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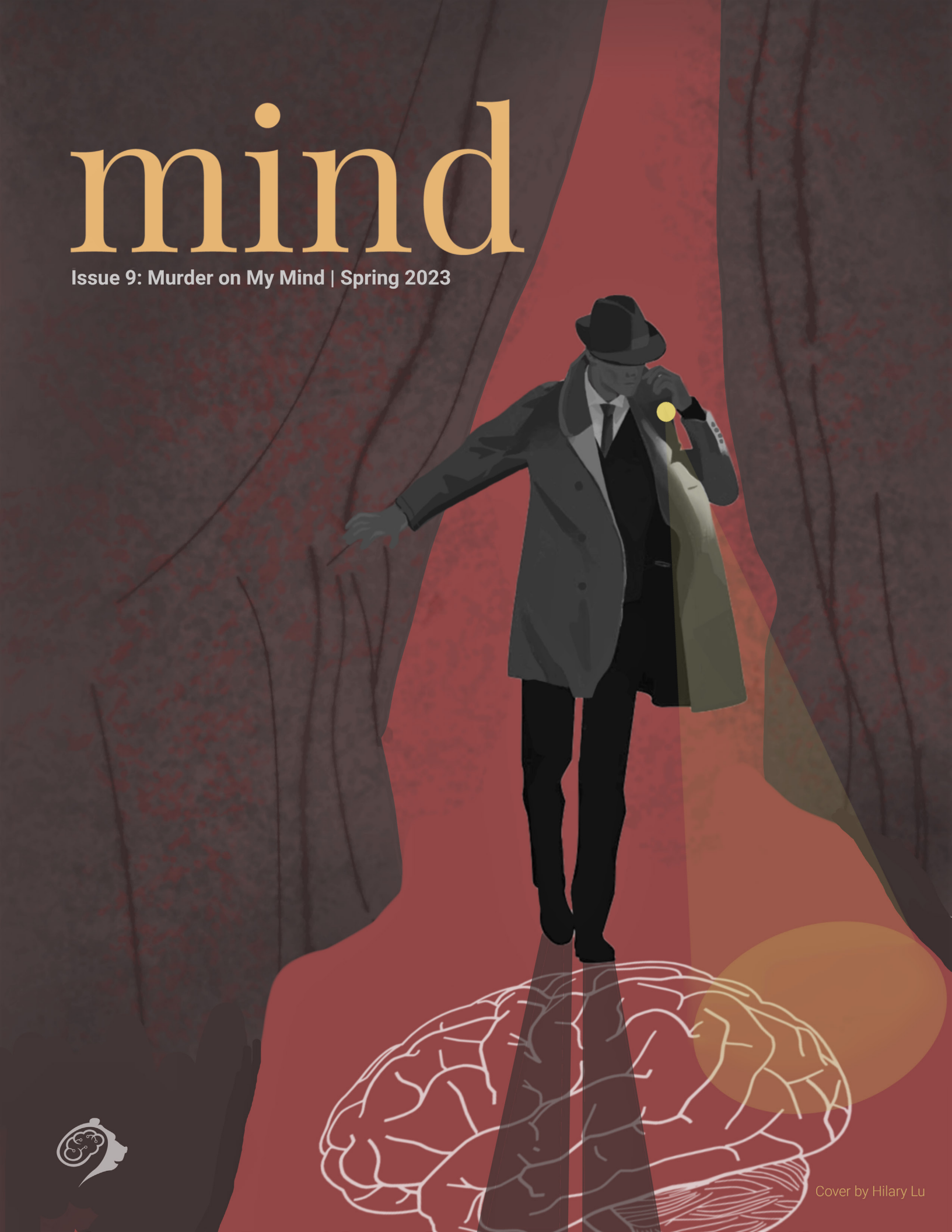

Cover by Hilary Lu

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Formatting: Hannah Corr

Letter from the Editors

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

Happy reading!

Best,

Shobhin Logani
Jacob Marks
Editors-in-chief, Spring 2023

**** Disclaimer: This article includes a few mentions of violence, child pornography, sexual assault, and other serious topics. Please feel free to skip this article if these subjects make you feel uncomfortable in any way.**

What Often Goes Unseen by Parvathy Nair

I'm sure many of you, at some point in time, have watched at least one episode of a true crime documentary or a suspenseful mystery show. Most of these series tend to follow a similar plotline: after the case is introduced and the clues are laid out one by one, the sharp, earnest law enforcement protagonist uncovers a key clue and leads their team straight to the criminal. In the end, the perpetrator is caught, the victim's family is given closure, and more often than not, the case is neatly wrapped up. Much of the focus during these series, however, is specifically placed on the perpetrator and victim. What these shows and their viewers often disregard is what happens to the people involved behind the scenes: the medical examiners, crime scene investigators, and even the therapists who counsel grieving family members. How are they affected by the gory crime scenes and tragedy they are exposed to daily? How do they learn to cope with the constant influx of death, uncertainty, and trauma that engulfs their jobs, well after their case is relegated to the books?

"I think I'm quite prepared, I'm quite resilient for it. What I didn't prepare for, I wasn't ready for was the fallout afterwards in terms of the psychological impact it had on me. Because I'm quite resilient but I found that very tough."

Oftentimes, crime scene investigators, police officers, and other law enforcement agents are forced to witness the aftermath of horrific, violent crimes while collecting evidence or reconstructing exactly what happened at the scene of the crime, whether that be a murder, manslaughter, suicide, or sexual assault. In most cases, crime scene investigators' trauma is not caused by one specific event or case: rather, it may stem from a buildup of cases over time. Although some law enforcement officers (LEOs) do experience direct trauma by witnessing or going through a traumatic event directly—for example, being shot by a suspect or seeing a colleague get shot in front of them—what occurs more commonly is when a LEO experiences trauma indirectly. Indirect trauma can result from conducting routine law enforcement work, such as being involved in the investigation of a crime or having to inform families of the death of a child or close relative.[1]

One recent example of large-scale indirect trauma experienced by first responders is a now infamously tragic event: The 2017 Manchester Arena Bombing. On May 22, 2017, twenty-two people were murdered and over a thousand were injured at the Manchester Arena following a brutal, senseless terrorist attack. The police officers who were working on the night of this attack reported that the most distressing part of the investigation was not witnessing the chaotic aftermath of the attack itself—rather, it was informing parents that their children had been murdered.[2] In addition, a study performed in 2021 found that many officers working on the night of the incident felt "unprepared for the stress and trauma they experienced after responding to the Manchester Arena Bombing." This feeling of 'unpreparedness' is prevalent throughout the study: officers also reported feeling unable to manage their own emotional reactions, much less provide emotional support to traumatized patients and families. Despite their extensive experience in trauma management, responders found "dealing with ballistic injuries—an unfamiliar type of injury— incredibly distressing."[3] Although these officers know such duties are required as a part

of their jobs, they can nonetheless take a toll on their mental health and alter their ability to cope in safe, healthy ways. First responders and LEOs are not robots without emotions—while many people assume that they are used to dealing with these situations and can brush them off easily, this narrative only contributes to these professionals' mental health struggles being overlooked or ignored.

Certain types of crimes can also affect these professionals more severely than other types. This is especially true when dealing with cases involving child pornography and child homicides—investigators who pursue child sex crimes have been found to experience disproportionately high rates of depression, stress, and turnover. This effect extends to not just those at the physical scene of these crimes, but also those who monitor the internet to prevent them. Digital forensic technicians, who examine image and video files containing child pornography in order to determine the severity of the crime, have also been found to be negatively impacted by their work.[1]

A study performed in 2016 in the UK investigated the effects of child homicide cases versus adult homicide cases on investigator wellbeing through an online survey. Ninety-nine homicide investigators taking the survey were asked questions related to what they experienced while working on both adult and child homicide investigations, such as pressure to solve the case, sleeping patterns, intrusive thoughts regarding cases, and the effect on their personal and social life. Researchers found that even experienced investigators felt that investigating child homicides had "greater negative effects" on their personal well being than adult homicide cases did. Specific examples of these effects included "higher levels of intrusive thoughts, more negative emotional reactions, higher perceived levels of investigative complexity and more pressure to resolve the case satisfactorily."[2] It was also found that the amount of experience investigators had in their field did not lessen the negative impact that child homicide investigations had on their wellbeing. In other words, even the most experienced investigator was just as susceptible to the same level of emotional harm as a less experienced investigator.

During the Manchester Attack, police officers reported being especially distressed by severe bomb-related injuries in children, along with the knowledge that these injuries had been purposefully planned and inflicted. These severe stress responses that result from working on these cases may lead to "behavioral changes, absenteeism, fatigue, anxiety, and feelings of worthlessness." [2] The officers' intensified responses towards such cases may have something to do with feelings of instinctive protectiveness towards children as opposed to adults, as it is more difficult for children to defend and protect themselves in dangerous situations.

These high levels of stress, anxiety, and trauma may result in actual long term medical conditions that can impact law enforcement officers and investigators for the rest of their lives. Many of these health conditions are placed under the general umbrella term Vicarious trauma (VT). There are several terms used to describe VT, which include secondary traumatic stress (STS), compassion fatigue (CF), burnout, and post-traumatic stress disorder (PTSD). Secondary traumatic stress refers to the emotional distress one experiences after, for example, intimate exposure to details of particularly violent events or working with someone who has experienced severe trauma. STS differs from PTSD in one key aspect: STS occurs after indirect exposure to traumatic events (such as delivering troubling news to someone, hearing a patient's stories, or observing someone else going through intense emotions), while PTSD occurs after direct exposure to a traumatic event.[4]

Six months after they assisted families of victims from the September 11th terrorist attacks, New York Police Department (NYPD) police officers were assessed for VT. At the end of the assessment, it was found that 1 in 5 of these officers experienced symptoms of post-traumatic stress. Yet, a very small number of these officers actually sought treatment for themselves. A similar pattern has been found in clinicians and physicians who develop personal relationships with a sexual assault victim to establish trust.[4] Another study on CSIs performed in 2014 measured the psychological impact of traumatic events using physiological data. The CSIs' heart rate variability was collected through a monitoring device, and their activities were categorized as either administrative, driving, physical activity, breaks, and on-site activity. Results indicated that the CSIs' heart rate increased above a resting pace while they were on-scene. This suggests that these CSIs experienced a stress response during their routine job roles. Factors such as the presence of a victim, social isolation, and working in unsanitary conditions may have affected this data as well.

Trauma can also impact LEO's by changing the way they form and maintain close relationships, whether that be with romantic partners, children, friends, or co-workers.

According to Brady et al. (2018), LEOs often become extremely "overprotective of their children and increasingly cautious of those who interact with [them]." Multiple LEOs have also expressed concerns about "not being emotionally available" to their partners and families.[5]

While there is a huge amount of evidence indicating that CSIs and LEOs jobs are incredibly mentally taxing and stress-inducing, many of these professionals do not seek out therapeutic support or help due to the negative stigma surrounding mental health and therapy in their field of work. Many police officers, for example, fear that they will lose their position or job if they are deemed unfit for duty through psychological evaluations indicating STS or PTSD.[1] As a result, they may turn towards unhealthy coping mechanisms such as alcohol and drug use, isolation, domestic violence, and suicide.

Formatting/Design: Emma Cao

Resources for Help and Support:

Although these officials may sometimes be reluctant to reach out and receive help, mental health treatment can help these officers cope with their trauma and stress in healthier ways. There are several agencies that provide therapy, support, and counseling for CSIs and other law enforcement officials who are exposed to traumatic events frequently. Some examples include:

Employee Assistance Programs (EAPs): Many law enforcement agencies offer EAPs, which provide confidential counseling services to employees and their families. EAPs typically offer a range of services, including counseling, referrals to outside resources, and educational materials on mental health and wellness.

Critical Incident Stress Management (CISM) programs: CISM programs are designed to help first responders cope with the emotional and psychological impact of traumatic incidents. These programs may offer individual or group counseling, peer support, and other services to help individuals process their experiences and develop coping strategies.

Police Benevolent Associations (PBAs): PBAs are organizations that provide support and advocacy for law enforcement personnel. Some PBAs offer counseling and other services to members, as well as assistance with legal issues, insurance, and other benefits.

International Association of Chiefs of Police (IACP): The IACP is a professional organization that represents law enforcement agencies around the world. The organization offers a variety of resources and training programs for law enforcement personnel, including resources on officer wellness and support for agencies developing mental health programs for their employees.

Without professional intervention, these officers may resort to maladaptive and avoidance style coping methods and enter a cycle of harmful behavior.[1] It is important for LEOs to develop healthy coping mechanisms, such as communicating their feelings with trusted family members or professionals, having interests and hobbies outside of work, and exercising regularly. Understanding that their mental health struggles are valid and treatable is an important step towards these professionals reaching out and receiving help. Lastly, on a personal note, I want to make it clear that in writing this article, I am not trying to take attention or focus away from the victims of direct trauma and crime. Rather, I hope this piece has helped shed some light on a group whose work we often forget to consider, and whose involvement with the worst of crimes in society often lasts far longer than our memory of the events.

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"The Shining" - Using Light to Maim Memories

By: Aileen Xia

"Who are you?"

A jarring voice through a radio just the size of an alarm clock fills a windowless office room. A young woman in work attire sits on the floor. She has just spent the past minutes desperately trying to escape the room, all while fighting the confusion in her head. Still clouded with panic, she refuses to answer the question.

The voice repeats itself:

"Who are you?"

This time, the woman replies with a scoff. What a simple question. But soon her unamused attitude is engulfed by fear. She spends a few more minutes looking for the answer to the question she should know. Her eyes dart quickly from left to right as she begins to stutter. Somehow the answer has escaped her mind, leaving only empty shadows of the memories that were once there.

"I don't…." She trails off. (Erickson et al., Good News About Hell 2022)

The opening scene of the thriller TV show *Severance*[1] sheds light on the terrifying possibilities of memory-editing technologies. Later in the show, it is revealed that the woman in the office room is an employee of Lumon Industries, a biotechnology company testing a pilot program that could separate work memories from personal ones.

Many viewers watch this show for entertainment, sitting in the comfort that exploitative technologies like those used by Lumon Industries are science fiction. However, innovative uses of optogenetics in the brain provide a glimpse of similar potentials to manipulate memory. Although not quite as sophisticated as the one in Severance, neuromodulation technology is quickly progressing. In fact, there have already been studies on mice where scientists could control the retrieval and response of certain memories.

How are memories created? What are memories?

In order to understand how optogenetics manipulates memory, it is important to learn how they are created and stored. Memory creation involves 3 different stages known as encoding, storage and retrieval. Encoding involves taking in information from one's surroundings through their senses. Following this stage, storage and consolidation of the memory will dictate what type of memory it will become. Different types of memory – short term, long term, working – involve different parts of the brain.

The strength of a memory is what differentiates a long-term memory from a short-term one. One of the main factors that facilitate memory strength is a process known as neural plasticity. Neural plasticity is the brain's ability to manipulate how often and how well neurons connect through their physical properties.

Repetition of a particular memory will better connect specific neurons, making recollection easier and the memory stronger. This process is called long-term potentiation (LTP). The growth of these neurons forms something analogous to a "tree branch" of neurons. In contrast, when a memory is recalled less, the connections between the neurons become weaker, and the memory begins to fade. This is known as long term depression (LTD).

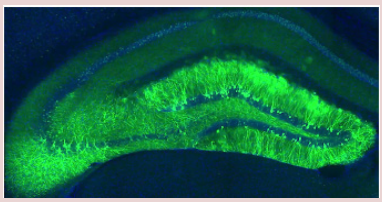
An easier way to understand long term depression and potentiation is to think of two neurons like two people in a room. These two people are separated by a curtain, which acts like a synapse – the space between two neurons. When you recall a memory, a voltage is passed

[1]Some details of the scene were omitted for the purpose of adapting it to the article writing structure.

Formatting: Hannah Corr

down a neuron, causing neurotransmitters to release from one neuron's axon to another neuron's dendrite. This is just a fancy way of saying that the end of a neuron releases signaling compounds to another neuron's start. Recalling a memory is like drawing the curtain back and having the people talk to one another. During long term potentiation, the memory is recalled often and the "curtain" is drawn back more frequently. With each interaction, the two 'people' are more familiar with one another, and thus become more willing to talk to one another, soon becoming 'friends.' Now take the analogy with the opposite situation, where a memory is recalled less. The two people stay separated by the curtain for long periods of time, and soon they become strangers. The next time the memory is recalled, the curtain is drawn back, and after many years of not seeing one another, the two neurons interact almost awkwardly, leading to a feeling of a "rusty" memory.

Because memories cannot be seen when they are recalled, it's easy to believe that they're elusive and intangible. However, memories are believed to live within physical spaces in the brain. It is not simply a puff of air in your skull - that would kill you - but rather an organized combination of parts of the brain, firing together. This network of neurons firing is known as the memory engram, coined by neuroscientist Richard Semon. The existence of the memory engram means that scientists can pinpoint the areas where neurons will fire when a memory is recalled. This means that it could be possible to see a memory in a picture, or "hold" a memory in your hands. If we can interact with a memory like we would any normal day object, like a tennis ball (although I don't recommend hitting your hippocampus with a tennis racket), it also means we can access and manipulate it. This is where optogenetics comes in.



Picture of what scientist Steve Ramierez calls a "cross section of a memory" (TED, 2013).

Memory Carving - Optogenetics

So far, the neurons that are associated with memories can only fire when the individual recalls that memory. However, since memory is tangible, it cannot escape the hands of neuromodulation technology. One of the most precise versions of neuromodulation technology is known as optogenetics. Optogenetics involves the process of injecting light sensitive proteins known as opsins (Ferenczi et al., 2019) into organisms via viral vectors. This creates genetically modified cells that are sensitive to light. When researchers use this method to target cells in the brain, they can use light to control when neurons fire, effectively "turning on" or "turning off" memories without a voluntary action by the subject.

A famous study done by researchers at MIT used optogenetics in order to "reopen" a memory to manipulate it (Ramirez et al., 2013). This was a demonstration of tampering with the encoding and storage phase of memory formation, resulting in an inaccurate recollection of a memory. The study involved editing a mouse's memory, and observing its fear response which could be characterized by a visual "freeze" in body language.

The researchers first genetically modified

Design Artwork: Emma Cao

the neurons located within the mouse's hippocampus (footnote about which specific ones), using what is known as ChR2-mCherry. This jumble of letters and numbers make up a protein that is both sensitive to light (the previously mentioned opsins) and can glow red when a blue light is directed at them. This powerful technique allowed the researchers to activate specific neurons while also seeing them,

As the mouse explored box 1, the researchers 'tagged' the neurons that fired. This was so that they could specifically identify which neurons were associated with the exploration of box 1. In the second box, the researchers then artificially "turned on" the memory of box 1, simultaneously sending electric shocks to the mouse while it was in box 2. When placed back in box 1, the mouse froze, hinting that it was expecting to receive an electric shock. This was a strong indication that although the mouse never received electric shocks in box 1, it remembered that it did.

Researchers have also found a way to manipulate a mouse's emotional response to an environment through altering its "memory valence." Memory valence is what a subject associates emotionally to an event. For example, a memory that elicits a fear response could be 'blended' with a positive memory, effectively decreasing the fear response when exposed to the same environment. This 'blending' occurs when scientists disrupt the consolidation of one memory with another.

In a study done in 2022, scientists tested this theory of memory valence manipulation on mice. This consisted of mice being fear conditioned in a box by electrical shocks. What the researchers found was that reactivation of a positive memory during memory reconsolidation resulted in a reduction in freezing. The researchers note that the results of the study "points to the dDG as a potential therapeutic node" in order to "suppress fear" (Grella et al., 2022). This suppression of this fear could mean those suffering from these mental conditions could prevent the effects of negative experiences permanently. The findings of this study are monumental, as they provide possible glimpses of revolutionary treatments for post traumatic stress disorder (PTSD) or other mental conditions that involve intrusive and abrasive memories.

The conclusions of these studies set the stage for optogenetics to be considered for human use to treat any and every pathological disease involving memory. There have already been studies that found activation of certain receptors in the brain enhance memory in mice with Alzheimer's disease. Other studies are soon to follow. Optogenetic applications to the brain can be innovative, precise, and effective. However, transition to human use would open up discussion about inherent consequences, and there could be many.

Tampering With Memories, Tampering With Identity.

Optogenetics taps into the world of memories, something that has always been inalterable and somewhat hard to control. However, it's important to consider the possible effects of this new technology. In contrast to its therapeutic outlook, optogenetics also has potential for misuse and exploitation.

To avoid the dystopian example observed in Severance, it is necessary to consider the consequences of this powerful memory editing tool.

Dr. Adamczyk and Dr. Zadwaski have opened ethics discussion surrounding optogenetics, emphasizing that it is important to "think ahead and act proactively rather than reactively" so that we will have enough discussion surrounding the technology to "fall back on" (Adamczyk and Zawadzki 2020). Memory itself serves as the foundation for self identity. It is an encyclopedia that contains information about anything and everything in our lives. Memory is the only way we interact with our past, and it informs us on how to act in the present.

Take, for example, the situation presented by

Dr. Glannon (2011). His example talks about a young academic (let's name her Ariel) who must perform a speech. The speech goes terribly, leaving Ariel with an embarrassing memory. In the absence of optogenetics, she must live with this memory and hope to do better next time. Determined to never embarrass herself again, Ariel spends hours honing skills necessary for a successful speech. She fixes what she remembers went wrong (which are also stored as memories) and practices her speech many times. She succeeds the next time she presents. Ariel has not only used her past memories as stepping stones to lead her to success, she also has learned the importance of resilience and perseverance in the face of adversity.

However, take the same situation but with optogenetic technology. This time, Ariel feels that her failure is too humiliating, and decides to erase the memory of the failed speech. What results from this? Ariel will inevitably make the same mistakes once again, and with each botched speech and erased memory, she makes no progress and remains oblivious as to why. The loss of this memory removes the beneficial value of failure.

Our sense of morality and logic also rely on our recollection of experiences through memory. Dr. Adamczyk and Dr. Zadwaski present an example of a soldier's experience in war. They discuss outcomes of treating a patient with PTSD through altering their memory valence. The veteran, who initially felt their experience in war was traumatic, instead associates it with a positive feeling. This association "may alienate a soldier from society as his/her reactions appear inhuman to third-parties" and the soldier could "develop a disposition to take pleasure in recalling his inhuman acts" (Adamczyk and Zadwaski, 2020). Manipulation of memory valence fundamentally alters the way we judge every single decision and event in our lives. Shifting the soldier's memory valence will permanently affect their sense of judgment, for they will go about their life remembering the days spent in war felt like weekends spent in the Bahamas. Scary, right?

The example above no doubt brings feelings of discomfort, a creeping sense of a world straight out of a dystopian novel. This is because editing the way in which we react to events can create opportunities for extreme and unopposed exploitation. For example, social change is driven by discontent with how current society operates. A marginalized group might have memories of prejudiced experiences, and thus wants to eliminate these instances through education and structural change. What if, to maintain the prejudiced status quo, a despotic government uses optogenetics to associate racist encounters with positive feelings? To many, this method of addressing discontent would be unethical and extremely surface level. Eliminating a structurally racist form of government now sits in the background, eclipsed by methods not to target the problem at its source, but instead to control the reactions to that problem.

Memory editing can become a slippery slope, where people start to develop inconsistent associations between how they felt and the actual experience, like associating hostility and aggression as delightful or pleasant. It forces us to question the possibility of optogenetics destroying our sense of humanity, and thus "murdering" our idea of self-identity.

Neuromodulation technologies are polarized in their potential. However, one thing remains constant: whether they are used for benevolent or malicious purposes, they fundamentally alter the story of our past. We are endowed with the power to reach into our minds and completely rewrite the stories that have shaped us. This potential slicing and dicing of memories forces us to question where we draw the line between ourselves and our memories, or is there even a line between the two?

It is no wonder Lumon Industries began by asking the woman a question about her identity. They knew that to assess whether they successfully manipulated her memories, they had to understand changes in her sense of self. This is because when we change memory, we inherently lose the ability to properly judge

our past experiences and to build ourselves and our personalities from them. Introducing possibilities to permanently alter the self-identity, to manipulate, twist and bend it in ways against nature, to maim and injure it, forces us to question, who are we? Who are you?

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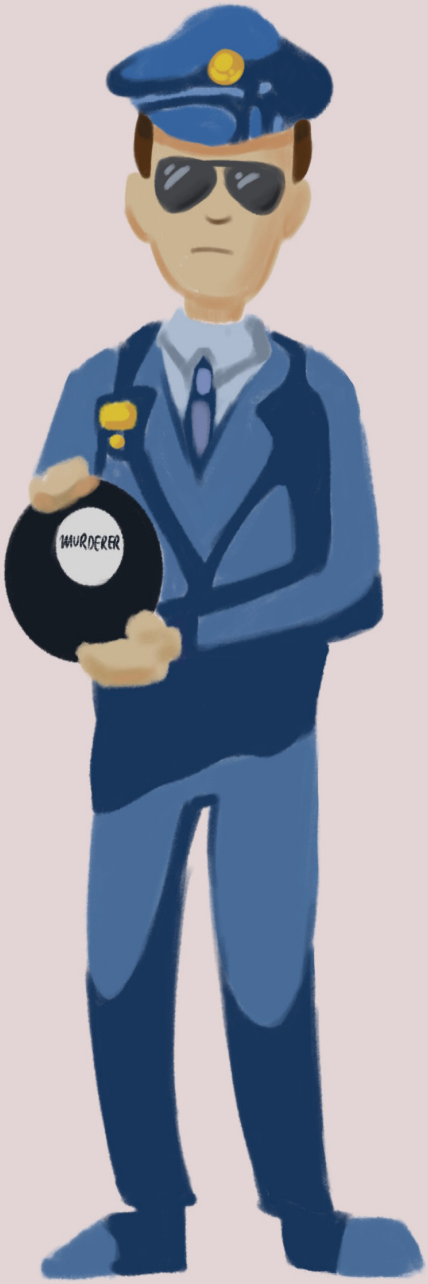
We Found Murder on YOUR Mind

By: Ryan Wu

Do you have a family history of homicidal behavior?
Do you have abnormal gray matter?
Do you have violent tendencies?
Have you committed a homicide?



Formatting: Hannah Corr
Design Artwork: Emma Cao

If you got a 100% on this quiz, bad news- statistically speaking, you might be a murderer. A simple questionnaire clearly is not enough to accurately assess someone's potential to be a criminal or murderer- the average murderer likely would not mark that they have committed their crime, and the other questions are circumstantial at best. But what if there was a test or algorithm developed on the premise of empirical data to accurately predict a person's potential to commit a crime against humanity? This potentially not-so-distant future leads us to think: would all crime and homicides end before they begin? Would it be worth living in a dystopian society?

Given the long-standing popularity of the movie and novel The Minority Report, it is clear that these questions reside in many people's minds. In the story, pre-crime chief John Anderton utilizes the psychic abilities of the supernatural "precogs" to view the impending future of a meditated murder. By doing so, the pre-crime unit is able to prevent homicides and premeditated murders. The proven success of the precogs becomes an unchallenged truth- until Anderton's entire life flips when it is envisioned that he will soon commit a premeditated murder.

Now consider artificial intelligence- is this our society's manifestation of precogs? The untapped potential of artificial intelligence and predictive policing gives insight into the possibility of a society completely rid of crime and murder. The development of a murder-detecting algorithm opens the door to a plethora of pressing ethical concerns regarding the design process and the ramifications stemming from its societal application.

Murder: A Predictable Activity?

Murder is defined "as one person killing another person with malice afterthought"[1] and is equivalent to illegal homicide. In 2021, the number of homicides per 100,000 people in the United States was 7.8, corresponding to 26,031 deaths caused by homicide[2]. Why are there so many homicides and is there a way to stop them?

Fully understanding what goes inside the mind of someone who has killed another person, whether it be intentional or not, has proven to be complicated. But neurotechnology has proven that it has the capabilities to help bridge this gap. In a study utilizing MRI and other modern brain technologies to study convicted individuals, the researchers contributed to a foundational understanding of developmental and physiological factors that could contribute to violent behavior. The results of the study showed that there were "widespread reductions in gray matter affecting brain regions involved in emotional processing, behavioral control, executive function, and social cognition."[3] Interestingly enough, the differences in brain composition expressed by homicide offenders were not directly attributable to differences in other variables such as age, IQ, psychopathy, substance use, or even duration spent in prison. This demonstrates that there could potentially be a statistically significant difference between the neuroanatomy of murderers and non-violent individuals. If future studies repeatedly arrive at and reinforce this same conclusion, then the implication is that there is a biological difference in murderers. As a result, the development of a predictive algorithm will have a strong biological basis and likely ignore many other impactful environmental factors. By disregarding other important factors, it opens up the possibility for this algorithm to form more inaccurate predictions. A single brain scan could be sufficient evidence to falsely prove someone guilty without even the slightest regard for their upbringing and other environmental factors. Given the impact of this study as a revolutionary first step closer to the possibility of a dystopian future, it once again forces us to reflect on just how far away that future is from becoming a possibility.

A Slippery Slope

With studies such as this having the potential to spur the development of a murderer-detecting algorithm, it is obvious to see room for both widespread fear and opportunity. In theory, if such an algorithm were to exist, it could have a tremendous positive impact on society because it could help improve the current state of policing. If developed with an unbiased algorithm and trained on an unbiased dataset, this technology could accurately predict a murderer or homicide offender and stop them before they have the chance to inflict any harm. Thus, crime rates would drastically decrease. Predicting a person's capacity for violence or murder through neurotechnological means should theoretically work.

However, this outlook rests on a slippery slope in that it relies on several assumptions. One of these assumptions is the possibility of having completely unbiased datasets and algorithms. With a flawed system, it would be possible for the algorithm to misjudge someone and as a result wrongfully subdue them to unwarranted treatments. A paper written with a neurolaw perspective, reemphasizes the need for an unbiased dataset, especially if neuroprediction is to be used in a legal setting. The authors note that there is potential for bias since A.I. is trained on data such as criminal files, which "might reflect biases on the part of police officers, prosecutors, or judges."[4] The implications are terrifying as once again, one single brain scan could be used to determine whether someone is innocent or should be subjected to a life sentence. Taking these assumptions into account allows us to take on more realistic expectations.

Is Predicting Crime Possible?

The full integration of a crime-predicting algorithm into all aspects of society is something in the distant future. But the development of such an algorithm is closer than you may think, as numerous researchers from interdisciplinary backgrounds are currently making progress in their attempts to refine one. In an experiment conducted by the Catholic University of Korea, Bucheon, the team reported an improved deep-learning approach relying on drawing from a broader set of data regarding environmental contexts. Dr. Hang-Bong Kang, the lead researcher, reports that the sources include "American FactFinder, Weather Underground, and Google Street View."[5] By incorporating these various sources into their own dataset, the goal is to create a representative and accurate dataset that can serve as a precedent for future research. The vast amounts of data constantly being collected on everything provides a catalyst for the simultaneous improvement of analysis methods.

At the same time, Kang cautions against the notion of having success-induced blindness– he asserts that their findings "cannot be applied when sufficient data is unavailable." This duality illuminates the day-to-day ethical dilemma that researchers encounter in their pursuit of improving safety via policing. While the analysis of context-based statistics and other public data-driven methodologies offers a comprehensive understanding of crime-predicting environmental factors, there is still skepticism among those potentially impacted by the algorithm. This skepticism is appropriate since much remains unclear such as whether the algorithm's data is derived from biased data or if they themselves have an innate trait to inflict harm.

Mother Nature's Presence in Violence

This fear of an unseen yet inheritable trait points to the question of whether our actions are influenced by our environment, our genetics, or some combination of the two. In the study above, the results only address the "nurture" side of the "nature versus nurture" argument, ignoring the

potential influence of genetics or evolution on criminal tendencies. It makes sense for the study of crime-predicting algorithms to support the nurture side because it considers environmental factors and their correlation with criminal tendencies. But in order to accurately build a murder-detecting algorithm, the biological control of behavior needs to be considered. By studying the nature side of the argument, we can find a biological pattern to explain often unquantifiable psychological conditions. The current inability to determine whether biological factors play a role in shaping our psychological tendencies has inspired a trove of unanswered questions: Are suicidal tendencies inheritable? Are there significant differences in the brains of a non-suicidal and suicidal individuals? Is violent behavior linked to the brain? However, with the recent integration of novel data analysis technologies such as machine learning into the biological sciences, we can now develop a better understanding of how suicide and self-harm appear in the brain. Applying machine learning to fMRI has allowed "a biological foundation for altered concept representations in those with suicidal thoughts and recent suicidal behavior,"[6] giving greater empirical backing to a previously subjective determination. Instead of solely diagnosing a condition based on a person's symptoms, which can sometimes be deceiving for asymptomatic individuals, the results can be corroborated or contested through data derived from the anatomy of the brain. Addressing important topics in suicide and mental health necessitates both observational and empirical evidence. Thus, as technology continues to improve and grow, so does the intersection of neuroscience and technology.

Machine learning provides the backbone for the future of neuroimaging. Whether it be through increasing an MRI signal-to-noise ratio for improved quantification or accelerating image acquisition from lesser-studied datasets, technology inevitably enhances neuroscience research.[7] But how can we distinguish whether neurotechnology will be used ethically, especially for something as sensitive as predicting a person's tendency for crime? Is AI in neurotechnology still unethical if it has the real possibility of helping out others and society as a whole, even if it sacrifices the idea that people's rights don't depend on their biology?

There's Still Time

Given the current progression and integration of A.I. into the neuroscience field, our expectations of a neuro-predictive algorithm are escalated. The result is a fiery and contentious environment filled with countless unanswered questions about the future of humanity. But in reality, this crime and murder-detecting algorithm is far from ready. Scientists conducting research relevant to this topic even note that the current data should not be mistaken for identifying or predicting homicidal individuals and behavior. Simply put, there is not enough literature and knowledge on the topic to make definitive inferences and conclusions.

Perhaps there is validity in the statement that the future of predictive policing resides in an algorithm predicting criminal or homicidal behavior. Floating around the idea are still many unanswered questions and unsolved problems that ultimately render this to be part of the distant future. Still, advancements in neuroscience and technology offer a glimpse into the possibility of a safer society. Time and research will greatly influence our abilities to assess whether someone truly has murder on their mind.

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The Murdered Mind

by Meltem Su

Formatting/Design: Emma Cao

Curiosity

Humans are innately curious beings. We always seek to understand our environments: whether to put meaning into something, optimize our solutions, or simply understand how something works for knowledge's sake. Curiosity was best defined by George Loewenstein in 1994 as "a cognitive induced deprivation that arises from the perception of a gap in knowledge and understanding." [6]

Due to the broad nature of the term "curiosity", psychologist Daniel Berlyne distinguished two types of curiosity: perceptual versus epistemic. An example of perceptual curiosity is biting into a chocolate to find out its flavor. Scientifically speaking, it is the type of curiosity when there is a direct answer to the question in mind and does not continue to spark a curiosity. On the other hand, epistemic curiosity occurs, for example, if you are interested in understanding more about how the human brain works. Scientifically defined, this type of curiosity is one that is a craving of knowledge that leads to more and more questions to be asked about the topic.[3]

As imagined, many regions in the brain are activated when curiosity is piqued. When humans' curiosity is activated from a stimulus (such as a loud, sudden noise) or a thought, the parietal lobe is triggered. The parietal lobe is the region of the brain that allows humans to perceive and understand their environment.[8] The acquisition of information that clears the curiosity is associated with the insula and the orbitofrontal cortex.[9] The insula is the region of the brain that allows for detection of salient inputs (stimuli that gain our attention due to their difference from the rest of the environment) which is important for curiosity as humans tend to notice and ponder on things that are distinct from the rest of their surroundings.[7] The orbitofrontal cortex is often associated with roles that relate to higher-order decision making.[5] Together, these brain structures work together to help form curiosity in our minds.

Murderers

Although curiosity is meant to be innate, the modern world in many ways reduces our potential to be curious. Factors such as Artificial Intelligence (AI), workaholism, and propaganda are among the most important factors that are causing this decline in curiosity stimuli.

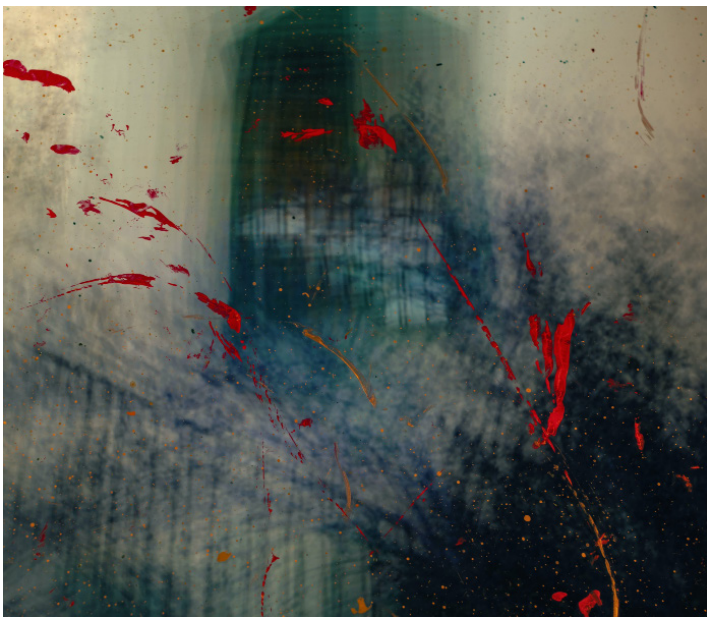
Artificial Intelligence

With the release of the novel AI tool ChatGPT, many people have now begun to test the limits of AI, from using it to write poems in foreign languages to writing up homework assignments. With the vast power of this program, many people have begun to exploit its powers — so much so that there are new programs being released to prevent tracking the use of ChatGPT.
ChatGPT, along with many other AI applications,

Where is my Mind?

When we were younger, it was our curious brains that helped us learn about the world and crave more information — something achieved by annoying adults with our countless questions. However as we grow, it seems that we slowly "lose" our sense of curiosity. As we continued to understand the world around us, our deepest curiosities became confined to mere shower thoughts.

How much curiosity does our society allow for us to experience? Do we lose our curiosity as we age? The name of this issue of Mind is Murder on My Mind. However, I am challenging the reader to instead consider the "murdered mind."



have allowed humans to put their brains on cruise control and let the machine do all the driving. While these applications can help humans do mundane tasks with relative ease, there is concern for humans having an increased dependence on this application.

In an analysis performed by the Pew Research Center, there are 5 main concerns summarized with the rapid development of AI. The list of concerns begins with the Human Agency, which describes how AI will reduce the authority inherent to human decision making and diminish humans' knowledge about how things function. The next is Data Abuse, which expresses how companies will use AI to make large profits and eventually allow AI to take governmental control. The next, and predictable, concern is Job Loss which expresses the concern of AI systems being so efficient that they replace humans in any work environment. The next concern is Dependence Lock-In, which discusses how human cognition and autonomous thinking will be diminished, while we increasingly rely on machines for learning. The last concern is Mayhem, described as the eventual loss of the commonplace sociopolitical constructions that have been developed throughout human history.[1]

The concerns of Human Agency and Dependence Lock-In are the most contributive to the loss of human curiosity and with due reason. These concerns directly show how the mind can quickly give up its curious capacity when we have machines that are able to achieve many tasks

that normally require human curiosity. The fear is that instead of trying to have a fundamental basis of understanding or interest, humans will rely on AI to obtain information.

While AI usage may seem to have many obvious reasons for concern, AI can also be used in a beneficial way to obtain information in a quicker manner and allow us to spend more time doing higher-order thinking and get through logistical barriers quickly. In response to these concerns, the Pew Research Center suggests that humans should focus attention more on improving collaboration and serve the interests of the general public by controlling the extensiveness of AI systems in an ethical manner.[1]

Workaholism

In our modern society's work mindset, humans are often pressured into overworking themselves in order to attain a perception of satisfaction. However, the action of overworking oneself juxtaposes with the end result of attaining satisfaction. Oftentimes, humans enter a cycle of constantly trying to achieve goals, creating a fruitless cycle like a cat trying to follow their tail. This constant pressure to do "more" prevents people from growing and truly enjoying satisfaction from the completion of their work.

Workaholics often possess a fear of failure, fear of boredom, and fear of self-discovery.[4] These fears combined ultimately cause a lack of curiosity because while trying to do everything to perfection, they create only one image of perfection and one correct path to this perfection. This binary success-or-failure mindset prevents workaholics from exploring curiosities because the brain has been wired to find a single solution or explanation for questions that prevent any further thinking or ideas. Additionally, to prevent derailing from the pathway to perfection, workaholics also limit their ability to think of other possibilities and discover alternative paths to achieve their goals.

Unfortunately in our modern society, people are pulled towards workaholism to perform at the standards of the modern world. For many people, this workaholism is not something that they are able to control. Similar to the Pew Center's suggestion to increase human collaboration and control how AI enters society, we can increase human collaboration in the workplace so people can work together to not only achieve goals faster, but also broaden the definition of perfection.

Propaganda

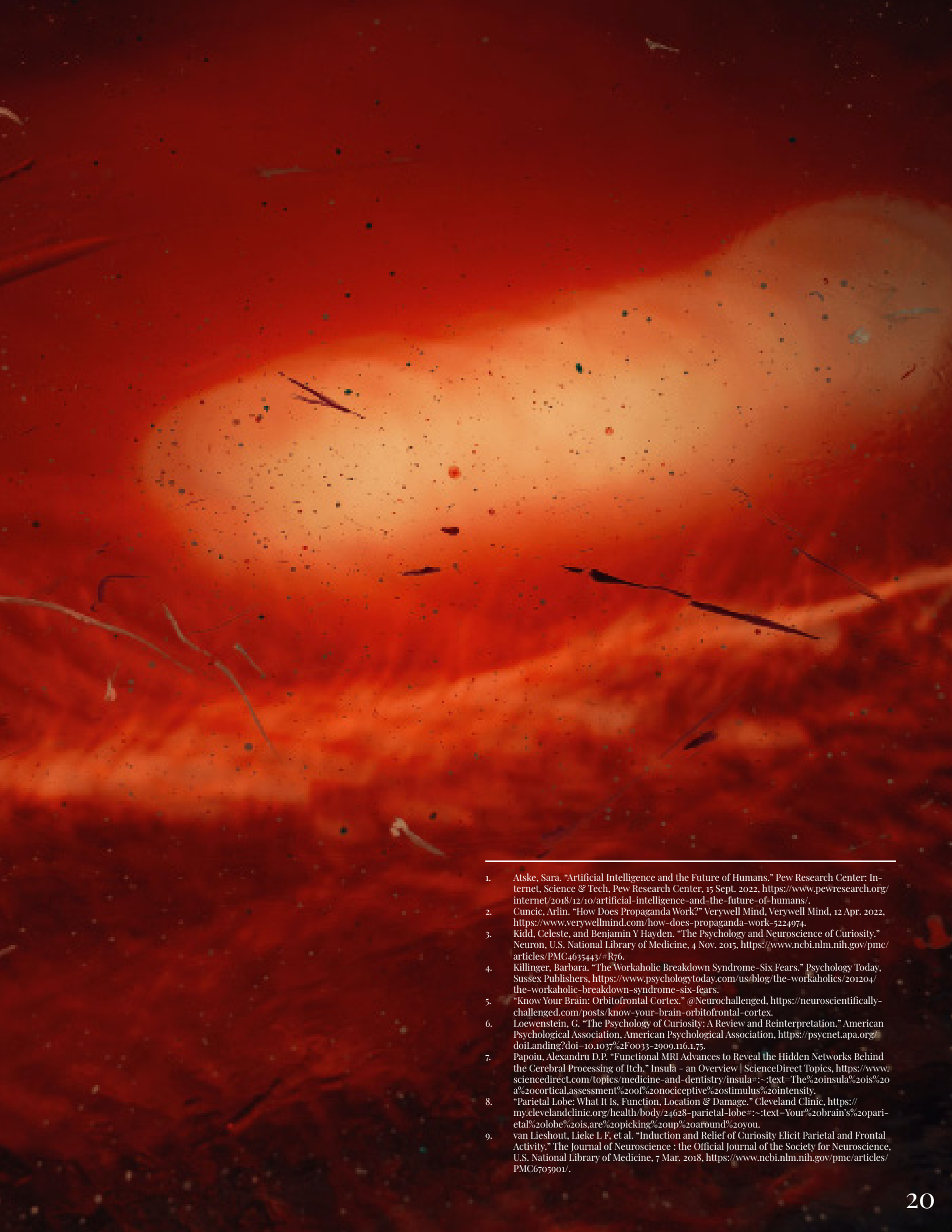
Often when we hear the word propaganda, our minds immediately think of the evil ideas propagated by our "enemies". However, we fail to realize that propaganda is easily found in the news we read on a daily basis, in conversations that we have with our friends, and even in our textbooks.

At the core, propaganda is a manner to push the agenda of a certain individual or a group. Propaganda is not only the slogans that we hear politicians say, but also can be as simple as testimonials or reviews you read when you research, for example, a new country you want to visit. This form of human manipulation is sometimes so imperceptible, that it becomes extremely effective in controlling human thoughts.[2]
Propaganda is a killer of curiosity. Instead of questioning why you have a certain belief, you just blindly accept your innate thoughts. Propaganda prevents us from understanding why it is that we think something.
However, the best way to prevent this curiosity "killing" and combat propaganda is to be aware of all the various techniques of propaganda and evaluate how a new piece of information you have obtained might be biased in subtle manners.[2]

Free Your Mind

The Human Agency and Dependence Lock-In concerns of AI, the fears of failure, boredom, and self discovery in workaholism, and the manipulation of thought through propaganda are all limiting our minds' ability to think and to think with curiosity.

While it is true that these factors will only continue to influence humanity's future, every individual can still take control of their own mind by having a strong sense of self awareness to help release their minds back into the world of curiosity.



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WHAT HAPPE

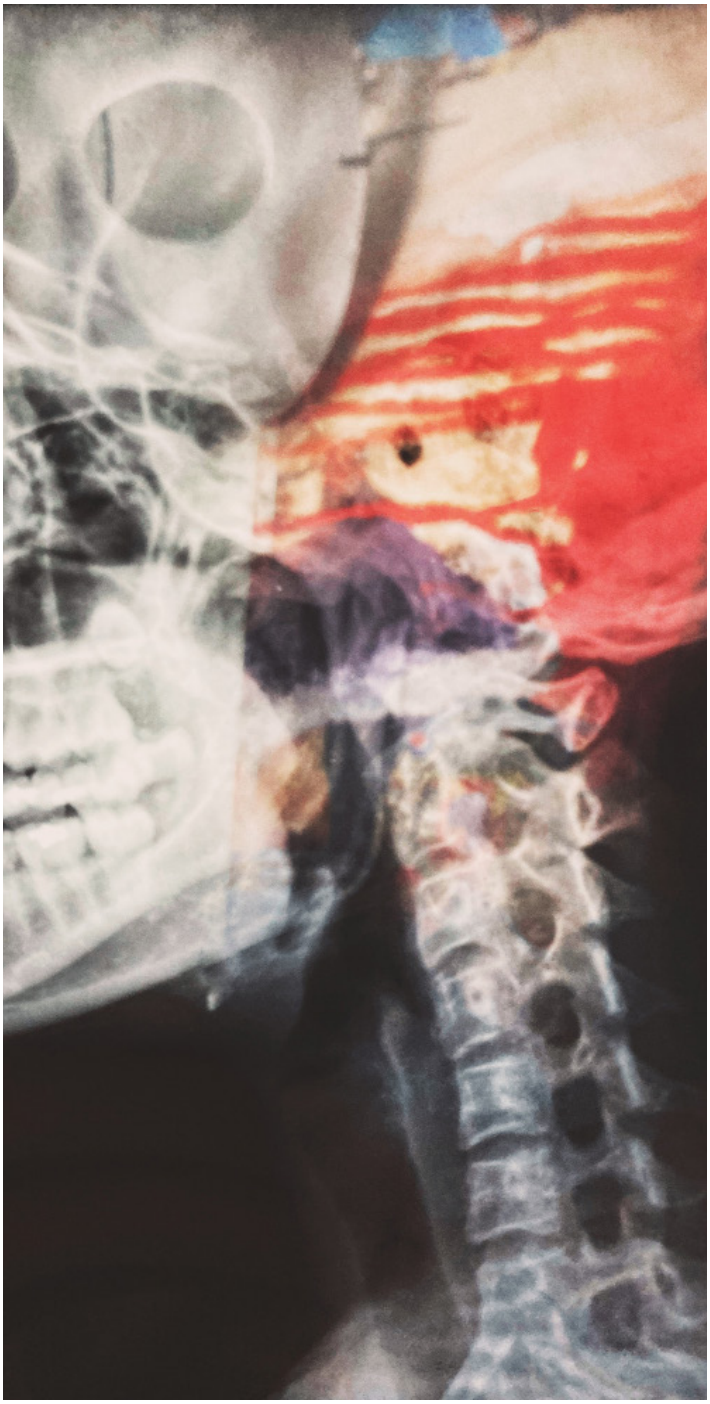
By Niki Parker

WHEN WE DIE?

Many of us have asked this question before, whether in school, through religious institutions, to peers and family members, or to ourselves. One of history's most famous and thought-provoking questions has been the question of what follows death, and though it still lacks a universal answer, there are quite a few approaches to questioning the afterlife, including answers that touch upon various topics of religion, physical science, and culture. Theories include, but are not limited to, phenomena such as reincarnation, full disappearance, dispersal of one's energy into the universe, and potential entrance to places like heaven, which depend on one's life. While an immediate response to the mysterious question of the afterlife might usually concern topics that focus on what happens in the larger picture, we might be able to illuminate the process clearer by highlighting the death of the conscience, part of human death, through the concept of life review. Many who have experienced a Near Death Experience, or NDE, have recalled a phenomenon known as life review, where their lives essentially "flashed before their eyes." This includes memories of their lives running through their minds, similar to a movie or slideshow, filled with important moments of their lives.

When an 87-year-old epilepsy patient unexpectedly passed away during a brain scan, the scan found that his brain seemed to replay memories in the 30 seconds before and after his heart stopped beating, according to an article published in Frontiers of Neuroscience. Having recorded the last moments of his brain activity, scientists monitoring the unnamed patient's brain were able to track his brain activity throughout the dying process, and uncovered the fascinating discovery, to be known as life review. While a brainwave monitoring test called EEG (electroencephalography) was being administered on the patient before and during death, the scan found an oscillatory brain wave pattern in which activity in the brain's alpha, beta, and theta bands decreased and activity in the gamma band increased, which is a pattern similar to that of a dreaming or meditating state, and suggest the usage of memory recall. This altered state of consciousness(ASC), the one associated with life review, is not only found in NDEs, however; attempts of simulating an altered state of consciousness through phenomena such as hypnosis have also been successful. According to Frontiers in Neuroscience, life-threatening situations are capable in inducing an altered state of conscience associated with NDE's, along with other stimuli such as Hallucinogens and psychotropic drugs, the results of psychiatric and neurological disorders, through hypnosis, meditation, and any agent capable of altering the involved brain circuits. A broad range of experiences may occur as a result of experiencing such stimuli, but the exact experience is dependent on one's mind and the state of it. Thus, it is important to recognize the uniqueness of life review to the individual who experiences it.

Scientific American writes: “The mind, whose substrate is whichever neurons remain capable of generating electrical activity, does what it always does: it tells a story shaped by the person’s experience, memory and cultural expectations. Given these power outages, this experience may produce the rather strange and idiosyncratic stories that make up the corpus of NDE reports.” Essentially, the memories produced by the brain as it shuts down are composed of what the brain has left. As the brain dies out, so do the parts of the brain and the amount of memory that can be recalled. While the brain goes through memories of life, it filters through these memories one by one in a form of survival, essentially holding onto what it has left in the given moment. The life review phenomenon can be linked with the concept of survival, as it is capable of providing individuals in near-death positions with feelings of purpose and meaning that can motivate them to continue living. Philosophically, it can represent the importance of an individual’s life and the story it has created. Physically, it can be viewed as a survival tactic employed on oneself when the body is trying to fight whatever is keeping the individual in a terminal state.Life review is not limited to just recall of memories, it is capable of demonstrating emotions and insights into one’s life and how their life made an impact, essentially like a grand reflection. As the individual is able to accept their life, they are thus hypothesized to get closer to accepting their death. This acceptance can potentially mitigate the common fear of death, serving as a survival tool or evolved method of making the dying process a bit easier on the individual and their loved ones.



Ultimately, the implications of understanding the purpose of life review are several. For one, understanding the near-death experience may allow for those in terminally ill circumstances to find comfort in knowing what they may experience if they do confront the dying process. Furthermore, loved ones of those who recently died or who are in terminal condition can find similar comfort in knowing the process of life review and the idea that it may provide a feeling of safety for their loved ones. As death can be the greatest-anticipated moments in life, understanding the near death experience and life review can introduce questions and reflections about one’s consciousness and the role it plays in one’s life. The phenomenon of life review can also be interpreted to demonstrate conclusions on a larger surface than what is experienced by the individual, such as illuminating the idea that one’s life has purpose beyond just existence. By studying and understanding the life review phenomenon within NDEs, we can gain new insights into the human experience and the nature of consciousness, and help individuals gain familiarity with the near-death experience.

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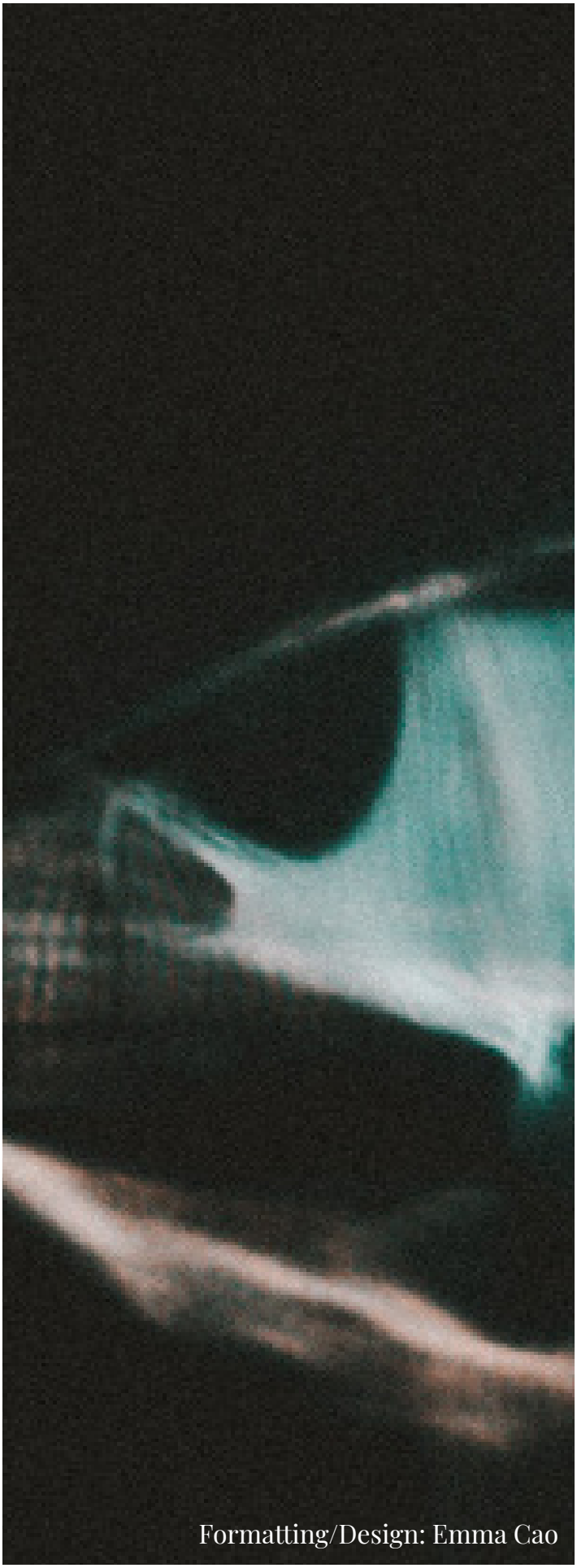

Formatting/Design: Emma Cao

The Satisfaction in Killing: Nature vs Nurture

By: Tessanya Gunatilake

For (almost) all of us, the act of taking a life is horrifying, unsightly, and unimaginable. However, there is a small population that finds satisfaction in taking a human life. Recently, Dahmer- Monster: The Jeffrey Dahmer Story has become one of the most popular shows on Netflix. This controversial true crime anthology series dives into the story of Jeffrey Dahmer, one of America's most well-known serial killers. The series analyzes Dahmer's troubled childhood throughout his time in jail and his death. Dahmer grew up in a toxic household, faced with extreme cruelty and neglect by his parents. Dahmer repeatedly witnessed physical and verbal abuse between his parents along with watching his mother suffer from depression and attempted suicide. Coupled with the emotional trauma Dahmer endured as a child, he also participated in taxidermy and used this as a bonding activity with his father. From the series, viewers see the satisfaction young Dahmer has from dissecting animals. After replaying his childhood, the series then follows Dahmer's series of killings and his (eventual and long-awaited) arrest. In the end, there was a trial over whether Dahmer's brain should be donated to science or cremated. Dahmer's mom wanted answers and wished to donate Dahmer's brain to science. His father, on the other hand, wanted closure and to cremate the brain. In the end, the judge ordered Dahmer's brain cremated. The inquiry to study Dahmer's brain brings up the question: was there something inherently altered in Dahmer's brain that caused him to be a serial killer, or was it the environment that led to his remorseless self? In other words, where does the satisfaction of killing come from– nature or nurture?[1]

Thinking about the nature side of this question, two genes are classified as "serial killer genes": monoamine oxidase A gene (MAOA) and T-cadherin (CDH13). MAOA is known as the "warrior gene." High levels of MAOA have shown a correlation with higher rates of aggression.[2] A study conducted had individuals pay money to cause physical pain to others who have previously taken money from them. The study consisted of 78 male subjects and collected genetic samples for the two subject groups– high MAOA and low MAOA. After three rounds of trials, the behavioral measure of aggression was collected through a test subject's willingness to pay to harm someone who had taken their money previously. The results showed a relationship between high MAOA and aggression. Individuals with high MAOA levels showed a greater frequency of behavioral aggression than individuals with low MAOA.[3]

If one "serial killer gene" is not enough, CDH13 has been linked to violent behavior as well. Previous research has connected mutations in CDH13 with autism, ADHD, and bipolar disorder. While this gene does not have as much existing research currently, a genome study of Finnish prisoners found that from 794 prisoners, 568 were positive for antisocial personality disorder and for mutations in two genes– MAOA and CDH13– which were both associated with criminal behavior. So, while there are proven "serial killer genes," how does this cause different behavioral outcomes, and how does this lead to antisocial behavior types?

With advancements in computational intelligence and data collection techniques, researchers focusing on serial homicide are now able to make predictive models of behavior. In other words, what are the behavioral patterns linked to serial homicide, and who is most likely to commit this act? The first method they used was grouping related behaviors using a typology approach, analyzing different scenarios to generate a specific profile. The typologies were classified into 4 groups: lust, anger, power, and financial gain. Next, researchers used a behavior sequence analysis to investigate how different types of childhood abuse led to acts of homicide in adulthood. After classifying each participant, researchers investigated the

details of crime scene behavior. The sample size of 233 male killers was classified by the type of abuse, and the results clearly showed a correlation between the type of abuse in early childhood and the typology of the serial killer. For instance, sexual abuse led to the power typology, psychological abuse led to the rape and financial gain typology, and physical abuse was linked to the rape/lust/anger typology. Overall, different types of abuse impacted the homicide typology and behavior the serial killers showed.[4] This creates an interesting direction for future studies – can we predict the type of serial homicide committed based on the type of childhood abuse one endured, and if we collect data from people who endured childhood abuse, would we be able to use this data to prevent future homicides from occurring?

From both these perspectives, we see that there is no clear answer about which is more important– nature or nurture– in determining one's likelihood of being a serial killer. The presence of a "serial killer gene" leads to many more open questions– what are the implications of having this gene? What does being able to predict violent behavior mean for future investigations? How do we determine who gets tested for these genes, and if found, what steps must be taken to prevent further violence? This new information brings the opportunity to save– or destroy– more lives.[5]

Each case is unique, as both genetic and environmental factors impact antisocial behavior. From Dahmer's story, we know there was a nurturing aspect of his childhood environment that led him to be a serial killer. Along with this, the Netflix show implies that there was also a genetic component that led Dahmer to have no remorse for the killings. Like Dahmer said after he was convicted "I hated no one. I knew I was sick or evil, or both."

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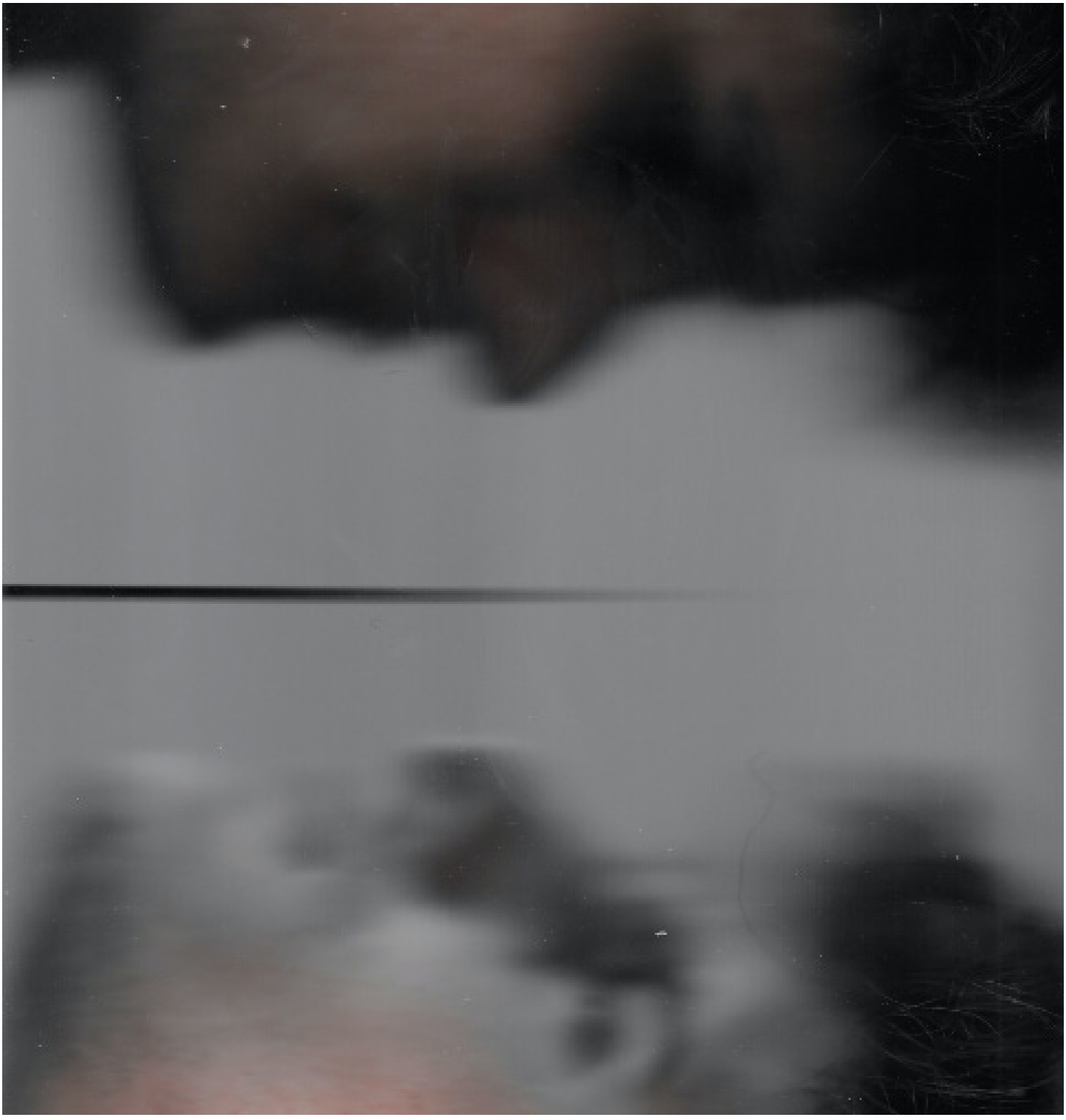
Formatting: Hannah Corr

Face-to-Face With My Consequences:



How Psychopaths and Psychologists Need to be More Aware of Their Actions

By Jade Harrell

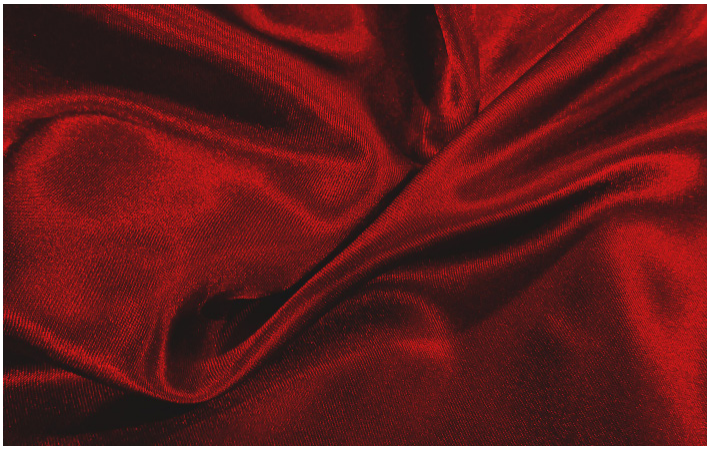
It is in our nature as humans to feel emotion. It is even in our nature to feel others' emotions. When you look at another person – and perhaps they are crying – you will recognize the emotion that they are feeling and you will even instinctively go as far as to reflect how they are feeling. Maybe you will share their sadness, or maybe the context of the crying is joy and you will feel bliss alongside them. Maybe, you are frightened by the emotional expression of others, and you become anxious in the presence of their crying as opposed to sharing their feelings. You cry with them, or you become fidgety. Regardless of how you react, your body and mind have an instinctive response when it notices the cues of emotions in others.

But, could you imagine not feeling anything? Is it possible to recognize a person's crying and not have an emotional response of your own? This is what psychologists believe is the fate of psychopaths. They are able to cognitively understand how someone is feeling and intellectually know the correct response to give them, but they do not hold the capacity to feel the emotion with them. It is like a blank wall in their mind. Now, returning to our hypothetical situation, the psychopath would instead see that this person is in a state of vulnerability – they start crying over whatever is going on. The psychopath then sees this vulnerability as an opening into how they can exploit this person's future behavior instead of empathizing. Perhaps, while faking reassurance cues that they learned is the correct response to crying, they are thinking how it would be so easy to motivate their sympathy in favor of themself later.

While this is the hypothetical situation, it is still unclear if this is the correct model for psychopathic behavior. Some psychologists even suggest that the psychopath does not exist at all, and that their existence is simply a fear of the therapist's. To further add to the uncertainty, there appears to be varying levels of psychopathy and also another distinct disorder – sociopathy – that many mistake to be psychopathy. All this confusion makes it incredibly difficult for psychologists to conclude a definitive prognosis for psychopaths and sociopaths, leading them to instead (counterproductively) focus on the criminal correlation between the personalities to at least make use of what we currently know. While most of the biological information we have found on the personalities is accurate and thus has been placed into our models, the dominating study of associated criminal behavior poses a unique threat to good further research into the personalities themselves.

Getting to Know the Sociopath and the Psychopath Neurobiologically and Psychologically

A leading dilemma in the research of sociopaths and psychopaths is the perceived intertwining of the personality disorders because of a few key features they have in common. Both the sociopath and the psychopath have a weak sense of morality and can be viewed as callous, manipulative, impulsive, and cold to people who encounter them. Their behavior makes it difficult to maintain long-term, meaningful relationships, also characterizing them as rather desolate and relationally unsuccessful individuals. Both have low arousal to neutral or threatening stimuli, which concur with models of emotion evolution (emotion is developed from a hyper-awareness/sensitivity to signs of distress from others or the environment in an attempt to avoid something potentially harmful to one's survival) to suggest strong emotional detachment. This hypoarousal also makes it impossible to become socially conditioned, as one must have an emotional reaction to a social interaction (for example shame, joy, or pleasure) in order to learn whether or not one should seek/avoid that interaction more. These combined moral quirks and detachment are the defining characteristics of the sociopath and psychopath, which often makes it easy to overlook the crucial differences that they have in the manifestation and potential causes of their behavior and their neurobiological makeup.



Sociopathy, also known as Antisocial Personality Disorder (ASPD), while characterized by its emotional coldness and weak relational skills, actually possesses some skill behind morality and emotionality – although it is, in a way, damaged and not up-to-date with most people's current beliefs on what constitutes right and wrong. Reflecting this, neuroscientific studies on the sociopath's brain have found an intact "empathy circuit." The empathy circuit involves a complex combination of various parts of our brain that have been linked to differences in beliefs and our capacity to feel emotions for others. It includes parts like the anterior cingulate cortex (ACC), which has been seen to have decreased activity when we view a punishment that we believe is just/fair; the medial frontal cortex, which helps us to be conscious of "the desires, intentions, and beliefs of others," understanding and distinguishing ourselves and what we personally believe, and being aware of how we are perceived by others; and the amygdala, which has been linked to world-views, conservatism, and generalized fear. Therefore, it can be assumed that the sociopath's capacity for morality and emotionality is very much still there, although perhaps it has been skewed as a result of traumatic past experiences.

Also built into the sociopath's biology are irregular levels of neurotransmitters including high dopamine, low serotonin, and low norepinephrine; and also high levels of testosterone, which explain some of their antisocial behavior. People who are high sensation seekers, criminals, aggressive, or who have difficulty controlling their impulses tend to have less of a serotonin metabolite, 5-HIAA, which indicates that less serotonin is being produced within them. Monoamine oxidase (MAO), likewise, is an enzyme that breaks down serotonin, dopamine, epinephrine, and norepinephrine, and is found less in antisocial/sensation seeking individuals. Testosterone has been shown to engage aggression and dominance within people, linking sociopaths again to aggression and sensation seeking. The importance of these observations is to make sense of them – if all of these levels are present in antisocial individuals, how does it relate to and manifest their long-term behavior? Currently, it is suggested that a positive feedback loop is occurring among individuals with this physiology. The low levels of these mood-regulating neurotransmitters and high testosterone make it more likely that the antisocial person will initiate aggressive behavior and to win fights requiring excessive dominance, therefore increasing levels of testosterone further after every fight won. This trains the antisocial person's brain to continue seeking out these interactions further. Overall, the behaviors of sociopaths are primarily indicative of antisocial behavior and impulse control. In simpler terms, a weak moral and emotional response creates a person who is always emotion seeking and impulsive, with little deeper awareness of the consequences of their behavior on the greater social world. This actively harms the individual in their relations with others and their standing in society, thus giving them the title "antisocial." Considering this, it is important to note that antisocial behavior is positively correlated with high-anxious behavior. If this is the case, and considering the sociopath's supposed lack of emotionality – it begs to question whether or not the sociopath's nature is not actually emotional detachment, but rather, a sort of rejection of emotions in the presence of a social environment. It has been said that when deeply engaged with a sociopath, many of their behaviors become similar to that of a person with Borderline Personality Disorder, a disorder that is characterized by high impulsivity, self-destructive behavior, a fear of abandonment and intimacy, and mania. If this is true, it suggests that the lack of emotionality in the antisocial personality is a masking defense mechanism as opposed to an actual inherent deficiency.

Psychopaths, however, are suggested to inherently lack emotionality – which is why the distinction between the psychopath and the sociopath is so important when researching either. Further, their hypoarousal seems to be present at a much deeper level and is differently manifested than the sociopath. According to motivation behavior models, psychopaths have a weak behavioral inhibition system (BIS), which is responsible for regulating one's responsiveness to aversive stimuli and gaining anxiety, but a normally functioning behavioral activation system (BAS), which is responsible for "appetitive" motivation and has been, at times, correlated with impulsivity. Theoretically, this combination would indicate an inability to be conditioned by fear but to still have the motivation to explore or do anything with initiative, therefore allowing a person to essentially have the emotional capacity to do whatever they might want or feel like doing in the moment despite its potential consequences. In a sense, they are unaffected cognitively by the normal concept of what a consequence is because they feel no fear (unlike what sociopaths might feel given their antisocialness!). This dynamic aligns with what psychologists believe is the definition of psychopathic behavior. To lack the understanding of "consequence," it opens up the psychopath to do anything that is immoral, to commit any crime, to harm someone in whatever way they please, and to lack the restraint in doing so simply because they don't really care. Adding on to this psychology, a study was done on identified psychopaths to see how they perceive various stimuli. In the study, psychopaths were made to watch a series of images, with the images ranging from something "pleasurable" (defined in the study as an image that incites erotic or thrilling feelings in an individual), to neutral, to something "unpleasurable" (defined as an image that implies a threat or shows mutilation or assault). As the psychopaths and control group (non-psychopaths) watched the images, they were watched for reflex potentiation using facial electromyography (EMG), their blinking, their overall facial expression, and their heart rate. The goal of doing so was to see if we could find underlying emotions within the subjects. For example, if someone showed strong reflex potentiation, we could determine that they were uncomfortable or threatened. Or, if someone had slower blinking, we could determine that they were in a state of relative calm and/or relaxation. The measured emotions showed that psychopaths had slightly less interest in mutilations, assaults, and thrill images; substantially less interest in threatening images; and slightly more interest in erotic and neutral images than the control. Psychopaths demonstrated feeling more dominant, pleasured, and alert while watching all stimuli, with especially more of these feelings in the unpleasant ones. To have disinterest in something that is terrifying – and to even go as far as to feel dominant and pleasured in such confrontations – continues to add to the current understanding that psychopaths have a strong lack of fear outside the normal, human range. Further, psychopaths often had an outward facial expression that was the exact same as that of the control group, despite their measured internal reactions being much different. Such evidence would suggest that psychopaths do, in fact, wear a "mask" when they are being watched by someone else. They are cognitively aware of their abnormalities from the general population, and therefore hide by acting like what they know to be the "correct" emotional response all while not actually feeling that way. This idea of emotional cognition and deeper, genuine emotionality within psychopaths is an important distinction when understanding how the psychopath behaves. The psychopath has complete intellectual understanding of emotions, especially others' emotions, but they are not able to empathize with it themselves because they lack the capacity to understand their own emotional responses. In another, smaller study, psychopaths were asked to distinguish between various words with different connotations. The psychopaths were seen to have a difficult time differentiating between neutral and emotional words. When one reads, they are able to pick out the "tone" or emotional meaning of the word because they intuitively notice how they felt when reading the word and they remember past emotions they have experienced to understand the word – similar to how one imagines a red chair that they've seen before when they read "red chair." If we were to try to explain why psychopaths could not distinguish between neutral and emotional words, it could

be theorized that they lack the emotional depth and emotional memory to understand how the word feels when processed in their mind.
The neurobiology of the psychopath supports this emotional deficiency as well as distinguishes their emotionality from that of the sociopath. The psychopath has a shrunken amygdala, an asymmetrical hippocampus, and a larger corpus callosum just to name a few of the abnormalities. Given that the amygdala is responsible for eliciting a fear response, the fact that psychopaths have a deformed amygdala aligns with the idea that they are unable to feel fear. Having an asymmetrical hippocampus and larger corpus callosum are signs of a lack of mental development – as they are structures which start out asymmetrical within childhood and become symmetrical when the child grows up. Other parts of the brain of the psychopath also failed to develop fully, including the ACC and medial frontal cortex, which as mentioned earlier are important for the development of the "empathy neural circuit." Such evidence then brings to question the causes of psychopathy. Of course, it would be foolish to suggest that this indicates causality – but if these parts of the brain are typically "grown out of" by adulthood – it should be considered whether or not an external event during childhood is causing a stunting of neurological development in psychopaths.

Brain Electrical Measuring: Then and Now!

Unlike the psychopath, which has been found to have reduced gray matter in the frontal lobes, the sociopath has been shown to have asymmetrical activity in the frontal lobes. This finding of the sociopath was identified in the 1970s using BEAM – "Brain Electrical Activity Mapping" – which at this point in time, was considered as a novel technology practice! BEAM was capable of creating a visual display of the brain's electrical activity, which was an attempt to fix the shortcomings of the EEG and how interpretation of the EEG's data was difficult without a visual mapping of the brain. The BEAM was capable of synthesizing data that the EEG would normally measure and spit out as pages of waves into one single image, making clinical use easier and more intuitive when identifying functioning in the brain.

Since the 1970s, neurotechnology relating to electrical activity in the brain has become much more ambitious. A problem with our current neurotechnologies regarding electrical activity is its locational limit. Electrodes that we would normally slap on to someone's head can only detect activity within the area that the electrode covers, which is generally fairly small considering the grander scheme of how the brain works – electrodes can only measure a fraction of neuron firing that occurs in the firing of an entire neural circuit because it can only detect a few of the closest neurons in the electrode's locational range. It is of current belief that in a neural circuit, neurons can fire and link across a chain of great distances and not just a small section of the brain, but we cannot detect this completely with our current limitations. The BAM (Brain Activity Mapping) Project seeks to resolve this problem by developing technology that:

1) images every spike from every neuron
2) can record deep electrical currents within the brain and not just a scratch of the surface
3) is "wireless"

Moving forward with these goals, scientists are working on new methods of capturing great spaces in an image through manipulations of light and optics that can hold large projections of space, enhancing silicon nanoprobes, and incorporating novel ways of measuring information, such as using encoded DNA polymerase strands themselves to collect data inside the neuron.

The Psychopathic and Antisocial Correlation with Crime

The underlying question is – does psychopathy and sociopathy indicate a criminal? It is hard to make the claim that they aren't, considering that crime is a construct built off of shared moral beliefs. A community thinks something is bad, so they make it a "crime," and then they stop people from doing bad things by placing criminals in prisons. Given that a psychopath, and even sociopaths to some extent, are incapacitated from fully understanding "right" and "wrong" on an emotional level, this predisposes them to have the ability to do fairly awful things as classified by society. When you read the word psychopath, you might even associate it with crime and horror in your mind. Your mental schema might paint psychopaths as crazy killers who are in and out of the mental asylum, perhaps from the media that you've consumed or because of their emotional detachment that you couldn't even begin to understand as an inherently emotional person. I recalled this idea when I was told that our magazine's issue would be "Murder On My Mind," leading me to write about this article's subject. Originally, my intent was to create a psychological model for why the cognition and behaviors of sociopaths and psychopaths causes them to commit crime – however, this goal, while not necessarily bad, was built off of the assumption that all sociopaths and psychopaths are criminals. This assumption is something that has not only governed my mind, but also the minds of many other psychologists as they were researching psychopathy and sociopathy. While there is a correlation between psychopathy/sociopathy and criminal behavior, the research that has found this is at times empirically questionable.

In a study that attempted to determine how psychopaths are able to emotionally detach and do immoral things, and whether or not there were "successful psychopaths," it was found that many used general moral disengagement strategies to excuse unethical behavior. Students from a large public university were sampled and tested for psychopathy (including if they had criminal tendencies, violence, interpersonal manipulation, erratic lifestyle, and callous effect), and then arranged into psychopathic and non-psychopathic groups. Each group took a survey with questions regarding whether or not they approved of various unethical decisions when given a workplace scenario, for example, if it was ever okay to focus on deadlines at the expense of quality. They were also tested for their rationale behind the answer by rating how much they approved of eight moral justifications, which were designed to align with moral disengagement strategies. Psychopaths chose unethical decisions more frequently than the non-psychopath control group and they agreed with moral disengagement justifications more often as well.
There are two important things to note about the finding of this study. First, the researchers were successful in finding psychopathic individuals who were currently attending a four-year public university. While this, of course, does not exactly show whether or not each individual's performance within academia/society was of particularly high standing – it does show that psychopaths are not just poor criminals with zero success in their lives. They are, at the very least, semi-functional people who go to academic institutions and are preparing for a potential career, who were not stopped by obstacles like incarceration. This also suggests that there are perhaps more psychopaths than we have originally thought, as these researchers were able to find an amount of psychopaths that could fill a substantial enough group for the study. Second, this shows that psychopaths demonstrate unethical behaviors in many ways – not just in the forms of violent fights in the dirty streets of the city like many people think. Psychopaths are thirsty for any sort of self-serving actions to take. These actions are not limited, but rather, they adapt to the environment that the psychopath is already in – like making unethical decisions at your office job. Such a discovery opens up many possibilities for how psychopaths can manifest within society outside of merely crime, although crime is still a possibility to consider, and what foundationally makes up a psychopath.
To have an inclination to self-serve predisposes psychopaths to crime, as oftentimes, crime

and indulgent self-servitude go hand-in-hand. For example, a bank robber is not only serving himself by getting himself the money that he desires, he is also a criminal because we, as a society, have deemed theft as a crime. But it does not guarantee that they will be criminals, as not all self-serving actions are against the law. For example, lying to your partner that you didn't actually cheat on them is not a crime.

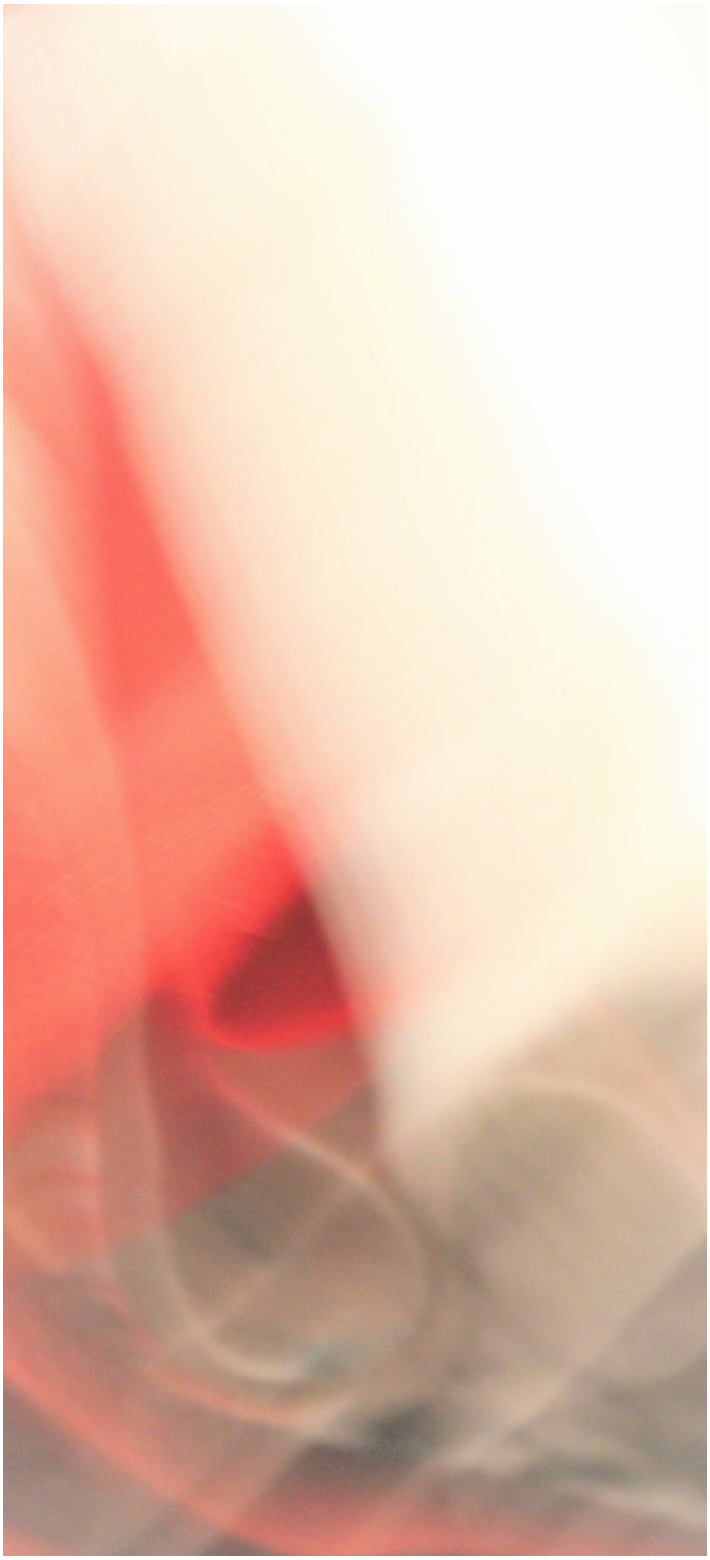
This very obvious and clear distinction, however, has gone neglected by many psychological researchers over the years. As the correlation between psychopathy and crime has become of more and more interest to scientists, it has somehow turned into a causation conundrum, in which scientists think that in order to be a psychopath, you must have committed crime because psychopathy causes psychopaths to commit crime. Take the Robert Hare's Psychopathy Checklist Revised (PCL-R), a classic and frequently used psychopathy diagnostic test, for example. While it does overall measure for psychopathic traits like callousness, machiavellianism, and lack of emotionality, these features are not tested to the deserved extent and instead, impulsivity, antisocialness, and criminality are. As discussed before, psychopaths are not by definition antisocial, as to be antisocial one is typically anxious to an extent – which psychopaths are not. Psychopaths are also not inherently impulsive so much as they lack restraint in the sense that they are not concerned with the emotional or moral implications of an action. They are not particularly "hot-headed" as one would imagine an impulsive person to be because they are not strongly affected by anything. Further, it has been shown just now that psychopaths do not have to be criminals. This makes the PCL-R go beyond the scope of just psychopathy in its diagnostic process, as it includes traits like these in the process of determining a psychopath to an overwhelming extent, and it makes the correlation between psychopathy and crime tautological. The PCL-R is therefore not entirely reliable in the diagnosing of a psychopath, nor is it reliable in the studying of psychopathy as a whole, yet it is our main tool for diagnosing psychopathy.

In fact, this incorrect application of diagnosing psychopathy has already shown to be dangerous to the study of psychopathy science. "Sociopathy as a Human Process" is an article in which George E. Vaillant argues that psychopathy is essentially a myth of psychology. He demonstrates a few case studies, in which patients diagnosed with sociopathy, when deeply engaged with, appear more like Borderline patients or Hysteria patients. I briefly mentioned this before when discussing the roots of sociopathy because, despite Vaillant's incorrect application of psychopathy into his argument, his observations of sociopaths are undeniable and thus valid. But a key thing to note is that all of the sociopathic case studies discussed were drug addicts, flighty in their relationships with others, impulsive, antisocial, and generally speaking criminals. They were emotionally detached, sure, but only to a certain extent. Vaillant then uses this to prove that, because these sociopaths actually do seem to experience emotion (like anxiety) after a while and still maintain some sociopathic traits, then the idea of a sociopath doesn't really exist – and neither does the idea of a fearless psychopath. Vaillant's assessment of the psychopath is a logical jump, though, likely due to the fact that psychopathy and sociopathy are often not distinguished appropriately, especially in regards to impulsivity and antisocialness. Again, psychopaths are not particularly antisocial or impulsive. For sociopathy, however, the conclusion is a bit more nuanced and holds relative weight into the understanding of sociopaths (like perhaps their emotional detachment is an illusion/defense mechanism, although one should consider whether or not drug abuse is playing as a confounding variable here). The logical flaw of "Sociopathy as a Human Process" regarding psychopathy was noticed and therefore did not hinder further research on psychopathy, but the article illustrates well how if we continue to pursue psychopathy in this misleading way it can lead to the end of understanding and potentially resolving the phenomenon. Vaillant was very quick to abandon psychopathy as a whole when his basis of a psychopath was incorrect, and currently the basis of psychopathy is incorrect for many.

Moving on, another failure in the correlation of crime and psychopathy is that most

studies on psychopaths are conducted in prisons, which neglects a larger potential population of psychopaths and makes the crime-psychopathy correlation tautological (in other words, always true). To explain this, let's say you are trying to study children's behavior. You go to a local ice cream shop, where you assume there will be lots of children, to recruit your research subjects. Part of your research is whether or not children like ice cream and why. Do you see the problem with this method? Of course if you find your subjects at an ice cream shop they are going to like ice cream, so you cannot validly answer whether or not children, as a whole, like ice cream by doing this. You might be thinking, "But don't most children like ice cream?" – and yes, you would be correct in that statement. Most children do like ice cream, but by going to the ice cream shop to determine this you are neglecting the possibility that they might not, and before you suggest that all children like ice cream you must account for the other possibility because it may be crucial to your understanding of children's enjoyment of sweets. However, if you were only going to study why children like ice cream, then going to the ice cream shop to collect your subjects would be the right choice. Likewise, all psychopaths found in prisons are going to have committed crime and therefore we cannot assess whether or not all possible psychopaths commit crime, even though many do – but we can try to see why their traits predispose them to crime. This research, however, has similarly been neglected as a result of people getting stuck in the loop of tautology: "people commit crime because of their psychopathy, which includes criminal behavior." Crime is therefore a good additive descriptor of psychopathy, but we cannot use it as a requirement to be psychopathic because this will inevitably lead to neglecting a wide range of psychopaths and potentially cutting short our understanding of psychopathy.

While we cannot say that psychopathy is an indicator of crime, or vice versa, it may be possible to suggest that antisocialness in general – so long as crime is kept out of the definition of antisocial to avoid tautology – is a good indicator of crime. Many criminologists speak of the "Antisocial Personality Pattern" in predicting crime, in which there is a strong correlation that those who have antisocial behavior often commit crime. Further, hypoarousal and sensation-seeking is also correlated with committing crime. The Antisocial Personality Pattern is thus a good tool for criminologists and investigators to use when trying to determine the risk of an individual, but we cannot conflate this tool (like we have been) as having validity in psychopathy and sociopathy research.



Discussion and Future Implications

To summarize, sociopaths are defined by their antisocial personality: with features like impulsivity, callousness, sensation seeking, emotional detachment, and poor relationships with others. However, they are not deficient in emotionality so much as they are likely out of touch with themselves. Their neurobiology supports this as they have an intact empathy neural circuit but an irregular amount of neurotransmitters and frontal lobe activity. On the other hand, psychopaths are machiavellian and deficient in emotionality – specifically they cannot feel fear – while characterized by similar features as the sociopath like callousness and poor relationships. The psychopath's brain confirms this as their empathy circuit is deformed and behavioral studies have repeatedly shown a lack of fear. To the dismay of further understanding of both disorders, many psychologists have conflated their definitions to also include "commits crime." While oftentimes sociopaths and psychopaths do commit crime, a large enough population of them do not, which would suggest that commiting crime is separated from the underlying disorder of sociopathy and psychopathy. So what exactly led scientists to go out of their way and try to conflate the two ideas? In the field of psychology, very strong correlations are often very difficult to find so that when an r-squared value of a study appears to be over 0.3 there is insane applause. This is simply the result of the subjectivity of humans and how human actions and behaviors are more difficult to pin down than a system of linear equations, which has a definitive solution. The correlation between psychopathy, sociopathy, and crime is strong relative to other psychological theories, thus creating lots of commotion and interest. It was at this point that some suggest psychologists, rather than verifying the data more, became fixated on how to increase this correlation and in their excitement lost focus of the empirical way to do so. Looking at all this confusion between psychopathy, sociopathy, and crime is an important reminder that in order for psychology to be regarded as the science it should be regarded as – we must be extremely precise and careful with our operationalization and empiricism. To maintain objectivity we must not allow psychopathy, sociopathy, and crime to be interchangeable when they simultaneously describe different concepts. Not only is this important in the area of cold-hearted personality disorders, but we have seen this issue occur time and time again in other manners of psychological operationalization. While we have been careful to operationalize processes like personality and intelligence over the years after begrudgingly realizing its nuance, we have been less accurate in our doing so of mental "disorders" as a whole. Still we place mental illnesses in black-and-white categories via horribly tautological strategies in order to keep things "nice and simple," as opposed to diving head first into the subjectivity and recognizing and treating these issues as spectrums. We spend too much time looking at people's outward behaviors instead of testing for why these behaviors come up. How can we expect to understand people when we hold back on digging deeper into them and seeing them for their foundations? The unfortunate truth is that all roots manifest and grow a unique tree – all people act differently even after experiencing the same event – and it is up to us to find their seeds in hopes of actually producing anything relevant about why they look the way they do. To begin again this process for psychopathy, we can first remove the requirement of antisocial behavior and crime that has plagued the PCL-R and start studying why and how psychopaths are consequence-less and fearless.

What we do not want is for psychologists to be the murderers of the true minds of their subject – and in order for this to be avoided, it seems that like psychopaths, psychologists need to come face-to-face with their actions and consequences.

Formatting/Design: Emma Cao

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Quantifying Fear: How Your Body Reacts to Near-Death Experiences

By: Sarita Celaya

Formatting: Hannah Corr

Near-death experiences (NDEs) are caused by a change in normal brain function. Many people who have NDEs report "seeing the light" or seeing dead relatives – in reality, these visions are perceptions caused by a brain experiencing fear through a traumatic event. Within this context, we can think of perceptions as the way in which an individual views a situation – how they felt, what they saw, and how it impacted them. But what exactly defines a traumatic event in this context? You might consider a car accident or perhaps being robbed, but researchers have found that an event can be relatively harmless and still cause this reaction. This is because your brain's response, though triggered by an event, is fundamentally a perception of that event: it is the severity and aftereffect of your brain's reaction that defines a traumatic event.

"Fear" is a broad term: what we're really talking about is how your mind perceives something it was not prepared for, something unusual. For example, people who have NDEs and see tunnels or light could actually be experiencing oxygen deprivation within their brain's visual system. At times, it can appear that our brains can respond drastically to fear. When faced with a new and threatening experience, these responses are a product of our brain trying to learn what to do to survive and then ensure these events don't happen again.

Noradrenaline and the Biological Fear Response

An important response lies within noradrenaline, a hormone and neurotransmitter in our brain that is responsible for the "fight or flight" response we typically associate with fear. As a neurotransmitter, noradrenaline functions as a messenger between our brain and our muscles. As a hormone, it is triggered by stress and released by our adrenal glands. It is at the core of our physical responses to fear, such as alertness, attention, blood pressure, heart rate, sleep-wake cycle, mood, and memory. Noradrenaline is a part of our sympathetic nervous system, which is a key component of how our bodies react to emergencies. "Fight or flight" is also known as an acute stress response, and it is a product of these systems reacting to fear and the unknown. Evolution has favored the fight or flight response because it is designed to keep us safe. Whether this means having to carry through with something that can cause fear, like learning to drive, or inherently backing up from a sudden loud noise, our bodies respond to stress with the goal of staying alive.

So what do our bodies undergo when our brains perceive danger? It all starts in the hypothalamus: perceived danger will trigger a stress response in the nerves in this part of our brain, producing a signal that gets sent down our spiral cord and into our body. Within the amygdala, a bilateral almond shaped mass in the middle of your brain, a signal is sent through the nervous system that triggers the release of cortisol. Fear response is not only visualized through the amygdala – the thalamus and brain stem also play an important role in your brain's fear response. Fear has a measurable effect on the entire body: our pupils dilate to receive more light and see better, our skin turns pale to divert blood supply to our muscles, our heart starts beating faster to deliver more oxygenated blood to essential organs and muscles, our blood pressure increases, our muscles receive more blood for increased strength and speed, we breathe faster for more oxygen, and stored glycogen in our liver is converted to glucose for energy. Noradrenaline also triggers the release of the hormones epinephrine and norepinephrine. These hormones are what keep telling your body to continue that biological fear response until the danger is over. This danger can be something arguably real, like narrowly escaping getting hit by a car, but in many cases there was no real danger – a person's mind just believed they were in danger of dying.

Fear Impairs Rational Thinking

In many cases, people who recount traumatic events can have difficulty recalling details they otherwise would have remembered had they not had a NDE. First, let's take a look at the amygdala. The amygdala is in the temporal lobe of your brain and it is responsible for

interpreting the "emotional salience of the stimuli". When the amygdala reacts to perceived fear, your cerebral cortex's ability to function properly becomes impaired because your body is diverting energy to other parts of your brain, typically the parts important to your biological fear response. Though your cerebral cortex does not stop functioning, there is less stability and energy in its function, leading to its inability to work at maximum capacity. The cerebral cortex is responsible for reasoning and judgment, which offers a reasonable explanation for why individuals who have NDEs can have responses that might not make sense, or why they can have trouble remembering specific details. When your brain perceives danger and/or risk of dying, it becomes harder to think clearly and make rational decisions. Take, for example, a group of friends watching a scary movie: though they know there will be monsters, some will still shield their face or yell when they feel fear, even though they are aware there is no real threat. This perceived fear is enough to elicit that fight or flight response.

Fear the Anxiety vs Fear the Enjoyment

An interesting branch of the psychology behind fear is that some people really like it. From teens who like haunted houses to hardcore thrill seekers who put themselves in genuinely risk-heavy situations, their pleasure derived from fear actually comes afterwards and is known as the excitation transfer process. After the situation that causes the fear response is over, a person's brain and body remains affected. If this situation was purposeful, such as riding a roller coaster, then your brain will release post-situation dopamine, creating a positive association. It is also possible for situations where someone is afraid to reinforce fears they already had, a negative association. The negative associations created by fear can cause unrest or trauma, but this is not the same thing as a fear developing into a phobia. The difference between the two is that a fear is a reaction to an event or object whereas a phobia impacts the quality of life and ability to function. A fear that ends up impacting quality of life and ability to function could be a phobia, but it could also be something like post-traumatic stress disorder (PTSD). These distinctions in terminology are meaningful because they allow us to take something like fear, which can often be nuanced and difficult to unpack, and discuss it in a more standardized way. Proper terminology can also help people understand their own experiences and effectively communicate how they feel to their friends, family, or doctors.

Neurotechnologies Used to Quantify Fear

Researchers use various neurotechnologies to quantify fear, with many of these technologies measuring the physical effects of fear we previously discussed. One research group published "Evaluation of Fear Using Nonintrusive Measurement of Multimodal Sensors," where they discussed their results from quantifying fear using technologies such as electroencephalogram (EEG) signals, eye blinking rate (BR), facial temperature (FT), and a subjective evaluation (SE) score before and after the user watches a horror movie. Quantifying fear is not just scientifically interesting, given that fear can be a highly nuanced concept, there are many practical applications to collecting data on fear response that the paper discusses.

The application I found to be most surprising was intelligent surveillance systems. It makes sense that this is one potential application of their work given that they relied on non-intrusive methods of gauging an individual's fear response. Their research also showed that measuring facial temperature and using other subjective evaluations was often more reliable than EEGs and eye blinking rates. Their research was based on non-intrusive, multimodal measurements of EEGs, blinking rate, facial temperature, and a subjective evaluation. One result from their research was that "the difference of subjective evaluation before and after watching a horror movie is the largest, whereas those of facial temperature, EEG and blinking rate are the second, third and fourth largest".

These intelligent surveillance systems, which can function similar to ordinary

security cameras, would have the capability to "sense" when crimes might be occurring based on scientific measurements. This could help loss and prevention staff stop a crime before it occurs. The evident downside is that this system is not perfect – someone may be ill, emotionally struggling, or experiencing anything else which may cause the symptoms the surveillance system would monitor. In those cases, being stopped for a potential crime could result in a bad situation. A more positive and less risky application of this technology could be for organized fear experiences, such as scary movies and amusement park rides. Gauging how afraid someone is could help for two reasons: 1) companies can measure if their scary experience is at all effective, and 2) companies can measure if someone is perhaps too afraid and at risk of a stroke.

Sometimes our brains can have exaggerated responses to stimuli: the "threat" at hand is not actually endangering us in any way. Fear-related mental health conditions definitely play a role in the ways in which individuals may respond to perceived fear. In schizophrenia, an individual may perceive that there is danger, a person or a monster, and react as if that perception was real. In reality, those things are not there, but to that individual it is real. Their bodies will react the same way. After traumatic experiences, individuals may develop new fears and have reactions that they did not previously have. For example, if a woman is assaulted on her daily walk home from work, she may now feel fear while taking that walk. Normal noises may now be perceived by her as the sounds of an incoming attacker, and people walking the same trail may trigger her fears of being assaulted once more. In this case, the trauma caused by an assault now impacts her perception of what was once a normal walk home.

Closing Remarks

Humans, like most other animals, learn fear through experience. When a child burns their hand on a hot iron, the pain they experienced leads them to avoid touching hot irons in the future – this fear protects them. When a child is beaten or humiliated for speaking their mind to their parents, that pain teaches them to keep their thoughts and feelings to themselves – this fear hurts them. While fear has the biological purpose of keeping our bodies alive and fighting when we are faced with danger, it is a double-edged sword because, as social animals, the role of fear in our lives is significantly more nuanced. Fear does not just come up when we touch something hot or get bitten by an angry dog, but it can come from other human beings who cause us emotional or physical harm. It can also come from mental illnesses that impact our feelings of safety and our worldview. Fear is not simple and the effects it can have on a person's existence are profound.

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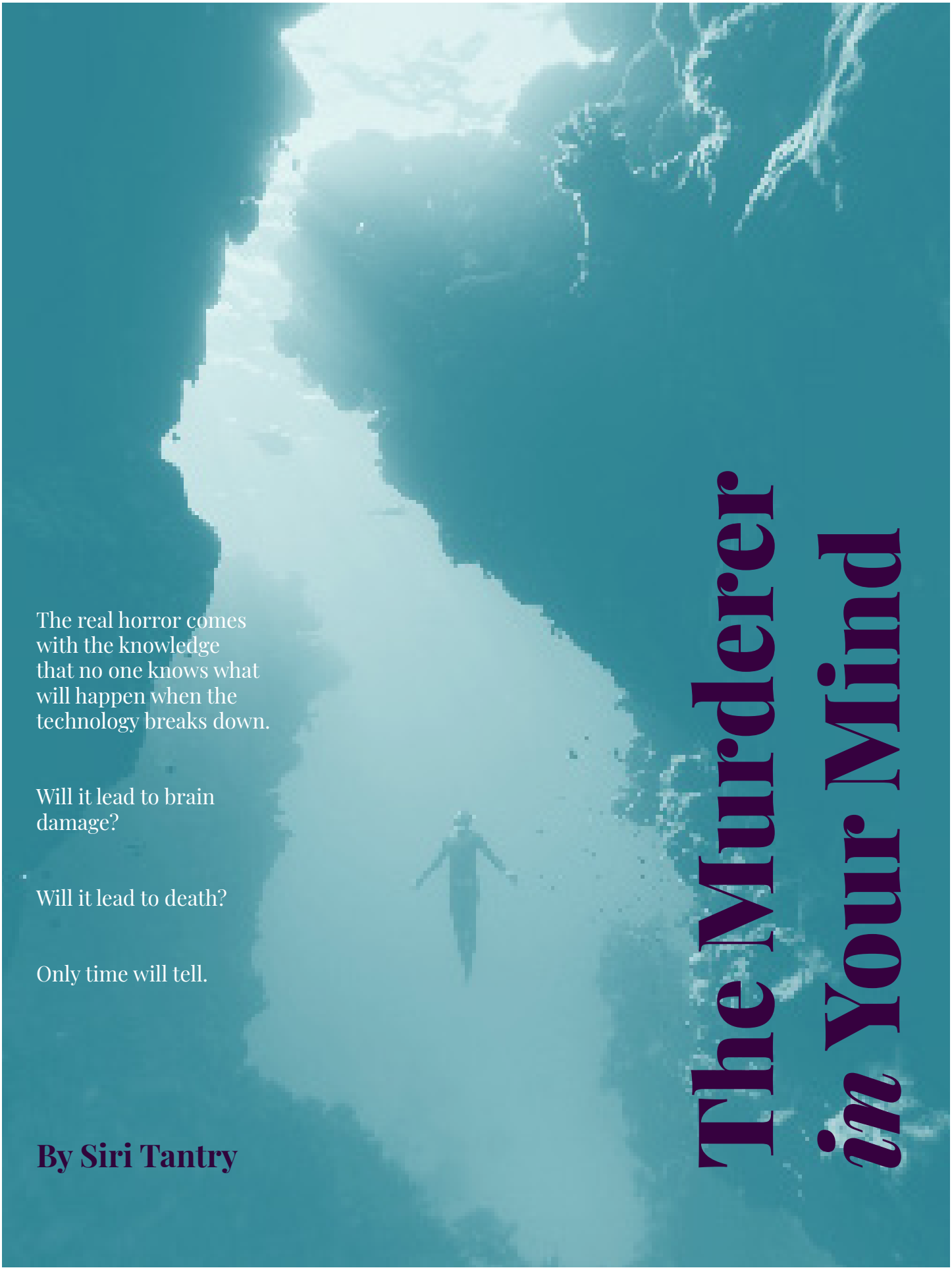

The Murderer *in* Your Mind

The real horror comes with the knowledge that no one knows what will happen when the technology breaks down.

Will it lead to brain damage?

Will it lead to death?

Only time will tell.

By Siri Tantry

Technology is meant to aid you in everyday life, but what if that same technology is, day by day, bringing you closer to death? This is the situation that many people who depend on invasive neurotechnology face. Each day they are gambling on whether the technology that has been implanted in their body will lose control and severely hurt them, or worse, kill them. Take Timothy White's own experience. Timothy White was a recipient of the neurotechnology that was developed by the start-up Autonomic Technologies, Inc. (ATI). The stimulator technology that he received allowed him to suppress his cluster headaches through a surgical implant in his cheek. With an external remote control, he could send electrical impulses to his brain during a headache to alleviate the pain. However, when ATI went out of business, White was left on his own. There were no answers when he asked about the possibility of the remote control breaking down or having the battery die. He was pushed to the dark solely with the knowledge that there was sensitive technology inside his body and the fact that this technology could break down anytime with no warning. The real horror comes with the knowledge that no one knows what will happen when the technology breaks down. Will it lead to brain damage? Will it lead to death? Only time will tell.

While this sounds like a scene from a sci-fi book, it is unfortunately the reality for many. There have been many cases of neurotechnology companies going under, forcing individuals to live with implanted technology for the rest of their lives. While these companies were up and running, their technology helped many people better deal with neurological disorders like migraines, seizures, and cluster headaches. However, once they have gone bankrupt or have collapsed, their technology continues to remain in the patient's body, but they no longer have access to the software needed to maintain the technology and recalibrate the device, thereby rendering the solution to their problem eventually useless. Even our phones are constantly being upgraded to the newest software to make sure no bugs affect their function. How can we expect such high-level and sensitive technology that sits inside someone's body to stay stable for years on end without any upkeep? Without the technology being supported or taken care of, it is only a matter of time before the wires are snagged or the battery causes the implant to become unstable, risking patients' health. Currently, there seems to be no feasible alternative to this problem – surgery to remove the implants is expensive and risky and there are not many other companies with the exact technology that can provide support to these abandoned individuals. This means that these patients are constantly living in fear with the uncertainty of what to do next and what will happen to them in the future. Is this neurotechnology the murderer waiting to prey on your mind?

When I talk about neurotechnology, I am referring to technologies that can be invasive (inside the brain) or non-invasive (outside the brain) that serve to understand or improve brain function. However, many of the neurotechnologies companies that have used invasive technology have greater potential to cause intense damage to a person's life – with or without knowing.

Before going into the why, it is imperative to understand the how. How does neurotechnology risk a person's health exactly? When invasive technology such as chips or surgical implants are inserted in the brain or body, they must be handled and looked after with extreme attention to detail. Even the smallest change such as a wire out of place could drastically hurt the patient. For instance, Markus Möllmann-Bohle has a "miniature radio receiver and six tiny electrodes" which spares him from clusters of headaches by releasing electrical pulses into the sphenopalatine ganglion (a bundle of cells in the trigeminal nerve). Before using the technology, Markus was constantly dependent on painkillers and antidepressants, even to the extent of being hospitalized numerous times. Imagine having chronic clusters of headaches for eight hours a day, everyday. That was the life Markus was leading before the implant in his cheek. Now, this technology implant, in his own words, allows him to "live a good life."

However, while this may seem like a positive outlook on neurotechnology and Markus' situation, there is more to the story – namely that the neurotechnology company, ATI, that manufactured these products, collapsed, leaving over 700 individuals alone with an implant in their body. One may think that even if the company collapsed the patients would still have access to the technologies and medical care, but that isn't the case. Because of the collapse, the people who used the stimulator no longer had access to the "proprietary software needed to recalibrate the device and maintain its effectiveness." Not only does this mean that the dependence that these individuals had on technology was being threatened, but also that there was an unstable piece of technology inside their bodies. If this were just one rare instance of neurotechnology harming people's livelihood, I wouldn't be writing this article, however, this is a systemic problem that affects hundreds of thousands of people who benefit from implanted neurotechnology. With the neurotechnology market estimated to grow by 75% by 2026, the possibility of neurotechnology companies going out of business and abandoning the people who have come to depend on their devices continues to grow as well.

Just like they say history repeats itself, after ATI collapsed, another neurotechnology company called Nuvectra also filed for bankruptcy, ending technological support for over 350 people. Critics noted that Nuvectra's failure may have been due to quality control issues as well as a lack of proper management in regard to the company's suppliers. As more companies go down under, more people will be negatively affected by the lack of support they will be facing.

What's the solution for this? Well for one, as alluded to above, it's not yet feasible to remove the implants from every patient. This means that people are forced to take matters into their own hands. They must find ways to manage the neurological conditions that they depended on the technology for, while also trying to find a solution to the non-functional implant. If they are unable to do so, they are left to suffer with no hope in sight. If this isn't bad enough, the neurotechnology that is being used itself is so niche that there aren't any "ready replacement[s] available."

While some people, like Markus and White, took matters into their own hands by making use of their educational backgrounds to create new technology or medicine, this doesn't mean it can be a solution for everyone else – especially when that same background and educational level is not equal for all patients. Markus repaired a faulty charging port for his remote and had to replace its battery several times, even though that battery was never supposed to be accessible to the user. White, using his medical background, developed a new drug to treat his migraines as a replacement for the technology he was previously dependent on. While this sounds great, the cost of this new drug is that he must take three times the regular recommended dose. Once again, this brings up the question of the long-term side effects of this methodology that involves taking matters into one's own hands.

Now, hearing about such heroic stories is great – but it's not feasible for everyone. What about the consumers who don't have a degree in electrical engineering or drug development? What are they supposed to do?

A mistake that many make is that they get overly excited about the possibility of advancement in the field which unfortunately often leads to the disregard of risk (whether they are business or science related). In such situations, it can be hard to remember or understand why exactly neurotechnology companies collapse. One of the main reasons is ethics and safety concerns. Data protection in this day and age is extremely important and laws are only becoming stricter, which means that many startup companies have a lot of background work they need to complete before being able to launch, and those that are already established have to restructure to comply with these laws unless they want to file for bankruptcy or be shut down for non-compliance. Another concern is safety. Medicine and the human body are ever-changing and different, so something that works for one person doesn't necessarily mean that it will work for everyone else. To put this in perspective, a company called Implant AG had to shut down, citing negative trial results as one of their causes. Just take Markus's remote for instance. The technology that he is tampering with isn't the same as another user's technology coming from a different company. This would mean that his approach to fixing the technology may not work for another person. Additionally, it puts more pressure on clinical trials that are constantly under the stress and critical question of what happens if or when the technology fails. For example, EndoStim had to shut down after a failed clinical trial where the "control arm experienced positive results." What if the trials are not representing a whole population of individuals who could end up using this launched technology? How could this lack of diversity affect the health of the consumers? Such questions are extremely important to answer and many times when they are unanswerable, the companies end up going under. Other issues include the lack of proper management in the company as well as the lack of quality control causing companies like Nuvectra to go bankrupt.

In short, while neurotechnology is something that truly is beautiful and has amazing potential for the future, it definitely doesn't mean that we can turn away from the dangers it also poses. People's lives are slowly put at stake as these companies one by one go under and offer no support to the already invasive technology present in the patient's body. A solution must be found, but until then, there is no denying that there might be a murderer amongst thousands of people's minds. The only question is… who's next?

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Now or Never? The Neuroscience Of Delayed Gratification

By: Tiffany Ho

Formatting: Hannah Corr

Your favorite milk tea shop comes into sight as you turn the corner. You know it's not a good idea–you'd already gotten a sugared beverage the night before. But you just completed an intense workout and your friends are ordering drinks anyway. Why not? It'll be a reward. Your body seems to have a mind of its own, reaching into your pocket and pulling out your phone from muscle memory. Before you know it, your go-to drink is in your cart, thumb hovering over the purchase button. You hesitate, mind blank as you struggle to make a decision.

Should you satisfy your cravings now and suffer the consequences later? Or, should you resist the temptation, considering the future?

In disorders including but not limited to ADHD, OCD, obesity, and substance abuse, patients have great difficulty resisting temptations that healthy individuals are otherwise able to withstand. This may be a result of differences in the connectivity of brain regions involved in decision making, future planning, and reward. Research on mice has identified that dopaminergic (DA) neurons in the ventral tegmental area (VTA) of the midbrain play a role in delayed gratification (DG).* In a 2021 study, Gao et al. reproduced DG in mice by restricting the amount of water available for consumption (See Figure 1).1 Gao et al. measured the relative activity of VTA DA neurons in the mice by recording neuronal calcium signals over time using fiber photometry.** For the mice in the experimental group, activity in VTA DA neurons increased steadily during the waiting period and peaked when water was consumed. No significant differences were observed for the control group. Additionally, optogenetic techniques revealed that inducing activity in VTA DA neurons led to a longer waiting duration, while inhibiting activity in VTA DA neurons decreased the waiting duration significantly. These results suggest that damage to DA neurons and/or regions of the VTA could be the cause of impulsivity and irrational decision making in various neurological disorders.

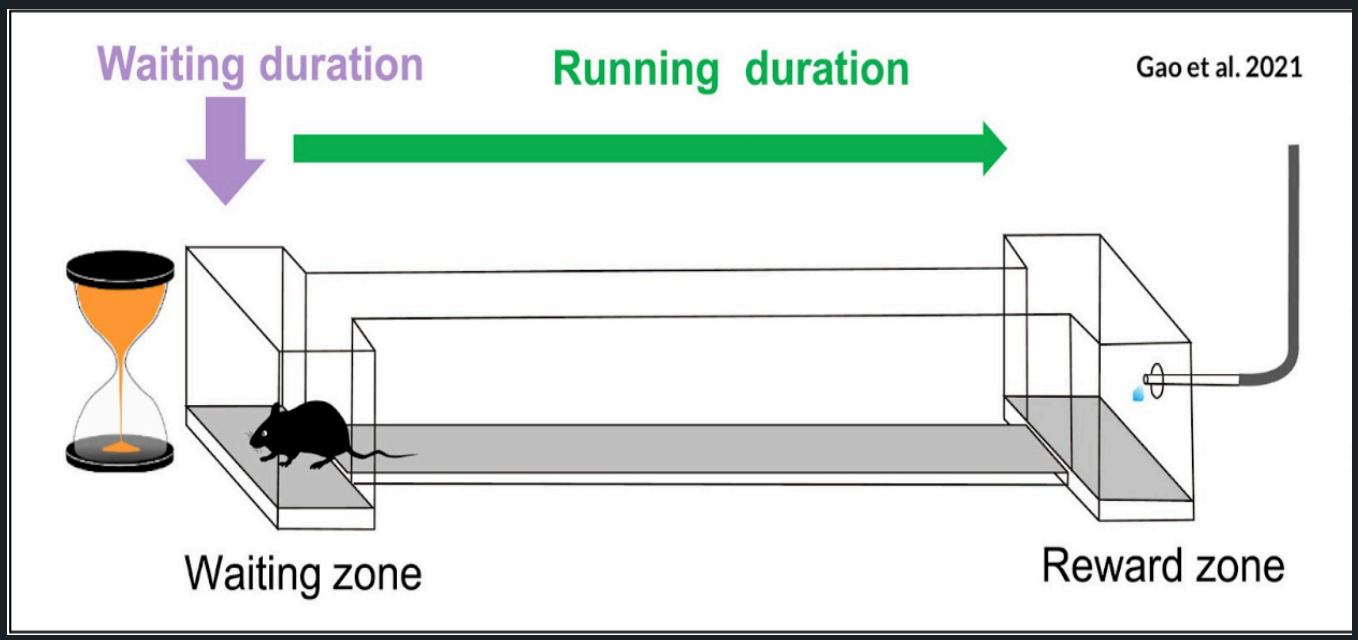

Figure 1. Mice in the control group were offered the same amount of water (10-μl) each time they licked the water port in the Reward Zone of the cage regardless of time spent in the Waiting Zone. In contrast, the amount of water rewarded to the experimental group was increased quadratically with the amount of time spent in the Waiting Zone.

involvement of GABA neurons in decision-making and reward. GABA, the primary inhibitory neurotransmitter in the brain, downregulates activity of several brain regions and neurotransmitter systems–including DA. In a 2019 review, Bouarab et al. reported that optogenetic stimulation of VTA GABA neurons resulted in the suppression of VTA DA neurons.2 Eshel et al. previously found that optogenetic inhibition of VTA GABA neurons increased activity in some DA neurons.3 Stress and drug abuse have significant impacts on the functionality of VTA GABA neurons, enabling deficits in GABAergic neurons to influence dopamine systems in reward and gratification. Other aspects of the brain found to play a role in DG include the dorsal prefrontal cortex (PFC),4 frontostriatal white matter,5 the right temporoparietal junction,6 and the ventromedial PFC.7 Thus, tumors and neurological conditions that alter the structure or function of these brain regions have the potential to impair reward systems in otherwise healthy humans.

In addition to the above brain regions, interactions between the cerebral cortex (CC) and nucleus accumbens (NA) have been associated with DG in children. The NA releases dopamine upon stimulation and plays an important role in feelings of satisfaction during reward. Functional magnetic resonance imaging (fMRI) studies examining associations between DG and the degree of CC-NA connectivity have shown conflicting results; Luerssen et al. found no significant association8 while Steinbeis et al. found a correlation between stronger ventromedial PFC and dorsolateral PFC connectivity with reduced discounting of DG.9 Further research is necessary to establish whether an association exists.

A pioneering study on behavioral aspects of DG was performed by Austrian-American psychologist Walter Mischel.10 In his experiment, nursery school children were taken individually to a playroom (the experiment room) and presented with two sets of potential rewards: two animal cookies or five 2-inch pretzels. After the children expressed which set they preferred, they were instructed to wait until the experimenter returned in order to receive their desired reward. If the children wanted to bring the experimenter back into the room at any point during the waiting period, they could do so by eating a 1/3-inch piece of pretzel and would instead receive their less preferred reward. The experimenter then left the room for 15 minutes to observe the children's responses.

Each child was left with either no reward, their preferred reward, their less-preferred reward, or both rewards in sight. No rewards in sight found the greatest mean wait time of 11.29 minutes (SD=6.84 min). In contrast, the mean wait time for the preferred reward group was 4.87 min (SD=6.57 min), the less-preferred reward 5.72 min (SD=6.43 min), and both rewards 1.03 min (SD=2.39 min). This suggests that visual cues work against an individual's ability to delay gratification, as the children who could see either one or both rewards during the waiting period exhibited significantly lower wait times. For adults and adolescents with diminished DG, preventing visual triggers, such as removing addictive substances from the vicinity of substance use disorder (SUD) patients, may improve ability to overcome instant gratification.

If you had taken a different route home from the gym, one in which you didn't see or pass by your favorite milk tea shop, would it have been easier to decide against purchasing a drink? If visual cues decrease one's ability to choose long-term benefits over immediate rewards, avoiding triggers or–even better–removing them from one's environment would be the way to go.

ADHD, short for attention deficit hyperactivity disorder, is often characterized by inability to concentrate for extended periods of time and difficulty controlling impulsive behaviors. Since delaying gratification relies on self-control and resisting immediate rewards, children with ADHD

often display deficits in DG.11 Due to increased impulsivity, children with obsessive compulsive disorder (OCD) tend to prefer smaller immediate rewards over larger delayed rewards as well. Obesity presents another disorder in which DG is impaired. Studies have found that children with decreased DG are more likely to become overweight or obese.12 While these conditions may themselves be the cause of deficient DG abilities, failure to treat the aforementioned deficits during childhood may lead to more serious consequences later in adulthood. Thus, research in these fields is crucial for preventing additional disorders such as alcohol and drug abuse.

Research on DG in children has found that a child's willingness to delay gratification is impacted by the trustworthiness of adults around them.13 It may be reasonably inferred that adult/parental influences guide the ability of children to delay gratification throughout childhood and development. Gong et al. studied adolescent smartphone addiction (ASA) and parental smartphone addiction (PSA) through parent-child pairs in Lanzhou, China.14 Statistical analyses revealed a positive correlation between ASA and PSA, allowing us to hypothesize that the presence of disorders such as addiction and substance abuse in household adults may be linked to the development of similar disorders in children.

Alcoholism is very common in the US. Over six percent of US adults develop alcohol use disorder (AUD) in their lifetimes, and alcohol abuse is the cause of thousands of deaths each year. Currently, most interventions for AUD target DG through behavioral training, brain stimulation techniques, and medication, as immediate gratification is the primary cause of repeated, unreasonable alcohol consumption.15 Available treatments have yet to be improved, though, as DG involves the proper function of many brain structures and networks that are often damaged by untreated pre-existing conditions. As in alcoholism, substance use disorders (SUDs) are also linked to impaired delay of gratification.16 Abuse of alcohol and drugs have been associated with increased likelihood of crime, making improvements in the detection and identification of these problems an important next step in the field of DG research.

In a 2020 study, Armstrong et al. confirmed that psychological abuse, impulsivity, and sensation seeking–each with a pre-established scoring system–possess statistically significant correlations with criminal behavior ($P < 0.001$).17 Other psychological traits including callousness and egocentricity have shown to be correlated with criminal behavior as well, suggesting that targeting only DG in those with impaired gratification systems may not be sufficient to prevent crime. Gambling disorder (GD), linked to impulsivity and other traits, is often associated with criminal activity as well. Mestre-Bach et al. studied 382 patients diagnosed with GD at the Bellvitge University Hospital in Spain.18 Personality trait questionnaires, substance use tests, and statistical analyses revealed that severity of GD, debts, impulsivity, psychopathology, and novelty seeking show significant associations with criminal activity ($P < 0.001$). Likewise, improving gratification in these patients may not be sufficient to completely stop crimes, but treatment remains effective for lowering criminal behavior in those victim to impaired DG.

I could go tonight without a drink. I'll save it for next time! As your phone is returned to your pocket, you breathe a sigh of relief knowing that you've resisted your cravings, denied the devil on your shoulder. It feels as though you've gained a beverage: the drink you chose not to purchase tonight will be one for another day–a day in which it is much more needed.

I deserve a little reward tonight. I can just hold back next time! You smile in anticipation, sitting down next to your friends as you wait for your order. One by one, your friends retrieve their drinks until, finally, your name is called. As you take your first refreshing sip, you feel a new wave of confidence. You'll be able to resist your cravings next time… right?

For thousands of years, the ability of humans to delay gratification for greater future gain has proved evolutionarily advantageous. Future investigations on differences in the neuronal networks responsible for decision-making and reward in those with faulty gratification responses will allow researchers to better understand the implications of these preferences in neurological disease and neurocriminology. Improving technology for the diagnosis and treatment of these conditions will lead to a world with less murder on our minds.

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Contributers

Shobhin Logani | Publications Lead, Editor

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

Jacob Marks | Publications Lead, Editor

Jacob Marks is a senior studying Cognitive Science and Data Science at UC Berkeley. He loves learning about the brain and interned at the National Institute of Neurological Disorders and Stroke over this past summer. 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 his third and final semester as Publications Lead and hopes to pursue medical school, then neurology after undergrad.

Aileen Xia | Author

Aileen is a freshman at UC Berkeley studying Molecular and Cell Biology with an intended major in Business Administration. This is her first semester at Neurotech@ Berkeley, and she's excited to discover more about neurotechnology as a field. Aileen Aileen wants to further discover the industry side of biotechnology during her time at Berkeley, and plans on going into biotech after graduation.

Tess Gunatilake | Author

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

Jade Harrell | Author

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

Contributers

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

Parvathy Nair | Author
Parvathy is a freshman at UC Berkeley studying Cognitive Science with a minor in Data Science. She is passionate about cognitive and psychological sciences and hopes to pursue product marketing management after graduation. Outside of the classroom, Parvathy enjoys art, Indian classical dance, and baking!

Ryan Wu | Author
Ryan is a freshman at UC Berkeley studying Bioengineering. This is his first semester as a writer for Neurotech@Berkeley. He is interested in studying computational biology and understanding how it could impact the medical field. Ryan is hoping to pursue a career in medicine after undergraduate.

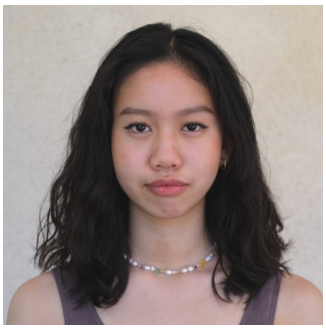
Sarita Celaya | Author
Sarita Celaya is a freshman planning to major in Molecular and Cell Biology. She plans to become a doctor to work as a researcher in neurology/neurosurgery. She is passionate about reaching underserved patient communities and aspires to aim her research at how to best reach and serve them. She is currently working as a physics research assistant in a laser lab and enjoys singing, dancing, running, and reading old thrillers (such as the Hercule Poirot mysteries).

Meltem Su | Author
Meltem Su is an undergraduate student specializing in Molecular and Cell Biology. When she is not writing, you can find her ballroom dancing and learning new languages. Her personal experiences with lucid dreaming and false awakenings has always made her curious in understanding how dreams function and their significance. Her curiosity drove her towards writing about dreaming and presenting her findings to a larger audience who may also relate to her experiences.

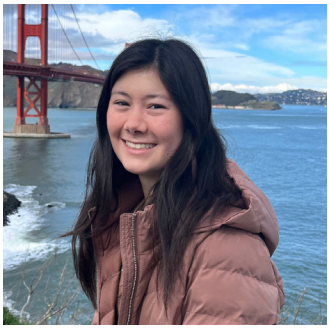
Contributers

Tiffany Ho | Author
Tiffany Ho is an undergraduate student studying Molecular and Cell Biology. She holds a deep passion for research and plans to pursue graduate and medical degrees in neuroscience and neurology. With her friends and colleagues at Neurotech@Berkeley, she hopes to bridge gaps between technology and medicine, using innovation to push science and medicine forward. Outside of UC Berkeley, Tiffany is an undergraduate researcher in the Ho Lab at the UCSF Schools of Dentistry and Medicine, as well as the Ostrem Lab with UCSF Neurology.

Niki Parker | Author
Niki Parker is a first year student hoping to pursue cognitive science and computer science at Berkeley! Ever since childhood, she's always been interested in the brain and how its study and understanding can be applied in various directions, stemming from biological to psychological to computational applications and much more. As a member of NT@B, she deeply enjoys contributing to the ever growing fields associated with neuroscience and technology! Outside of NT@B, she's a research assistant in the Gopnik Lab at Berkeley, focusing on child cognition and development. She hopes to incorporate her passion for the brain in her future career, no matter the direction.



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



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

NEUROTECH@BERKELEY