sedated my uncle, John and intubated him and sent him to ICU and he didn't need to get [intubated].

Hospitals are getting paid just one sum for the diagnosis. It's called diagnosis related group payment, DRG based payment. (And for those of you young Berkeley students, if you want to really be a pioneer and have a solution for unmet need, think about the realities. You can't really just close your eyes and hope the best.)
Currently hospitals are not being paid for all sorts of procedures. They are [getting paid] for diagnosis. You just intubated my uncle, John, and tomorrow it's going to just show that he didn't have anything. You're just going to get the little bit money from the government

[and] from payers, but you spent a lot on medications and [the] ICU. One ICU night is above $5,000.
So it's more money out of the pocket for the patient as well as the hospital. So there is an unmet need there. The hospital wants to have a device, a technology, that will reduce over over-treatment wasteful spending. And if your uncle John lives in Fresno, what will happen? They don't have EEG, good luck. Seems like in the United States, we still haven't figured out how to do [away] with disparity of care. And that's sad. Many poor hospitals can't afford anything. Do you know what they do? They transfer uncle John to this almighty Stanford and [he pays] out-of-pocket for the ambulance.

Well, let's assume that uncle John is lucky. We are in California. Let's say Medi-Cal covers all of it. But guess what? Uncle John's daughters and grand kids, plus two sons are worried about him dying. They transferred [their] uncle to Stanford before he dies. All of them basically leave their jobs behind in Fresno and come to Stanford.

Do you think they can afford hotel rooms in Palo Alto? No. What do they do? They sleep on the couches at Stanford. And let me show you some pictures I have from these tragic setting. When you transfer from poor to rich hospitals, you need to think about all of these social problems.

So that's where the unmet need is. There was a profound unmet need in multiple domains.

[Hosts] Perfect, I think we now know what the unmet medical need is. You have the description: there's over care going on, there's health disparities between where patients live and not having, you know, a more efficient and faster way of diagnosing seizures which increases mortality and morbidity.

Now focusing more on the solution, one of your technology's biggest boons is reducing wait times. A lot of the studies behind it shows that four hours was the average wait time for typical EEG-based care and your technology reduce it drastically. Can you talk more about how technology is a good solution to health disparities and unmet medical need, especially in the context of our healthcare system that has a lot of policy issues and stuff like that.

[Dr. Parvizi] Great question. Great question. So yeah, time matters. And there's a turning point as well. You can't say there's a linear relationship between time and usefulness, there is this really 'S' curve type of relationship. If you go beyond a certain limit, even 20 minutes, then it's going to really [be] not be as helpful. So that's where the ultra-fancy kind of dry electoral systems, unfortunately won't be as easy in the hands of unexperienced users [and] won't give the information within two to five minutes. It will take so much tweaking, so much troubleshooting, et cetera, in the hand of unexperienced users.

In poor hospitals, they cannot afford hiring 24-7 EEG techs and cannot have, let's say, 24-7 neurology backup, cannot have this epileptologist who is super specialized in reading EEG, --

[Hosts] I'm assuming most hospitals can't afford to have all of these things.

[Dr. Parvizi] -- in the United States of America, and let me ask you how it is in Africa.

They are human beings, they are suffering, right? You need to think about the global problem. There's a gigantic need there. And this is where technology can actually come and help the poor and help hospitals that are inefficient and engaged in wasteful practice.

What I haven't told you-- I already told you the origin of this technology starting with the sound-- but then later, of course, what happens is that if you are in the company of superbly, intelligent people-- which was the case with me.

I was very lucky-- once we start kind of forming a team, forming a group, a lot more people have to take credit for what came afterwards. I came up as a clinician with the unmet need. I came up with a very simple solution and that simple solution has gone its own way and has become better and better and better as you make your team richer and richer and richer in intellectual power. So now in 2022, we are offering artificial intelligence (AI) as part of the solution as well. AI, for those of you really thinking about career in medicine, AI is incredibly powerful and it's going to change the course of medicine [for] the better. You're dealing with unequal access to care, so you cannot afford having everything in this hospital, but now AI makes it much cheaper. AI makes it a lot more available. And our AI allows non-experts, immediately after putting the sensors on the head, we need about five minutes of EEG data to be accumulated in the cloud so that the computer can start running all sorts of algorithms and it communicates back to the device and gives the diagnosis.

So you just bought a neurologist. I'm not saying that it will replace neurologist, but you kind of got to actionable diagnostic information. And if it's a 0% chance by AI standards that this patient is seizing, then you don't need to freak out. And if it's showing hundred percent, then you know what to do.

So it kind of helps tremendously triage the care of the patient.

[Hosts] I think that's a really important point that I was thinking about when I learned about Ceribell, because I think a lot of public discourse is about how technology and neurotechnology can be used to cure or diagnose diseases. But I think what's as important, what I think you've pointed out is just even triaging, even just screening patients so that we don't overload providers with hundreds of patients that don't need to be there is a really important aspect of this whole thing.

[Dr. Parvizi] Yeah. And AI doesn't take vacation. It's very easy. It's always there and you can actually have the AI monitor the brain function while you as a doctor go and sleep and you have programmed the AI to call you if something wrong happens. You go and sleep with great peace—in the morning you come back. If something happened in the middle of the night, AI would call you, it would wake you up.

And this is what Eric Topol is talking about, that AI will make medicine human again so that we doctors are less overburdened with all sorts of crazy stupid menial tasks. AI saves a lot of time for us to rest, take care of ourselves and then pay it back in terms of being present with the patients.

[Hosts] I did want to ask you, Dr. Parvizi, as someone who grew up in a third world country, what efforts is Ceribell taking to globalize this product and make it accessible to areas that are harder to reach or not technologically advanced or don't have much access to electricity. Because there's a lot of promise by biotech and neurotech companies that say, oh, we're going to make life better, we're going to make life easier for all. But who exactly are you talking about? People in the Bay Area, people in America?

[Dr. Parvizi] I think many people going to medicine go with idealistic goals in their mind, me included. We need to help those who are really suffering from a clear disparity of care in the United States.

Definitely community hospitals and smaller hospitals are clearly on the map for this. Outside the United States, in countries that you mentioned-- third world, I don't like to use the third world-- but in countries where they are not hugely industrialized like us, clearly this has a way to perform.

We cannot globalize at this very early stage of our startup. We are hoping to go public soon. Once that happens with more secure plans ahead of us, we can definitely globalize.

[Hosts] Thank you for that. And I think that gives all of us like a direction of where companies such as Ceribell are heading towards. I know we're almost out of time, so we did just want to end [with] one last question if that's okay with you.

Addressing Ethical Concerns and The Future of Clinical Neurotechnology

One of the unifying themes of this podcast is to think about what the public is talking about in terms of neurotechnology, what the discourse is, and what research is being done behind the scenes and studying brainwaves, which is done through EEG, has a lot of connotations, especially with a lot of neuro technology companies becoming so prominent.

There are ethical concerns about incorporating devices into your brain. Ideas like mine control, behavioral manipulation, scary sounding things, being able to understand private thoughts. We had already discussed accessibility and inequity concerns, but where is the future of this kind of field heading in terms of addressing some of those more ethical concerns or privacy concerns that people have?

[Dr. Parvizi] Yeah. Yeah. I think when we talk about neurotech brain devices, unfortunately some of us have a tendency to go the slippery slope way. This is a well-known, slippery slope argument that used to be very, very, very prominent during gene technology. Oh my God, now the gene technology comes, we are going to clone each other. We are going to modify genes back and forth, et cetera, et cetera, decades have passed. No, we didn't do it. You know why? Because we are not really just free chickens following each other. We are a society with rules. We are societies with law. and we are societies with intelligent critical minds. They are watching us and they should be watching us. When you talk about brain tech, people think about, oh my God, mind reading devices. Come on, slow down. There will be probably decades before we actually even understand how the brain works and reading mind is not as simple as the novice people think, or as Elon Musk pretends to know.

That's not the case, it's going to be extremely difficult to jump to those type of unethical uses of technology. Right now, Ceribell provides an example of how technology can fill the gap in places where there's a huge disparity of care. It also helps us appreciate how technology will save healthcare from overspending and wasteful, inefficient expenditure. And it's helping us understand how it really elevates the quality of life of physicians. It also creates precision in the care of patients, et cetera. But it's good to have people who are watching the progress of technology, and rest assured there will always be people that will start the dialogue whenever we start diverging from the course.

[Hosts] By that same token, that's why we thought it was so important to have things like this podcast to just educate like the general population about the implications of industries like neurotech. Oftentimes it's easy to jump to these conclusions, like you mentioned, and go down that slippery slope. So we really appreciate you talking to us.

[Dr. Parvizi] My pleasure.

Contributors

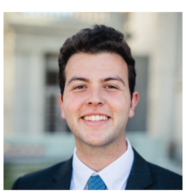
Aneal Singh | Author
Aneal Singh is a freshman studying Molecular and Cell Biology. He is fascinated with unraveling the complexities of cognitive development, especially in reference to chronic brain disorders and neuropsychopharmacology. In his spare time, he will be seen at the beach as a SoCal native and DJ for local SF venues under the name $noozzz.

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

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

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

Haya Halabieh | President and Design
Haya Halabieh is a junior majoring in Cognitive Science and Applied Mathematics. She has helped shape the introductory level neurotechnology material taught through a Decal at UC Berkeley and hopes to continue academic pursuits of neurotechnology in the future. She enjoys spending time crafting curated playlists on her Spotify and jamming out to live Indie Rock bands. She hopes to continue exploring the insight to the human brain through a technical lens in her future



Jacob Marks | Publications Lead and Editor
Jacob Marks is a junior studying Cognitive Science and Data Science at UC Berkeley. He loves learning about the brain and will be interning at the National Institute of Neurological Disorders and Stroke over summer 2022. While not in class, Jacob enjoys playing for the Cal Club Golf Team, rooting for his hometown Los Angeles Dodgers, and spending time with his dog. He is looking forward to continuing as one of the Publications Leads next semester and hopes to pursue neurology after undergrad.

Mary Shahinyan | Author and Editor
Mary Shahinyan is a junior studying Molecular & Cell Biology: Neurobiology and Theater at UC Berkeley. She is passionate about neurobiology, affective science, and cognitive development. From delving into human behavior on-stage via performance to studying the neurological and anatomical basis of behavior via research, she is constantly expanding her knowledge of the human brain and behavior. Outside of academics, she enjoys singing, acting, spending time

Megan Lui | Design Lead
As a sophomore studying Molecular and Cell Biology (Neurobiology) and Cognitive Science at UC Berkeley, Megan Lui is passionate about neurodegenerative disease progression and neural mechanisms of cognitive reactivity. Megan has worked as a research assistant on a multitude of projects that explored neural pathways in mice with Alzheimer's, blood flow patterns in children with plagiocephaly, cognitive symmetry bias in children, and polysomnography studies for the elderly. She hopes to apply her passions of research and Neuroscience in her pursuit of becoming a physician. Outside of school, Megan enjoys playing tennis, jamming on the guitar with her roomies, exploring new cafes, and testing the limits of friendships with unbearable puns.

Meltem Su | Author

Meltem Su is an undergraduate student specializing in Molecular and Cell Biology. Her experiences living in large and dense cities such as New York City and Los Angeles has always made her curious in understanding how cities are able to sustain themselves. Through her research and curiosity, the question "is it better to be feared or loved?" seemed to be the right question in understanding the complex systems involved in cities.

Oce Bohra | Author

Oce Bohra is a second-year student studying Molecular & Cell Biology and Cognitive Science. Outside of school, she loves reading psychological thrillers, falling on her face while rollerskating, and studying cool viruses in the lab.

Sameer Rajesh | Author

Sameer graduated in May 2022 with a degree in Molecular and Cell Biology. He's had an absolute blast of a time working with the NT@B community and publications the last few semesters, and he's excited to see what they do next. Currently, he's in his gap year applying to medical schools.

Shobhin Logani | Neurotalk

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

Waleed Latif | Neurotalk

Waleed Latif is a junior at UC Berkeley studying Computer Science and Cognitive Science. He is particularly fascinated with the mechanisms that the brain uses to modulate our day-to-day decisions, and the interplay between human brains and artificial ones.

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