FEATURED ARTICLES

Cotard's Syndrome: The Real Walking Dead
- Shruthi Ganesh

The Impacts of Social Isolation and Loneliness on the Brain: An Overview
- Magda Wojtara

Changes in the Neurological Expression of the Hippocampus on Kainic Acid-Induced Neurotoxicity
- Celestine Suyeon Reuben
## CONTENTS

### INTRODUCTION

| Letter from the Editors | Journal Leadership | page 6 |

### GENERAL NEUROSCIENCE

| Changes in Neurological Expression of the Hippocampus on Kainic Acid-Induced Neurotoxicity | Celestine Seyon Reuben | pages 7-13 |

Kainic acid (KA) is an acid originating from seaweeds in Japan. It serves as a useful model for studying damaged neurons by mimicking the actions of glutamate on the glutamate receptors in the brain. From rapid and complete degeneration of neurons in the entire hippocampal formation to the gliosis and atrophy of those neurons, microglia & astrocytes, decades of experimental research has unearthed that KA has a toxicological impact on the nervous system. This article aims to unveil research project outcomes at the histological and molecular level in the variations in the expression of the hippocampus after kainic acid administration, and also suggest areas for future research studies where neuroscientists can collaborate with biochemists and nutritionists to study the effects seafood products have on the biochemical expressions of the brain. How does the excessive expression of kainic acid in the hippocampus affect its immune response? What could the effect of reducing the potential of synaptic plasticity after kainic acid administration mean, considering its metabolic rate? If these questions tickle the curious bone in you, tune into the latest IYNA journal to find more articles like this!

| The Impacts of Social Isolation and Loneliness on the Brain: An Overview | Magda Wojtara | pages 14-18 |

The COVID-19 pandemic has resulted in unprecedented levels of social isolation in an attempt to reduce virus transmission. From marked changes in several brain regions to looking at the influence of video chat technologies on psychological factors, this article looks into a broad overview of the features of the COVID-19 pandemic and how it influences these negative impacts on people's psychological and physiological well being. In the end, this article serves to be an alarming reminder to address and tackle these issues in the pandemic - either by providing counseling or improving accessibility of communication technologies. Can increased levels of social isolation affect reasoning and memory performance, hormone homeostasis, and directly impair the immune system? What does the suppression of the Tac2 (tachykinin) signaling system due to social isolation, mean in terms of fear-related behavior? Check out the recent IYNA journal article to find the answers yourself!

| Implicit Social Cognition: Connection to Brain Regions and Measuring Tools | Jiwoo Park | pages 19-25 |

Our brains are incredibly powerful; sometimes we can't even realize it. Implicit Social Cognition (ISC) is a term coined to explain our brain's unconscious response to the external world. It can exist in forms such as attitudes and mentalities toward certain actions. If we can't control it, we shouldn't worry, right? That might
not be the case. In the article Implicit Social Cognition: Connection to Brain Regions and Measuring Tools, author Jiwoo Park dives into the multiple parts of the brain and tests that play a role in our current understanding of ISC. One study that is described is the role of the amygdala in developed bias. In the paper, Jiwoo Park describes how tools including fMRI and IAT tests have shown the amygdala may develop with multiple social cues to form implicit biases. Interested in learning more? Check out this article in the new issue of the IYNA Journal!

Neuroplasticity: Rewiring and Repairing the Nervous System  
Alexander Julian Rayo  
pages 26-31

The human brain changes as it learns new behavior. Fascinating, right? New research has shown that neuroplasticity, reformation of the nervous system, occurs as we learn new skills and tricks. The neurons in our brain have dendrites which are long “arms” used to talk. Protrusions along these dendrites allow our brain to edit itself and learn new skills quicker. For example, as you kick a soccer ball, you will eventually learn how to kick it properly and with time, your kick will become more and more efficient. In the article Neuroplasticity: Rewiring and Repairing the Nervous System, author Alexander Julian Rayo explores the application of this novel neurology study as well as its applications to diseases that are affecting the elderly population in large numbers today. Understanding neuroplasticity can be crucial to how we treat behavioral and memory problems. As Alexander Julian Rayo explores, there are 4 principles behind the practical usage of neuroplasticity knowledge. Applying these principles to biotechnology and using them to create new treatments may be a key role in our combat against these age-related disorders. Interested in reading this take on the principles behind this incredible process? Check out Neuroplasticity: Rewiring and Repairing the Nervous System in the new edition of the IYNA Journal!

DISEASES AND DISORDERS

Akinetopsia: Motion Blindness  
Keira Ayoub and Tania Ajel  
pages 32-36

Oftentimes, we take our ability to see for granted. Our senses, including our vision, help enhance our body and understand the world around us. One disease often overlooked is Akinetopsia, which hinders people’s ability to visualize motion. A rare neurological condition that needs action, authors Keira Ayoub and Tania Ajel, discuss this disease in their article entitled Akinetopsia: Motion Blindness. Split into two forms, inconspicuous and gross, Akinetopsia is a real struggle for those who are diagnosed with it. First documented in 1983, a relatively recent time, many brain scans have shown that patients sometimes only see snapshots of the world instead of seeing any motion. Imagine that? If you want to learn more about this unique disease, check it out in the April Issue of the IYNA Journal!

Amyotrophic Lateral Sclerosis: Membralin-Boosting Gene Modification  
Srikar Chintala  
pages 37-39

Amyotrophic lateral sclerosis (ALS) is a neurodegenerative disease that is characterized by the deterioration of the nerve cells responsible for voluntary muscle movement, or motor neurons, leading to loss of muscle control. There is currently no cure for ALS, but recent studies have identified a membralin protein’s
deficiency may be the reason behind motor neuronal death. In Amyotrophic Lateral Sclerosis: Membralin-Boosting Gene Modification, Srikar Chintala gives an in-depth review of current research surrounding this novel target, the mechanism behind ALS, and how CRISPR, a powerful tool in gene editing, can target and modify the gene that codes for the membralin protein in order to cure individuals of this fatal disease.

Correlations Between Schizophrenia and Bipolar Disorder
Adele Raillot

Schizophrenia is a mental disorder that is known to distort thought, emotion, and perception of reality; it is among the top 15 causes of disability and affects around 1% of the world’s population. Bipolar disorder, characterized by manic and depressive episodes, is the 6th leading cause of disability in the world and has a similar frequency as schizophrenia. Despite their rarity, it was found that the disorders tend to occur simultaneously in individuals. Historically, psychiatric disorders have been treated individually, but recent studies suggest that the disorders’ correlation and frequent misdiagnosis of the other are no coincidence. In Correlations Between Schizophrenia and Bipolar Disorder, author Adele Raillot provides insight into how the disorders are linked and how further research into their correlation may lead to improved treatment of concurrent psychiatric disorders.

Cotard’s Syndrome: The Real Walking Dead
Shruthi Ganesh

What if The Walking Dead was real? Cotard’s Syndrome, first identified in 1880 by Dr. Cotard, is described as a mysterious illness with common tendencies including depression and not believing that certain body parts exist. Similar to many other psychological disorders, Cotard’s syndrome may stem from brain abnormalities. Cases point that this syndrome might be associated with misfiring in the fusiform gyrus. Though some understanding of the pathology exists, treatment is still far. ECT therapy can create small seizures via elctry to possibly treat some symptoms of Cotard’s syndrome. With the craziness behind this article and if you are a fan of the Walking dead, be sure to check out Shruti Ganesh’s article Cotard’s Syndrome: The Real Walking Dead in the new IYNA issue!

Insomnia: An Overview
Shivani Verma

Have you ever wondered if anyone doesn’t sleep? Although it may be true that some people struggle to keep normal sleeping schedules, there are greater issues such as insomnia. Insomnia is a significant sleeping disorder that makes it difficult to stay asleep. Moreover, it can change someone’s mood and performance during the day. There are two types of insomnia: acute and chronic. While many people can experience acute insomnia due to various factors in their lives, chronic insomnia can lead to severe complications and issues. Read on to learn more about the treatments, preventative measures, and links between insomnia and the current COVID-19 pandemic.

The Gut in Parkinson’s Disease Pathogenesis
Richard Zhu
Most of us have heard of Parkinson's disease whether that be through school, family relatives, or even the media. This disease has affected millions globally and it is characterized as neuronal death in the central nervous system and can have both motor and non-motor symptoms. Now, when you see this, would you think of such a disorder to be associated with the guts? Probably not, however, recent research points towards there being a biological connection between these two systems. Specifically, changes in the PD pathology, including alpha-synuclein and inflammation prove the hypothesis. Read on to learn more about the extent of this connection and the methods used to find better treatments!

**NEUROETHICS**

Games of Abuse: The Neuroethical Issues of Gaming Addiction

*Michael Bai*

From substance abuse to social media, the dopaminergic system which mediates the most basic reward pathways of the brain, has been “hijacked” by those who attempt to misuse human nature for financial profits. Specifically touching upon gaming addiction, this article aims to compare just that with substance abuse, where certain structures of the dopaminergic system and the PFC (Prefrontal Cortex) have been stated to have variations in individuals addicted to gaming. The article also highlights the ethical concerns of the gaming industry’s impacts, where it urges legislators to encompass restrictions for age and overall timing of gameplay. What connection do research studies suggest about individuals who report persistent craving for online gaming with the ventral tegmental area-nucleus accumbens (VTA-NAc) pathway? Are gaming addicts more likely to have an antisocial personality or neurotic personality? If these questions intrigue you, find the answers to them in the latest IYNA journal!

Consciousness: A Philosophical and Scientific Mystery

*Francesca Venditti*

Have you ever thought about where thoughts come from? All of us have a consciousness or a state of awareness regarding our existence. Consciousness allows us to experience the world interactively. However, there is a persistent debate between philosophers and scientists. In fact, this question has been asked since the earliest days of antiquity up to the present day. Read on to find out more about the new discoveries being made by neuroscientists and philosophers relating to the origins, implications, and existence of our consciousness.

The Brain, Evolution, and Intelligence: An Overview

*Rutvi Vaja*

Have you ever wondered what makes you capable of solving that difficult math problem or learning a new language? Neuroimaging and computational software have allowed neuroscientists to understand that there is no one structure responsible for intelligence, but recent studies suggest that brain size is a determining factor of cognitive ability. For a long time, humans have assumed that they are cognitively superior beings in the animal kingdom, but in terms of brain size, elephants and whales far exceed humans. In order to rectify this contradiction, scientists created the encephalization quotient, an alternative measure of brain size that is the ratio of brain mass to expected brain size for animal size, with humans leading the scale. In The Brain,
Evolution, and Intelligence: An Overview, author Rutvi Vaja gives an anatomical overview of the brain, research related to the most prominent structures of intelligence, and the correlation of brain size and intelligence over evolutionary time.

Towards New, Modified Human Rights in the Era of Neurotechnology: Call for International Human Rights Law

Ehab S. Mohamed

Have you ever wondered if anyone doesn’t sleep? Although it may be true that some people struggle to keep normal sleeping schedules, there are greater issues such as insomnia. Insomnia is a significant sleeping disorder that makes it difficult to stay asleep. Moreover, it can change someone’s mood and performance during the day. There are two types of insomnia: acute and chronic. While many people can experience acute insomnia due to various factors in their lives, chronic insomnia can lead to severe complications and issues. Read on to learn more about the treatments, preventative measures, and links between insomnia and the current COVID-19 pandemic.
Letter From the Editors

Journal Leadership

Dear Readers,

Welcome to the fifth installment of the fourth season of the IYNA Journal! As the gloomy month of April draws to a close, the arrival of May signifies hope in the midst of recent turbulent events, such as the rising COVID-19 mortality rates in India, gun violence and racially motivated police brutality in the states, and Islamophobia in France just to name a few. We at the IYNA Journal stand in solidarity with everyone who is hurting during these trying times and hope that this latest issue can bring a moment of joy into your lives despite the circumstances. While vaccination is becoming more ubiquitous in certain parts of the world, we understand that vaccine distribution remains an inequitable process, and the impending return to normal is not a privilege that all of our readers will be able to enjoy at the same time in the near future. And for those who are graduating or finishing up another semester in school, congratulations on all of your hard work. We hope your upcoming summer (or winter for our readers in the Southern Hemisphere) is a time of happiness, health, and relaxation for you and your family.

Throughout the month of April, our editing team has worked tirelessly in conjunction with our roster of contributing authors to perfect the articles you can see summarized by the journalist team in the preceding table of contents. With that being said, here are the previews of the featured articles published this month:

Shruthi Ganesh provides an overview of Cotard’s Syndrome, Magda Wojtara enumerates the impacts of social isolation and loneliness on the brain, and Celestine Seyon Reuben surveys the changes in neurological expression of the hippocampus on kainic acid-induced neurotoxicity.

As you read each article, we hope you leave feeling more informed and curious about the enigma that is the human brain. At the very end, you can see all the names and positions of the journal department staff on our Contributors page. If you have any questions, comments, or suggestions for us, please feel free to contact the Editor-in-Chief directly at swagle@youthneuro.org. Happy reading!

Best Regards,
Sojas Wagle - IYNA Journal Editor-In-Chief
Annie Pan - Head of Assembly
Shyam Soundararajan - Managing Editor
Ashvin Kumar - Senior Editor
Kunal Dhirani - Senior Editor
Anca-Mihaela Vasilica - Senior Editor
Gasser Alwasify - Senior Editor
Sampath Rapuri - Senior Editor
GENERAL NEUROSCIENCE
Changes in Neurological Expression of the Hippocampus on Kainic Acid-Induced Neurotoxicity

Celestine Seyon Reuben

Abstract

Kainic acid has aided neuroscience in advanced research and conceptualization of the molecular, neurochemical, and pharmacological mechanisms of underlying conditions like epilepsy and seizures. Over the decades, the kainic acid effect was not fully recognized. However, primitive researchers took note of the signs revealed after concurrent administration. Following further investigations into the brain tissue and a thorough study of its histoarchitectural regions, it was later discovered how the impact is made on areas of the brain and the degree of the impact \[5\][6]. The hippocampus, the long-term memory processing and storage tool, is most susceptible to change in neurological dynamics after the administration of kainic acid. Kainic acid is currently a model in Neurotoxicological research projects \[7\].

The aim of the article is to reveal research project outcomes at the histological and molecular level in the changes in the expression of the hippocampus following kainic acid administration.

Kainic Acid

Kainic acid (KA) is similar in function to glutamate, which displays powerful, long-acting excitatory and toxic chemistry on the nerve cells of the nervous system. In neuroscience research studies, KA serves as a useful model for studying damaged neurons and mimicking the actions of glutamate on the glutamate receptors in the brain \[16\]. Glutamate is a neurotransmitter, a chemical messenger of the nervous system that transmits impulses from the terminal of a neuron through the synapse to the targeted neuron. KA originated from seaweeds in Japan in 1953. It was used as a traditional medication for several years without any observations of its potential side effects. Decades of experimental research studies revealed that kainic acid has a toxicological impact on the nervous system.

The receptors of KA are receptors of the glutamate neurotransmitter that mediate rapid excitatory neurochemistry. These receptors are located on the synaptic terminals of the designated...
neuron, the presynaptic and postsynaptic terminals. The rapid influx of sodium ions is regulated by the excitatory action of KA on occupied neurons, and in this case, KA is referred to as an excitant. These receptors (along with AMPA receptors) underlie the central nervous system, rapid synaptic transmission, and gate an ion channel regulating the influx of sodium ions [7]. The receptors to which KA binds to are ionotropic receptors with subclasses. The receptor subclasses include alpha-aminon-5-methyl-3-hydroxyisoxazolone-4-propionate (AMPA), N-methyl-D-aspartate receptors, metabotropic receptors, and kainate glutamate receptors. The sporadic rush of sodium ions that produces an excitatory signal the postsynaptic terminal of the targeted neuron is triggered by the binding of glutamate to the kainate subclass of glutamate receptors. KA also rapidly produces excitatory effects when bonded with the kainate subclass glutamate receptors [6].

Roles of the kainate receptors include synaptic signaling and plasticity. These effects may occur quickly. Agonists of kainate receptors include glutamic acid (glutamate), KA, Domoic acid, and 5-iodowillardiine. Antagonists of the kainate receptor include Ethanol, Kynurenic acid, Tezampanel, and Theanine.

**Hippocampus**

Memory storage for the enhancement of cognitive processes and judgment is controlled by the hippocampus. The hippocampus is the region of the brain associated with memory functions and storage. It is deeply located in the temporal lobe of each cerebral cortex [12]. The hippocampus belongs to or is part the limbic system that functions in motivation, emotion, learning, and memory processes [13].
Anatomy of the Hippocampus

The hippocampus is a structure situated along the axis of the medial segments of the temporal lobes, forming the medial wall of the lateral ventricular inferior horns. It is made up of three components:

- Hippocampus proper (Cornu Ammonis)
- Dentate gyrus
- Subicular cortex

Histology of the hippocampus is composed of many layers ranging in surface areas, which include:

- An external molecular or plexiform layer
- A striatum oriens layer
- A pyramidal cell layer
- A striatum radiatum layer
- A stratum lacunosum molecular layer

Histological studies have shown that the hippocampus is divided into different regions called fields: CA1, CA2, CA3, and CA4. CA stands for Cornu Ammonis.

The first field, also called the CA1 field and the field of Sommer largely consists of the pyramidal cells closest to the Subicular cortex. CA2 and CA3 are located in between CA1 and the Subicular cortex. The conus ammonia IV (CA4) is formed by the cells of the hippocampal hilus [12][13].

Gliosis and Atrophy of Neurons

After several studies on the neurological effects of kainic acid on the hippocampus, it was revealed that there was a significant neuronal loss in the hippocampus. On the entire hippocampal formation, there is rapid and complete degeneration of neurons, followed by gliosis.
and atrophy. A decreased number of positive cells is observed in all areas of the hippocampus and in both blades of the dentate gyrus after administration of kainic acid [1]. Massive degeneration is observed in CA1 and CA3 areas of the hippocampus and the hilus of the dentate gyrus. Cells affected include Microglia, Astrocytes, and most of the pyramidal cells. Shrinkage or morphological changes of these neurons are revealed after the administration of kainic acid [2].

**Changes in Enzymatic Machinery of Neurons**

Enzymes that catalyze the transmission of impulse chemically are also affected. The mechanisms of enzymatic activity change from the normal state and rate after the administration of kainic acid in the hippocampus. Studies have shown that there is a significant decrease in the activity of specific biomarkers [3]. Biomarkers for GABAergic neurons, which include the glutamic acid decarboxylase, have been tested and proved in multiple instances. Additionally, a change is observed in the cholinergic and noradrenergic afferent neurons of the hippocampus. When kainic acid is induced, no significant alteration occurs in the activity of choline acetyltransferase, but an increase in tyrosine hydroxylase is observed [6].

**Reversal of Calcium Loading**

The accumulation of calcium, which has been revealed in several research studies, mostly occurs in the postsynaptic neurons of the hippocampus. Little or no changes in calcium loading were discovered immediately after administration of kainic acid. Many hours after administration, however, demonstrated the reversibility of calcium loading after the termination of seizure activity. It was also demonstrated that calcium accumulated in the soma of the pyramidal neurons and mitochondria dynamics of basal neurons of the CA1 and CA3 areas of the hippocampus. Astrocytes were also affected with significant ischemic reactions, limiting the rate of their functions in the hippocampus [4].

**Seizure Activity**

Kainic acid is referred to as an excitotoxic substance, and its administration induces seizures predisposing to neurodegeneration. Studies have shown that kainic acid vandalizes the third and fourth field of the conus ammonia of the hippocampus but occasionally spares the first field and dentates gyrus [9]. Destruction of the neurons in these areas leads to a reduction in the efficacy of feedback on neurons, most commonly to the pyramidal cells. Studies have shown that 5 days after kainic acid administration, seizures were
initiated in rats. Before that, neurons were damaged in and out of the hippocampal area of the brain. The seizures may have been convulsive or non-convulsive depending on the histoarchitecture of the hippocampus or an underlying condition like Parkinson’s, Alzheimer’s, or Huntington’s disease [8].

The ratio of the physiological and toxicological effects of kainic acid is drastically engulfed. The kainic acid research model has shown that it does not only affect the hippocampal area or limbic system of the brain. The striatum, thalamus, and other vital areas are also affected by the induction of this acidic substance [6][11].

Conclusion

Seaweed consumption has been terminated as kainic acid, which was initially thought to be a neurophysiological agent but has now been confirmed as a neurotoxicological agent. A recognized glutamate neurophysiological action is to aid the cognitive process of the brain, which can only happen when the glutamate neurotransmitter binds the appropriate receptor to elicit the designated action without any antagonism. Kainic acid excessively expresses itself in the hippocampus to cause harm to the microglia, reducing the immune response of the hippocampus. In addition to this, it slows down metabolism by affecting the astrocytes and reducing the potential of synaptic plasticity. Neuroscientists should collaborate with biochemists and nutritionists to further research studies on seafood products and their biochemical expressions on the brain.

Glossary

- **Epilepsy**: a seizure disorder characterized by the disturbance of neuronal activity in the brain
- **Histoarchitecture**: the structure of biological tissue
- **Excitatory**: related to promoting the generation of an electrical signal in a receiving neuron
- **Impulse**: a message or signal transmitted from a sensory organ or tissue to the effector organ or tissue
- **Dendrites**: branched extensions of a neuron that serve as the receptive role in a synapse
- **Synapse**: a neuronal junction that is the site of transmission of an impulse from the terminal end of one neuron to the dendrites of another neuron
- **Receptors**: biochemical structures made up of protein that are responsible for the reception of impulses and signals
- **Influx**: the arrival, entry, or invasion of a substance
- **AMPA receptors**: glutamate receptors that function in the integration of neuronal plasticity and synaptic transmission of impulses at the postsynaptic membrane
- **Plasticity**: the adaptability of the brain to changes in the environment of its processing mechanisms
- **Agonist**: a chemical substance that binds to a receptor and activates the receptor to produce a biological response
- **Antagonist**: a chemical substance that inhibits the action of an agonist
- **Amygdala**: a limbic structure in the brain that is often regarded as the emotional control center
- **Hypothalamus**: a structure in the brain that is responsible for regulating hormone levels, hunger, and satisfaction
- **Lateral ventricles**: the largest ventricles (hollow spaces within the brain that contain cerebrospinal fluid) in the brain, situated bilaterally (one on the left side and one on the right)
- **Entorhinal cortex**: a region of the brain that is located on the medial side of the temporal lobe and is responsible for memory, navigation, and the perception of time processing
- **Dentate gyrus**: the hippocampal circuit that is thought to be responsible for the formation of new memories
- **Astrocytes**: glial cells in the central nervous system that are responsible for blood-brain barrier permeability and the maintenance of extracellular homeostasis
- **Microglia**: glial cells that serve as the immune defense mechanism of the central nervous system

References


The Impacts of Social Isolation and Loneliness on the Brain: An Overview
Magda Wojtara

Abstract
The COVID-19 pandemic has resulted in unprecedented levels of social isolation in an attempt to reduce the spread of the virus. Social isolation has previously been established as a significant predictor of the risk of death, and loneliness has been shown to directly impair the immune system [1]. With many countries around the world implementing more stringent social distancing measures, it is important to consider the negative impacts on people’s psychological and physiological well-being and ways to tackle these impacts [2]. The following article aims to provide a broad overview of how the COVID-19 pandemic’s accompanying social distancing, isolation, and increased loneliness affect the human brain and how helpful virtual connections are at reducing these negative impacts.

Introduction

Many countries have been implementing and enforcing social distancing guidelines with varying degrees of severity. In some cases, social distancing has been implemented in the form of strict lockdowns and curfews, whereas others have simply reduced the allowed density at places like grocery stores and retail centers. Regardless of the approach, it is clear that the prolonged effects of the pandemic over the past several months have had several repercussions. Research has shown that people who are more socially integrated have better-adjusted biomarkers for physiological function, including lower systolic blood pressure, lower body mass index, and lower levels of C-reactive protein [1]. Conversely, the pandemic’s accompanying stress and restrictions have led to increased levels of social isolation, which can affect reasoning and memory performance, hormone homeostasis, brain grey/white-matter, and resilience to physical and mental disease [1]. Furthermore, feelings of loneliness affect neural communications’ strength between the limbic system and the default mode network [1]. The default mode network is visualized using fMRI techniques and includes the medial temporal lobe, medial prefrontal cortex, posterior cingulate cortex, ventral precuneus, and parietal cortex.

Despite an acknowledgment that these are “difficult times,” in many cases, there have not been appropriate measures in place to address the mental and emotional strains of the pandemic. For
instance, in a nationwide Chinese study, 11.0-13.3% of participants had anxiety, depression, or insomnia symptoms, yet only 1.9% of the 23,500 participants received counseling during the pandemic [2]. Additional risk factors for these mental strains include working on the frontline and not having outside activity for 2 weeks [2]. Current psychological interventions may be less prioritized than needed. It is considered by many to be essential in preserving the mental health of individuals and in developing psychological interventions to improve the mental health of vulnerable groups during this pandemic [3].

In general, several studies examining the psychological disorders related to or as a consequence of the pandemic have reported that individuals show several symptoms of mental trauma [3]. Some symptoms include emotional distress, insomnia, attention deficit hyperactivity disorder, mood swings, and anger [3]. The prevalence of stress, anxiety, and depression in the general population due to the pandemic are 29.6%, 31.9%, and 33.7%, respectively [3].

Social Distancing and Brain Changes

Social distancing, beyond psychological impacts, may also be implicated in physiological changes in the brain. Neuroimaging techniques, like fMRI, found greater gray matter density and stronger connectivity in the default network region of the brain of people experiencing loneliness [4]. Loneliness also better preserved the fornix, which is a collection of nerve fibers carrying signals between the hippocampus to the default network [4]. It is believed that these changes occur for a few reasons. One of the most cited reasons is that the up-regulation present in these brain regions may be an attempt to fill a social void [4]. Another explanation is that loneliness could promote imagination and reminiscence, which results in a strengthening of the associated neural pathways [4].

Having established that loneliness is a state that indicates the basic psychological need for social connection is not being satisfied, research demonstrates another brain region impacted by this predicament [5]. The ventral striatum (VS) is most commonly associated with food cravings, but it is now believed to contribute to “social cravings” when one is lonely [5]. According to this, lonely individuals had increased ventral striatum activity upon viewing a close other, as opposed to a stranger, and this may reflect an increased desire for social connectedness [5]. In a longitudinal study that was not directly associated with the pandemic, loneliness was one of the criteria that demonstrated the most detrimental negative impacts - to the same magnitude as a positive effect from exercise [6].
Given the COVID-19 pandemic, social distancing places additional difficulties on the human ability to socially collaborate. There is a perceived interconnectedness, demonstrated by this putative model, between isolation, physiological responses in the form of activation of the HPA axis and increased cortisol, and worsening of sleep and health conditions [6].

Another area of interest pertains to a neurochemical called tachykinin, which is colloquially called the Tac2 gene [7]. Tachykinin is a neuropeptide that binds to specific neuronal receptors, thereby altering their properties and influencing their functionality [7]. This results in two main responses. The two up-regulated responses are aggression and fear. Through further experiments suppressing the gene in different brain regions, it was discovered that Tac2 affects several areas. Suppression of Tac2 in the amygdala eliminated increased fear behaviors, but not aggression, while suppression in the hypothalamus eliminated aggression, but not fear-related behavior [7]. Although this study was carried out in mouse models, it is believed that humans have an analogous Tac2 signaling system [7].

Conventional forms of mitigating social isolation and loneliness have often been to go outside, interact with clubs or groups, and to exercise [6]. However, the nature and spread of the pandemic are prompting a reconsideration of other ways in which we can address these challenges. Loneliness is often discussed in the context of geriatric populations or in individuals with pathologies like dementia or Parkinson’s Disease. However, people are now beginning to consider loneliness as an issue that impacts the population as a whole [4][6]. This is especially true for the disabled or for individuals with pre-existing health conditions, who encounter additional challenges with accessibility.

**Video-Chatting and Other Forms of Mitigation**

Nationally representative and longitudinal studies are crucial next steps in determining the long-term impacts of social isolation, as well as its accompanying feelings of loneliness, on brain structures, physiological states, and psychological well-being. In one analysis, it has been stated that findings and results primarily come from a time prior to COVID-19 [8]. There are benefits to these types of technologies outside of the pandemic. Older adults who use video chat technologies, namely Skype, have a lower risk of developing depression [9]. However, using email, social media, and instant messaging or texts did not experience this added benefit [9].

Another finding demonstrated that autonomic arousal, an effect provided by eye contact, is similar in live and video call interactions, but not in response to a video presentation [10]. The ability to see other people and make “perceived eye contact” is an essential prerequisite for autonomic arousal [10]. Autonomic arousal relates to automatic bodily processes such as heart rate and digestion. Conversely, it was not necessary to have the other person’s physical presence in order to have autonomic arousal [10]. As long as the perception of a direct gaze was present, there were affiliative facial reactions automatically elicited [10]. This demonstrates an automatic response to the perceived presence of another person. These psychophysiological responses to eye contact are
promising preliminary results to overcome the constraints of physical distance in a productive and effective manner [10].

Another study demonstrated that participants may be able to gain a sense of connectedness using communication technologies. Despite reporting having felt connected even when unable to see and hear one another, participants felt most bonded during the in-person and video-chat conditions [11].

Conclusion

Current research has indicated that social distancing, isolation, and loneliness can impact individuals on a physiological and psychological level [1][2][3]. This research has indicated marked changes in several brain regions, including the ventral striatum and brain regions associated with the default network region [4][5][6]. Initial data on the efficacy of ways to provide feelings of connectedness is promising, but further research is still needed in order to find representative nationwide data taken over a long period of time [9][10]. Such data will help inform responses to addressing mental and emotional concerns held by everyone from frontline staff and essential workers to average individuals and those with pre-existing health concerns [8]. The long-term implications of the pandemic and its associated challenges are yet to be fully studied, but this provides an important reminder to consider ways to address these issues [8][11].

References


Implicit Social Cognition: Connection to Brain Regions and Measuring Tools
Jiwoo Park

Abstract
It is easy to assume that humans have full control over how they react to different societal encounters. However, this is not the case. Individuals can exhibit certain reactions without being aware of their own motives or even the actions themselves. Anthony Greenwald and Mahzarin Banaji explained such a phenomenon using the concept of implicit social cognition. Despite being a recently introduced topic, it has drawn the attention of many researchers who came up with neuroscientific explanations as well as different types of measurements. This article discusses three regions of the temporal lobe - the amygdala, hippocampus, and perirhinal cortex - that are intertwined with implicit social cognition and the recent techniques that are used to study where and how different types of implicit mechanisms are being promoted.

Introduction
Implicit social cognition (ISC) refers to any type of cognitive response that is unintentional, unconscious, and therefore, uncontrollable. It can be applied to areas such as attitude, bias, or even self-perception [1]. ISC may differ from what the person expresses outwardly, either because they are not aware of their honest feelings or opinions or are intentionally hiding it from others to secure a positive social reputation. Hence, the elements of ISC cannot be captured through explicit measures such as self-introspection or direct responses from people. Studying how ISC develops neurologically and further characterizing its trends are crucial for uncovering certain cognitive associations that are left without being noticed and understanding issues stemming from microaggression [2].

Different Regions of the Brain That Contribute to ISC

I. Amygdala

There is a strong correlation between the role of the amygdala and ISC. The amygdala is located in the frontal portion of the temporal lobe and contains three major subnuclei—central
(CeA), basal (BA), and lateral (LA) nuclei—to detect external cues that are potentially harmful to the body [3]. The activation of the amygdala enables nearby regions of the brain to release cortisol (a stress hormone) that stimulates fear and physical responses for self-protection. Fear itself is categorized as an unconscious mechanism that is built through past experiences [4]. Therefore, regardless of people’s awareness, when they encounter a stimulus similar to the ones that they have identified as threatening or unfamiliar before, their amygdala evokes negative emotions including fear [3]. When the amygdala is repeatedly associated with a certain social group or environmental cues, it can lead to the development of implicit bias. Many experiments have used the relationship between the IAT scores and fMRI results to demonstrate that the amygdala is especially involved in provoking ISC responses to race. Those with negative implicit attitudes towards a certain racial group exhibited a greater amygdala activation when they were presented with the faces of people in that group [5][6].

![Figure 1. While both explicit and implicit bias influence human behaviors, implicit bias, which is an aspect of ISC, lies below the line of consciousness [25].](image)

II. Hippocampus

The hippocampus, which is located on the edge of the temporal lobe, systematically maps the information acquired from the environment into long term memories and uses them to guide future decisions and responses [7]. Neurologists often refer to implicit memories, which build the ISC, as 'hippocampus-independent memories,' assuming that they do not rely on one another. Previous studies have supported this hypothesis as patients with hippocampus damage experienced few difficulties with implicit memory, while their explicit memories were damaged [8]. However, recent studies have questioned this hypothesis. They propose that certain implicit learning mechanisms require the support of the hippocampus [9]. In 1998, Chung and Phelps suggested that the hippocampus is responsible for the performance of contextual (visual) cueing tasks, which is an implicit learning skill that allows people to spend less time searching for a certain target when they are repeatedly exposed to the same image or scene. In their experiment, two groups of participants—one with normal memory (control group) and another with amnesic impairment due to hippocampal
damage (experimental group)- were shown twelve different sets of a T-shaped target randomly placed among L-shaped targets. Both groups were asked to identify the direction of a T-shaped target but none of them was informed that some sets were being repeatedly shown while going through thirty different trials. People with normal memory took advantage of visual cueing tasks and spent less time responding when they were given the image that they were previously exposed to. The amnesic patients did so too; however, they still took longer than when they were shown with the images for the first time [10]. The validity of the statement made by Chun and Phelps is still under controversy, not only because the statistical difference in reduction of time between the control group and experimental group was insignificant, but also because there is not enough evidence to prove that contextual cueing tasks are solely dependent on the hippocampus. There is also a possibility that explicit memory, which the hippocampus also plays a role in, may have influenced people's performance as well [9]. The relationship between hippocampus and ISC is still under active study and therefore is worthwhile to pay attention to.

III. Perirhinal Cortex (PRC)

Unlike the hippocampus, the PRC has been shown to play an important role in conceptual implicit memory, which refers to the use of conceptual information that has been unconsciously acquired from the past [11]. The PRC is a region of the medial temporal lobe that is placed on the back of the hippocampus and the amygdala. The PRC usually works with the hippocampus to carry out skills such as the learning of faces and scenes as well as different types of memory [12]. However, the PRC itself is also responsible for familiarity-based discrimination of societal elements, which is a cognitive practice of differentiating something as either familiar or unfamiliar [13]. The processing of conceptual implicit memory shares a closely related, fundamentally almost the same, mechanism with familiarity-based judgements [14]. Therefore, it is reasonable for PRC to be involved in certain conceptual implicit memory as well as tasks such as semantic decision making and exemplar generation priming, which is the ability to come up with examples that fall into a certain semantic category [11]. The fMRI results and implicit task experiments both revealed that the patients with the damage in PRC are unable to hold proper conceptual implicit memory. Even for those who are healthy, the activity of PRC during implicit encoding of information is directly proportional to the person's ability to connect the concept with other societal characteristics [15].

Different Techniques of Studying the Neuroscience Behind ISC

I. Implicit Association Test (IAT)

The Implicit Association Test (IAT) is a psychological research tool that studies people's unconscious evaluation of societal characteristics such as skin color, religion, or disability. Participants are given two contrasting traits of a concept and are asked to categorize them with either positive or negative words. Participants show faster performance when they are dealing with highly associated groups, which plays a role in revealing their stereotypes and preference towards certain attributes [16]. For example, a Weight IAT indicates that one has automatic preference over
Thin People over Fat People if one was faster at responding when Thin People and Good were assigned to the same response key than when Fat People and Good were classified with the same key. Based on the amount of difference between the time spent, the automatic preference can be divided into “slight”, “moderate”, and “strong” as well [17]. The IAT is especially useful in detecting stereotypes in categories in which people are relatively more concerned about how they are represented to others [1]. However, some psychologists have pointed out the limitations of the IAT: because it is accessible to anyone in any environment, results can be inconsistent due to external factors and are not a strong predictor of real-life behaviors in areas outside certain associations of race, age, and sexual orientation [18]. Therefore, it is suggested that the results of the IAT can be better used when they are compared with explicit results or other implicit measurements that provide neurological insight about which region of the brain influences a certain ISC [19].

II. Non-Invasive Brain Stimulation (NIBS)

Non-invasive brain stimulation (NIBS) allows neurologists to target specific parts of the brain with electrical current without dissecting the brain. By doing so, researchers can identify which parts of the brain are involved in people’s implicit association between different social concepts and evaluations. For example, one study discovered that people’s stereotypical association between “Arabs” and “terrorists” were reduced when NIBS was done to their anterior temporal lobe region [20]. There are four types of NIBS techniques categorized based on how the electrical current can be applied to the brain: electroconvulsive therapy (ECT), transcranial magnetic stimulation (TMS), repeated transcranial magnetic stimulation (rTMS), and transcranial direct current stimulation (tDCS). rTMS is an enhanced version of TMS, and they can directly excite neurons to cause them to fire action potentials. On the other hand, tDCS sends low and steady pulses of electrical current through anodal (positive) and cathodal (negative) electrodes to alter the ion threshold, and therefore, the activity of neurons [21]. NIBS techniques, especially TMS and tCDS, are widely used to enhance people’s implicit cognitive skills. For instance, the anodal tDCS of the left temporal cortex and cathodal tDCS of the right temporal cortex can improve people’s recognition of sad faces in women [22]. Furthermore, when there is a loss of function in the damaged area of the brain, NIBS can compensate for it by activating a nearby region of the brain that serves a similar cognitive role.

III. Functional Magnetic Resonance Imaging (fMRI)
Functional Magnetic Resonance Imaging (fMRI) measures the duration of electrical signals being sent out from different areas of the brain to detect regions that are associated with a certain behavior or cognitive function. One method to do so is to observe CBF (Cerebral Blood Flow) and BOLD (Blood Oxygenation Level Dependent) effects. The active neurons require a relatively larger amount of oxygen than those in the resting state. Therefore, when a certain cerebral region is carrying out a task, the concentration and the rate of oxygenated hemoglobin flowing into surrounding capillaries increase [23]. fMRI has made significant contributions in studying how people’s brains react differently to certain stimuli due to unconscious intergroup bias [6]. For instance, a case study conducted by Princeton University discovered that people tend to dehumanize homeless individuals more than middle-class individuals, as fMRI suggested that the activities of medial Prefrontal Cortex (which is responsible for identifying others as “highly human”) were only fully activated while they were making judgements about middle class people [24].

Conclusion

The invention of tools such as IAT, NIBS, and fRMI exhibits real-life cases of ISC and therefore hands important clues about how certain parts of the temporal lobe and potentially other regions of the brain interact with one another to produce implicit social behaviors. To solidify the understanding of ISC, there are more complex questions that need to be answered such as: “How do implicit and explicit processes interact?” and “What innovations to measurement methods can help capitalize on key operative processes, and minimize the influence of extraneous factors of measurement?” [5]. Once enough data is collected to be able to generalize the patterns of ISC and to resolve the defects of technological devices, implicit measurements can be used to confirm people’s self-report in psychological experiments and to deal with microaggression using neurological interpretations.

References


Neuroplasticity: Rewiring and Repairing the Nervous System

Alexander Julian Rayo

Introduction

Neuroplasticity refers to the nervous system’s ability to rewire and reorganize itself in response to new stimuli. In the past, the brain was generally believed to be unable to change. However, recent research in neuroplasticity has begun to demonstrate just how dynamic the nervous system truly is [1]. A variety of neurobiological mechanisms facilitate neuroplasticity, and most are generally induced through new experiences or environmental stimuli [2]. Current research in neuroplasticity is not only concerned with studying these mechanisms, but also translating them into therapies for various neurological conditions [4]. This article provides an overview of neuroplasticity, discusses its implications for rehabilitative therapies, and lists a few key principles that are currently driving neuroplasticity research.

Overview

Throughout the history of neuroscience, scientists have perceived the brain to be a stagnant organ throughout the course of one’s life. However, novel research has demonstrated that the central nervous system is actually very dynamic and possesses the ability to rewire itself throughout one’s life—a process termed neuroplasticity (or neural plasticity). This process occurs as a result of a wide variety of neurobiological mechanisms including the creation of new neurons, changes in synapses, and the formation of new neural pathways [2].

Neuroplasticity most often occurs in responses to new stimuli, which can induce one of the aforementioned mechanisms. When an organism encounters a new experience or learns a new behavior, its nervous system must change in some manner to “encode” the experience and enable behavioral change [2]. This is why the process is sometimes termed experience-dependent neuroplasticity, as changes in the nervous system are most often induced by novel experiences or stimuli.

One mechanism that is particularly impacted by such experiences is termed synaptic plasticity. This type of plasticity specifically refers to the various changes that synapses may undergo as a result of environmental change. For example, new synapses may be created to form additional
neural pathways that encode new experiences [3]. In other instances, axons or dendritic branches may undergo structural changes that can either increase or diminish synaptic strength [4].

![Diagram of spine formation and elimination within mice motor cortices](image)

**Figure 1.** Illustration of spine formation and elimination within mice motor cortices, as a result of learning multiple tasks [5].

Lastly, recent studies in animal models suggest that synaptic plasticity is highly driven by changes in protrusions along dendrites, categorized as either spines or filopodia. These studies demonstrate that the formation and elimination of such protrusions are part of the structural basis that allows organisms to learn new behaviors. For instance, several studies in the mouse motor cortex have illustrated that when mice learn a new task (i.e. reaching for an object), new spines and synaptic connections are formed. Some pre-existing spines are also eliminated at the same time, once again suggesting that some reorganization in the nervous system takes place to accommodate for new experiences. The number of spines that are formed and not eliminated is also associated with the degree of learning acquisition and maintenance of the skill learned [5]. As a result, such studies demonstrate that new experiences not only induce neurobiological change, but that these changes also have actual behavioral effects on an organism.

**Implications**
The nervous system’s unique ability to change and adapt is of great importance to rehabilitative research [4]. Currently, few therapies are known to be effective in treating neurological conditions, especially in restoring any cognitive or behavioral functions that may be impaired by them. For instance, the most common result of strokes is impairments in motor function in the brain hemisphere opposite to the hemisphere impacted by the stroke [3]. Stroke patients are often left either unable to perform certain tasks, or may only be able to perform them with much difficulty, and not many therapies are available to rehabilitate stroke survivors. Thus, much optimism can be found in the prospect of exploiting neuroplasticity to restore functionality in the nervous system [2].

Evidence from motor system research has demonstrated that following brain damage, connectivity maps and behavioral skills can be somewhat restored through intense practice and rehabilitation. More specifically, therapies that particularly depend on skill training have the greatest ability to induce and optimize plastic changes within the motor cortex [6]. These changes allow the nervous system to reorganize itself using the undamaged tissue that remains after nervous system injuries, and in effect, this may allow the nervous system to compensate for loss following an injury [2][3].

For instance, robot-assisted bilateral arm therapy (RBAT) is a therapy that relies on neuroplastic changes to restore motor function. RBAT involves the use of a robotic device to aid an individual in various motor tasks, as well as to provide instant visual feedback during therapy sessions. In one study, stroke patients were subjected to RBAT for 90 minutes a day, 5 days a week, for 4 weeks. Participants were tasked with performing movements involving their wrists and forearms, using both their nonparetic and paretic limbs, and sometimes with occasional support from the robotic device. RBAT was also followed by several minutes of practice with various functional tasks such as picking up coins. Resting-state functional magnetic resonance imaging (RS-fMRI) was then used to observe internal brain connectivity and interactions within the participants during wakeful rest, conducted at the beginning and end of the study. The results of this study

![Figure 2. RS-FC results showing (A) pre and (B) post-treatment differences in connectivity between various brain regions. The results show positive increase in connectivity in most regions [7].](image-url)
demonstrated that despite damage in one hemisphere due to stroke, the participants had greater functional connectivity between the motor-related areas of both hemispheres. In addition, this increase in connectivity was also correlated with improvements in performance in motor tasks after RBAT [7]. Thus, this study evidently supports the notion that neuroplasticity allows the brain to reorganize its neural pathways, compensating for loss of motor function following brain injuries. RBAT and many other similar therapies are able to induce this natural process through functional task experiences, which in turn translates to restoration of motor skills.

Relevant Principles of Plasticity

Neuroplasticity can clearly be exploited to develop therapies for nervous system injuries. However, recent studies in animal models have identified several key principles – outlined below – of neuroplasticity that must be considered as therapeutic research progresses. Adherence to these principles ensures that therapies are not only effective, but also prevents them from potentially becoming maladaptive.

Principle 1: Usage of neural circuits improves function and prevents degradation.

If the neural pathways involved in certain tasks are not actively and continuously used, they will begin to degrade [8]. Studies dating back to the 1960s, for example, found that depriving kittens of light causes a decrease in the number of neurons and synapses in their visual cortices. A similar study saw that after the removal of one digit from owl monkeys, the neural regions correlating to the digit now responded to other parts of the hand, suggesting some degree of reorganization. Conversely, training experiences have also been shown to induce and optimize plasticity within corresponding brain regions [2]. Training activities, for instance, have been shown to enhance the structure and function of the neural mechanisms for the behaviors involved. However, studies indicating this have only involved simple movements such as reaching tasks in rats, so further research is needed to support this principle in the context of more complex movements [8].

Principle 2: Tasks must be sufficiently repeated during training.

Training experiences may only induce plastic changes after prolonged and repetitive practice [8]. Certain tasks must be repeated for a sufficient amount of time to induce effective reorganization, and as a result improve the functionality of certain skills. Arguably, this principle is perhaps the most important for neuroplasticity, as the specific number of repetitions required to create effective change is highly debated. Several studies in animal models estimate that anywhere from 1000 to 10000 repetitions of a task may be needed to fulfill such a goal [6].

Principle 3: Rehabilitative training must be sufficiently intense.

Training experiences must also be sufficiently intense to induce plastic changes [8]. One recent study found that participants who engaged in moderate to high-intensity exercise experienced less of a decline in brain processing speed and long-term memory across 5 years,
compared with participants who engaged only in low-intensity activities [9]. In addition, other studies have also found that low-intensity stimulation can actually be maladaptive, weakening synapse strength over time. Moreover, training may be maladaptive if it is too intense for an individual, so future studies must be cognizant of the appropriate intensity level per participant [6].

**Principle 4: Neuroplastic changes can either improve or impair related neural circuits.**

Training that induces plasticity in one set of neural circuits may also lead to changes in another [2]. Moreover, training in one skill or behavior may lead to improvements in unrelated ones [6]. For instance, one study involved participants aged 60-89 engaging with a challenging computer program. As a result, the study observed that individuals had improved memory for tasks that they had no previous training with, suggesting plasticity in brain regions unrelated to the initial task [9]. Conversely, some studies have also shown that plastic changes in one neural circuit could negatively impair the functioning of another. This has been observed in stroke patients, for instance, whose reliance on their unaffected limb interfered with improvements made in the affected one [8]. As a result of this principle, future research around rehabilitative therapies clearly must consider the wider implications that training may have on patients.

**Conclusions and Future Outlook**

Discoveries made around neuroplasticity continue to illuminate the dynamic capabilities of the nervous system, allowing it to adapt to change. Numerous therapies are now being researched and developed to harness on the various mechanisms involved in neuroplasticity. From strengthening synapses to reorganizing neural pathways, these therapies are able to induce changes that may restore functionality in impaired nervous systems [10]. As research progresses, certain principles relating to neuroplasticity must also be considered to ensure that induced changes are positive, rather than maladaptive [9]. Finally, despite the potential for negative implications, exploiting neuroplasticity might very well be one of the greatest avenues towards effective rehabilitative therapies in the future.

**References**


Abstract

Akinetopsia is a condition that prevents patients from seeing motion in their visual field, following a lesion in the V5 portion of the brain. When light hits the retina, the optic nerve carries signals to the brain, which are interpreted into a series of images, perceived as motion. There are two reported types of akinetopsia: one is inconspicuous, where movement is perceived as a series of snapshots, and the other is gross, which is the invisibility of moving objects. The following review aims to describe the two types of akinetopsia from a neuropsychological standpoint by discussing two relevant cases and touching upon the future of motion blindness.

Overview

Akinetopsia can be separated into two different groups: inconspicuous and gross. Inconspicuous akinetopsia is the most common type, in which patients describe motion as a cinema reel, viewing the world as a series of snapshots. It usually occurs with palinopsia, meaning the images are static at every frame of motion [i]. Gross akinetopsia is an extremely rare condition in which patients are unable to see motion. This results in a struggle to carry out everyday activities, negatively impacting one’s quality of life.

Several factors contribute to the development of akinetopsia. The condition could result from lesions, specifically in the posterior side of the visual cortex [i]. This region is also known as the V5 area of the brain. In the middle temporal cortex, the motion-processing area of the brain, neurons respond to moving stimuli. Therefore, damage to this area results in motion blindness. Patients taking large doses of Nefazodone, an antidepressant, are usually subject to inconspicuous akinetopsia. When the dosage of the antidepressant is reduced, however, one’s vision returns back to normal [i].

Inconspicuous Akinetopsia
The first recorded case of akinetopsia was identified in 1983 at the Max Planck Institute in Munich [3]. It was discovered that patient M.P. had a loss of motion perception as a result of inconspicuous akinetopsia. For example, when pouring a cup of tea, she would see the empty cup and fail to notice the liquid rising, causing it to overflow. This is just one example of the debilitating life difficulties that patients with akinetopsia experience daily. Other issues they may face may be as simple as crossing the road, navigating through a store, playing sports, and walking with others. Patient M.P. was reluctant to cross the road. She stated: “when I’m looking at the car, first it seems far away. But then when I want to cross the road, the car is suddenly very near” [3].

Several tests were carried out on patient M.P. to determine her motion perception. One task required her to follow a wooden cube on a flat surface to and from her line of sight to determine her perception of motion depth. She was unable to recognize the movement in depth; however, she could distinguish that the cube’s position had changed. She could also judge the cube’s distance in relation to other objects. Another test required M.P. to follow the path of a wire using her finger. The patient found that she had difficulty following her finger as it moved, though she could follow the wire by feeling where it led [4].

Computed Tomography (CT) neuroimaging scans of the patient showed large bilateral lesions, encompassing temporoparietal cortices and the posterior and lateral portions of the middle temporal gyrus [3]. These lesions also affected the areas of the brain that correlate with motion perception. The lesions were lateral in the area of the brain identified as V5; motion perception deficits are much more subtle, however, when unilateral to V5 [5]. Motion is determined over a period of time; when the patient has more time to perceive motion, the signals have a chance to travel from the damaged part of the brain to the unimpaired hemisphere.

**Gross Akinetopsia**

This case is of a patient who presented with gross akinetopsia. Unlike inconspicuous akinetopsia, patients with this type of motion blindness completely lose their ability to see motion. When objects began to move, the patient could not see them and his perception was that the objects had disappeared [6]. This patient, a man in his 60s, developed akinetopsia after a unilateral right temporoparietal subcortical hemorrhage. After his positron emission tomography (PET) scan, it was found that he suffered from severe hypoperfusion in his right cerebral hemisphere. This means that there was reduced blood flow to the brain. As a result, he underwent cerebral artery bypass surgery.

![Figure 2. The diagram above illustrates the parts of the brain operated on during a cerebral artery bypass surgery [8].](image)
One month after his surgery, he noticed that moving objects were entirely invisible to him. Consequently, he could not recognize when a cup was full, bumped into others while walking, and struggled to navigate his surroundings. Compared with his preoperative status, his left hemiparesis, left facial palsy, left hypoesthesia, and left hemispatial neglect were slightly improved on neurological examination [6]. He was able to recognize and touch objects when they were still. However, when the object was moving, he could not see or touch it in any direction.

The patient’s ability to view motion was assessed in both two-dimensional and three-dimensional tests. In the 2D motion assessment, dots moved around on a screen; some moved in the same direction while others moved randomly. When 75% of the dots moved in the same direction in parallel motion, the patient recognized their direction. This was far inferior to the score of 13-14% of normal subjects [6]. During a three-dimensional motion assessment, the patient could not catch a ball when it was thrown to him. He could only determine the location of the ball by the sound of it hitting the ground.

Implications

Due to the rare nature of this condition, there is currently no effective treatment or cure for akinetopsia. Nonetheless, a doctoral student in Psychological and Brain Sciences at Dartmouth College, Zhengang Lu, revealed how the brain recognizes motion [8]. He discovered that the brain interprets inanimate and animate motion differently. This shows that the brain categorizes objects into separate classes. This also indicates that the pathways interact with each other when processing motion. His findings have countless potential applications, including the development of a treatment for akinetopsia. Although their results may not provide direct treatment, they suggest that people with motion blindness should consider checking the functional interaction between these two pathways [8].

Conclusion

Akinetopsia is a rare neurological condition in which patients are unable to perceive motion. There are two known types of akinetopsia: inconspicuous, in which patients can see the world as a series of snapshots, and gross, in which patients cannot perceive motion. Though there is no specifically established cause for akinetopsia, a lesion in the V5 portion of the brain is a primary contributing factor to this condition. Akinetopsia has proven a vastly under-examined issue that can have severe implications on patients’ lives. Although recent research on the topic has opened up a path toward possible treatment options, a cure is yet to be found. This article emphasizes the nature of akinetopsia through a combination of the recent scientific literature and real-life patient stories, explicitly revealing the impact it has on patients’ quality of life. Understanding this rare condition will reveal insights into the perception of motion and how different brain structures work together to help navigate life, ultimately bringing scientists closer to understanding akinetopsia and how to treat it.

Glossary
• **Nefazodone**: an antidepressant that increases the amounts of certain natural substances in the brain that are critical for mood elevation [9].

• **Temporoparietal cortex**: the region of the brain where the temporal and parietal lobes meet [10].

• **Brain hemorrhage**: bleeding in the brain; can reduce oxygen delivery to the brain and create extra pressure, atrophying brain cells [11].

• **Hemiparesis**: motor weakness on one side of the body; makes it difficult to perform activities of daily living (ADLs) [12].

• **Facial palsy**: a condition in which the facial muscles are (usually temporarily) weakened [13].

• **Hypoesthesia**: partial or total loss of sensation in a part of the body [14].

• **Hemispatial neglect**: a disabling condition following brain trauma in which patients are not aware of items located on one side of the field of vision [15].

---

**References**


[8] Lu, Zhengang et al. (24/10/2014). Encodings of implied motion for animate and inanimate object categories in the two visual

---

35
pathways. ScienceDirect.
Abstract

Amyotrophic lateral sclerosis, or ALS, is a progressive nervous system disease that causes the death of motor neurons in the brain and spinal cord which leads to a loss of voluntary muscle control. Currently, there is no cure for this fatal disease. However, novel research has deduced that the deficiency of membralin proteins present in nerve cells may be the cause of death of the motor neurons in ALS. Since all proteins are encoded by genes, researchers can target and modify the ClgORF6 gene that codes for the membralin protein. In doing so, astrocytes would no longer be deficient in membralin, possibly curing individuals of ALS.

Introduction

Amyotrophic lateral sclerosis (ALS) is a progressive, degenerative disease that destroys the nerve cells in control of voluntary muscle movement. These nerve cells are called “motor neurons”. Motor neurons initiate their pathway in the brain, travel through the brainstem, and signal responses to muscles that control voluntary and involuntary movement such as those in the arms, legs, chest, throat, mouth, etc [3]. When the motor neurons die, the muscles that are supposed to respond gradually atrophy.

Generally ALS is sorted into two categories: upper and lower motor neuron disease. In upper motor neuron disease, nerves of the brain are affected. In lower motor neuron disease, nerves from the brainstem are affected. Yet, regardless of the type of motor neuron disease, the motor neurons still become damaged and die. This is eventually fatal because most people with ALS die from respiratory failure, which occurs when people cannot get enough oxygen from their lungs into their blood or when they cannot properly remove carbon dioxide from their blood. This happens because the disease can eventually lead to paralysis of the muscles that control breathing. Based on US population studies, a little more than 5,600 people in the United States are diagnosed with ALS each year. Some of the common symptoms include “weakness in muscles of the hands, arms or legs, impairment in the use of arms and legs, twitching and cramping of muscles, weakness in the muscles that control speech, swallowing, or breathing, and slurred speech” [3]. There is no current cure for ALS, but much research is being conducted to find the role of possible genetic and environmental
factors. One of the novel research findings involves the discovery of the membralin protein present in nerve cells [2].

**Current Research on Links Between Membralin and ALS**

Until recently, researchers were not aware of the membralin protein's function. Membralin (TMEM259) is an evolutionarily conserved endoplasmic reticulum (ER) membrane protein. It is a novel component of the ER-associated degradation machinery, the targeting of misfolded proteins and the subsequent degradation of those proteins [4]. It has been previously noted that membralin mutations or deficiency in mouse models induce ER stress, rendering neurons more vulnerable to cell death [5].

More recently though, researchers at Sanford Burnham Prebys in San Diego identified that membralin may play a key role in ALS. To understand the role of membralin in neurodegenerative diseases, the researchers designed mice that lacked this protein in all the cells of the body. Then, the scientists also designed mice that specifically lacked the protein in different brain cells, such as motor neurons and glial cells (cells that surround the neurons to provide support). These glial cells include astrocytes, microglia, and oligodendrocytes. The investigators found that lack of membralin in astrocytes led to a loss of motor neurons in the spinal cord and caused motor defects, mimics of the defects that could occur in people suffering from ALS. It is believed that the membralin deletion in astrocytes may result in the accumulation of neurotoxic components in the extracellular environment. More specifically, the astrocytes are associated with an elevation in extracellular glutamate and reduced EAAT2 expression. Astrocytes play an essential role in the homeostatic regulation of extracellular glutamate, and the glutamate transporter EAAT2, which is the primary mediator of extracellular glutamate uptake.

Given glutamate's excitotoxicity feature, an excess of glutamate can lead to the motor neuron damage present in ALS due to the overactivation of receptors for glutamate. Given that these are all features of membralin deletions in nerve cells, the researchers also ensured to test whether or not membralin expression could ameliorate lethality and the pathological effects associated with ALS. The membralin injected mice proved that membralin expression could reverse neurotoxic effects, extend lifespan, and reduce gliosis. Although these results are currently specific to mice, the researchers did find a strong correlation between EAAT2 expression and membralin levels in both human and mice models [2]. This proves that there is a good chance that such a treatment could also work for humans suffering from ALS.

**Discussion**
Given that membralin expression is vital in astrocytes towards reducing the death and damage of motor neurons, gene therapy targeted at boosting membralin in astrocytes could potentially reverse the effects of ALS. In the study discussed, researchers used a form of gene therapy (injecting membralin) towards reversing the neurotoxic effects. Although the results did show an extended lifespan and reduced symptoms, CRISPR might potentially be better for curing ALS. CRISPR is regarded as a powerful tool in gene editing because it has made gene modification or editing very simple. Unlike traditional gene therapy where additional copies of the normal gene are introduced into cells, CRISPR repairs the defects on site by removing the problematic DNA or correcting it to restore normal gene functions. CRISPR has proven to improve genome-wide targeting accuracy and, thus, function [6]. Sequence analysis has revealed that there are no closely related genes for membralin, suggesting that membralin represents the sole member of a unique protein family [7]. Thus, there must be a specific gene that encodes for membralin. This gene was discovered to be the human gene CI9ORF6 which localizes to chromosome 19p13.3 [7]. The lack of membralin in astrocytes is likely caused by defective ribosomes, which can be caused by several factors. However, most defects in ribosomes are generally caused by mutations in or damage to the rRNA. This rRNA would have to be encoded by the CI9ORF6 gene, which means this gene has to be mutated itself. Hence, CRISPR could target the mutated or damaged CI9ORF6 gene and repair the defects to result in normal gene functions. By having these normal gene functions, membralin would be expressed at its normal and maximum capacity which could potentially reverse the effects of ALS. However, before this occurs, further research has to be conducted to discover what specific nucleotides are mutated in the CI9ORF6 gene to attribute to a lack of membralin in astrocytes. Solely from this research could the potential impact of this type of treatment become more evident.

References


Correlations Between Schizophrenia and Bipolar Disorder

Adele Raillot

Abstract
Schizophrenia (SZ) and bipolar disorder (BD) are psychiatric disorders that make daily life difficult. The two disorders share similar risk factors and outcomes and are both difficult to diagnose and treat. SZ and BD have also been observed to have high rates of comorbidity, which has led researchers to investigate possible links and similarities between them. Neuroimaging studies have found significant correlations between these two conditions in white matter integrity and grey matter volume. Continuing to focus on how mental illnesses such as SZ and BD are related, rather than researching them individually, will contribute to discovering possible underlying causes and developing better ways to treat comorbid disorders.

Schizophrenia

Schizophrenia (SZ) is a chronic and disabling mental disorder characterized by disruptions in thought processes and emotional responsiveness, distorted perceptions, and abnormal behavior [1,2]. Despite only affecting around 1% of the world’s population, it is among the top fifteen leading causes of disability worldwide, and individuals with SZ have a significantly higher risk of premature mortality [2]. The causes of the disorder remain unclear; genetics, brain chemistry, and environmental factors are all believed to contribute to its development [1]. However, specific risk factors have been identified, such as a family history of SZ, consumption of mind-altering drugs during adolescence and young adulthood, stress, pregnancy, and birth complications [1].

The wide range of SZ symptoms generally fall under three categories: psychotic, negative, and cognitive [2]. Psychotic symptoms include altered perception, as well as abnormal thinking and behavior that may result in a distorted experience of the world [2]. Negative symptoms are a diminished ability to live normally, as patients may exhibit social withdrawal, lack of motivation, difficulty showing emotions, and disinterest in daily activities [1, 2]. Problems regarding attention, concentration, and memory are categorized as cognitive symptoms [2]. Symptoms of individuals with SZ vary case by case in severity and type over time [1].

Bipolar Disorder
Bipolar disorder (BD), formerly called manic depression, is a mental illness that causes extreme shifts in mood, activity levels, energy, and concentration [3]. Individuals with the condition experience “periods of unusually intense emotion, changes in sleep patterns and activity levels, and uncharacteristic behaviors” called mood episodes. Mood swings include emotional highs and lows known as mania/hypomania and depression respectively, while the experience of both types of symptoms in the same episode is called a mixed episode [4]. BD is the sixth leading cause of disability in the world and is associated with a shorter life span [6].

Manic symptoms are characterized by heightened energy, creativity, euphoria, impaired judgment, impulsiveness, lack of sleep, and extreme irritability [5]. Hypomania is a less severe form of mania that generally won’t interfere with day-to-day activities but often precedes manic or depressive episodes [5]. Bipolar depression can be identified through symptoms such as loss of energy, feelings of hopelessness and emptiness, irritability, physical and mental sluggishness, concentration and memory problems, suicidal thoughts, and inability to feel pleasure [5]. Severe episodes of mania or depression may include psychotic symptoms such as delusions or hallucinations [4]. Symptoms vary in frequency, severity, and length of time based on the type of BD, which include bipolar I disorder bipolar II disorder, and cyclothymic disorder [4]. Though no single cause has been identified, factors that contribute to developing BD include brain structure and function, stress, and genetics [3].

Comorbidity

Though psychiatric disorders have traditionally been viewed as unrelated to one another, recent studies have demonstrated high levels of comorbidity between multiple illnesses, which suggest that there may be an underlying cause [7]. SZ and BD are both mental illnesses that often occur together and are exacerbated by other conditions. They are also highly associated with depression and anxiety (SZ: 16.7%, BD: 22.4%), and substance use disorders (SZ: 25.1%, BD: 20.1%) [8, 9, 22, 23].

Obsessive-compulsive disorder (OCD) and obsessive-compulsive symptoms (OCS), as well as their high rates of comorbidity with SZ and BD, are also well documented. Up to 30% of patients with SZ report OCS; 12%–14% of them meet the diagnostic criteria for OCD, while 17% of BD patients were found to also have OCD [11].
A study conducted by the University of Aarhus in Denmark over a 35 year period established a large comorbidity index between SZ and BD along with schizoaffective disorder, a mental illness characterized by symptoms of both SZ and a mood disorder [10, 12]. Risks of the three psychiatric disorders were estimated through a survival analysis method, while the comorbidity index was indicated by measuring the resulting overlap [10]. According to this method, a SZ patient’s risk of also being diagnosed with BD was found to be 20 times higher than that of the general population [10].

It’s not yet clear whether the high rates of comorbidity represent the frequent occurrence of two independent disorders, the development of symptoms of one disease in a different disease, or the possibility of one being a risk factor for another. However, comorbidity has been observed to negatively influence the course of SZ and BD [11]. Thus, the treatment is highly challenging, as regular measures for a certain disease are consistently less successful when applied to comorbid disorders and may even exacerbate symptoms [11]. As a result, the diagnosis of and recovery from such disorders is impeded.

Neuroimaging

As evidence suggesting an etiologic overlap—or an overlap in causes and origin—between schizophrenia and bipolar disorder will continue to grow, researchers have turned to neuroimaging techniques, such as MRI scans, to detect and compare distinguishing characteristics in the brains of patients with the two disorders.

White matter (WM) is responsible for neuronal connectivity and is composed of closely packed nerve fibers, or axons, that are coated in myelin sheath [16]. By uniting the different regions of the brain, white matter forms networks that perform various mental operations necessary for normal mental function [16]. Through diffusion tensor imaging, an MRI-based neuroimaging technique, WM can be mapped out in the sense of a skeleton [21].

Structural neuroimaging studies of BD and SZ suggest white matter integrity deficits and abnormalities are consistently widespread over 30% of areas of the whole-brain WM skeleton in both SZ and BD [13][14]. Shared white matter abnormalities in SZ and BD were observed in the brain regions uncinate fasciculus, corona radiata, anterior limb of the internal capsule, and anterior and posterior thalamic radiation [13].

Figure 2. The diagram above shows regions containing white matter abnormalities and illustrates the neurological differences between schizophrenic and non-schizophrenic (in red) individuals with the white matter skeleton represented in blue [20].
White matter abnormalities were consistently found in the corpus callosum for both disorders, suggesting that disruptions in interhemispheric communication may be a common component in the two diseases [14]. The white matter integrity of the corpus callosum is related to cognitive performance such as sustained attention, processing speed, and problem-solving abilities, which are frequently impeded in SZ and BD [14]. Both conditions also showed impaired integrity of the white matter microstructure between the frontotemporal and frontal-subcortical regions, which are areas associated with emotional and cognitive processes that tend to be disrupted in BD and SZ [14]. The extensive white matter deficits indicate that abnormal structural connectivity may play a key role in the pathology of both disorders [15]. Notably, no significant correlation was found between WM integrity and any type of medication, psychotic symptoms, or manic symptoms in either SZ or BD patients [15].

SZ and BD have also been found to be associated with grey matter volume reductions, though abnormalities are more widespread in SZ than BD [13]. Various neuroimaging studies have reported extensive grey matter deficits in frontal, temporal and subcortical structures in SZ, while BD has reductions in overlapping brain regions [17]. Shared regional decreases of grey matter volume in the thalamus, dorsal anterior cingulate, and insular lobe have also been documented [13,14].

Conclusion

In the past, mental disorders such as schizophrenia and bipolar disorder have been treated as separate and unassociated diseases. However, there is growing evidence that SZ and BD share significant similarities in risk factors, symptoms, neurobiological features, and outcomes [17]. Thus, an increasing number of scientists have been shifting towards investigating possible links between the two disorders, with clear commonalities in characteristics having been found through neuroimaging that point towards connections in pathology. Further studies may eventually be helpful in identifying individuals at risk for developing either SZ or BD and make diagnoses more accurate. Findings may also aid in making the treatment of comorbid BD and SZ more effective. Individuals with comorbidity usually have worse symptoms and treatment outcomes, and treating the underlying cause or the comorbid diseases together would likely be more successful than treating them separately [18]. Mental illnesses are more closely correlated than previously thought, and researching them as such may lead to significant progress for scientists and healthcare professionals.

References


[4] Lee, Dong-Kyun et al. (07/052020/). Common gray and white matter abnormalities in schizophrenia and bipolar disorder. PLOS ONE. https://doi.org/10.1371/journal.pone.0232826.
Cotard’s Syndrome: The Real Walking Dead

Shruthi Ganesh

Abstract

Cotard’s syndrome is a rare condition under which patients may deny the existence of certain parts of their body, have delusions of immortality, and even believe that they are deceased. First observed by Dr. Jules Cotard, the syndrome has multiple symptoms, including nihilistic delusions, depression, and anxiety; in addition, it often accompanies other psychological disorders.

The underlying pathophysiology is still being researched, but distinct abnormalities in the brain have been found to be associated with the syndrome. Treatment options, such as electroconvulsive therapy and pharmacotherapy, are also proven to work in several case studies.

Introduction

Delivering a lecture in Paris in the year 1880, French neurologist Dr. Jules Cotard presented a bewildering case: a 43-year-old woman who denies the existence of several parts of her body. The woman, “Mademoiselle X,” claimed she “has no brain, no nerves, no chest” and “only skin and bones of a decomposing body.” He referred to the condition that would later be named after him as “Le délire des négations,” or “Nihilistic Delusions.” Since then, there have been a number of cases involving this mysterious mental illness [1].

Formerly known as Le délire des négations, Cotard’s syndrome (Walking Corpse Syndrome) is a rare condition in which a person denies the existence of certain parts of their body, or in extreme cases, their entire existence. Many patients also have delusions of immortality and other various nihilistic delusions, such as the belief of their organs rotting. The syndrome commonly accompanies other neuropsychiatric disorders, such as schizophrenia, psychosis, and extreme depression. Although Cotard’s syndrome is not listed as a separate disorder in both the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) and the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM), it is still important to understand and research the neuropsychological mechanisms that underlie this unique condition in order to advance existing treatment for those who suffer from this syndrome.

Symptoms and Studies
Cotard initially characterized this syndrome as a type of depression with the following symptoms: ideas of damnation or rejection, pain insensitivity, anxious melancholia, delusions concerning the existence of one’s body, and delusions of immortality [6]. Although the disease is popularly recognized by the symptom in which a patient believes they are dead or non-existent, an analysis of 100 cases found that the most common symptom is actually a depressive mood (89%) [12]. Nihilistic delusions concerning one’s own existence followed behind (69%). Anxiety, delusions of guilt, delusions of immortality, and hypochondriac delusions were also present in 60% or less in the sample. Enoch and Trethowan asserted that the syndrome slowly progresses, starting as vague anxiety and developing into nihilistic delusions, suicidal behavior, and other behavioral manifestations of feelings of guilt, despair, and death [3].

In 1999, Yarnada suggested three stages of the illness: the germination stage, which featured significant hypochondria and depression; the blooming stage, which included nihilistic delusions and immortality delusions; and the chronic stage, which consisted of either a depressive type of the syndrome or a paranoid type of the syndrome [4]. This theory, however, is not substantially supported by many, as the syndrome’s symptoms are not as consistent and concrete as the theory suggests.

Although research regarding Cotard’s syndrome is undeveloped, and studies mostly consist of relatively small sample populations, the results are still significant. For example, in a 2017 study that analyzed medical records of patients with Cotard’s syndrome between 1996 and 2016, data showed a gender predilection for males and a median age of 52 for affected individuals, contradicting a previously held misconception that the syndrome mainly affected the elderly [5].

Pathophysiology

Like all psychological disorders, Cotard’s syndrome stems from neurological abnormalities that cause various nihilistic and depressive symptoms. Cotard’s syndrome falls under the category of “delusional misidentification syndromes,” or DSMs, and is thus pathophysiologically similar to other disorders, such as Capgras syndrome. These disorders have a key neurological commonality: disconnections in neural circuits that directly influence the perception of self, which induce feelings of depersonalization. In particular, a deep right frontal lesion could disrupt connections between the limbic region and frontal lobe, which affect familiarity of self, people, and places.

For Cotard’s syndrome specifically, studies point to a misfiring in the fusiform gyrus of the brain as a cause for the delusions. One of the earlier CT imaging studies associated the syndrome with multifocal brain atrophy and interhemispheric fissure enlargement [9]. Damages to the frontal lobe, as discussed earlier, were also shown to accompany changes in the non-dominant temporoparietal areas. It is possible for Cotard’s syndrome to result from a traumatic brain injury, as shown in a case study of a young man who started believing he was dead following an injury that affected the temporo-parietal areas of the right cerebral hemisphere [13]. In short, as Debruyne
suggests, “these studies point to an important role for the fronto-temporo-parietal circuitry in the pathophysiology of the syndrome.”

**Treatment**

Several treatment options have been presented, although only in case report form. Electroconvulsive therapy (ECT) has been cited as the most common treatment, in which small electric currents are induced in the brain to create brief seizures under general anesthesia [2]. Partnered with pharmacotherapy, ECT has been shown to work exceptionally well. In a case study conducted in 2010, a 37-year-old female patient with Cotard’s syndrome was completely cured with the administration of ECT along with venlafaxine and olanzapine [14]. Another case report saw an improvement in Cotard’s symptoms after treatment with fluoxetine and risperidone. Chan also found a combination of venlafaxine and quetiapine to provide relief of nihilistic delusions in a 68-year-old patient [11]. Like many treatments, ECT does come with its own risks; memory loss, confusion, and heart problems are just a few of its side effects.

Since Cotard’s syndrome is linked with many other neuropsychological disorders, it has similar psychopathological pathways to other existing diseases with treatment such as Capgras syndrome, which is why there are already existing treatments to help control this mental disorder. However, more research is needed to formulate a treatment that specifically addresses Cotard’s syndrome. Hopefully, future studies will analyze pathophysiology in greater detail to gain a greater understanding of this rare disease and treat it more efficiently in patients.

References


Insomnia: An Overview
Shivani Verma

Introduction

Insomnia is a prevalent sleep disorder that makes it difficult to fall or stay asleep. It can also cause nonrestorative sleep and impact one’s mood, energy, and performance during the day [1]. Most adults need at least seven hours of sleep, and insomnia prevents this from happening on a regular basis [1]. Many people experience short-term or acute insomnia at some point in their lives, while others struggle with chronic insomnia, a more severe condition [2]. This article provides an overview of insomnia, including its possible causes, risk factors, consequences, treatments, preventative measures, and examines a possible link between insomnia and COVID-19.

Causes and Risk Factors

Depending on the person, insomnia can either be a primary disorder or the result of another condition. Primary insomnia occurs when there is no underlying condition as the cause [2]. Distinguishing between chronic and acute insomnia depends on the span of time in which it occurs. Acute insomnia usually lasts for up to three months, while chronic insomnia usually occurs at least three nights a week for months or even years [3]. Some of the main causes of acute insomnia are stress, discomfort in one’s sleeping environment due to temperature, lighting, noise level, certain medications that cause insomnia as a side effect, and sickness [3][4].

On the other hand, causes of chronic insomnia include mental illnesses (most commonly PTSD), anxiety, depression, and other medical conditions associated with insomnia, such as diabetes, asthma, and Alzheimer’s disease [4]. Other possible causes of chronic insomnia are disruption in the body’s circadian rhythms, non-sleep-related activities in one’s bed during the day, bad sleeping habits, and the use of substances such as caffeine, alcohol, and nicotine [5].

Insomnia is also categorized as a disorder involving hyperarousal, a state of heightened alertness and cognitive activity [6]. Several theories suggest that hyperarousal while trying to sleep is a cause of acute and/or chronic insomnia. Hyperarousal occurs in both the central and peripheral nervous systems for insomniacs [6].

Another possible contributor to insomnia (acute or chronic), is genetics. About 39.1% of the time, insomnia is caused by genetics [7]. It is possible to inherit traits such as sleep duration and
timing of sleep [6]. The genes involved with brain functioning, arousal control, and the sleep-wake process are found to be directly involved with insomnia [6]. Specific gene variants that have proven to be risk factors for insomnia are ApoE4, PER3^{4/4}, HLA DQB1*0602, homozygous Clock gene 3111C/C Clock, and short (s-) allele of the 5-HTTLPR [6]. While there isn't much research on the genetic factors underlying insomnia, future studies can help scientists understand the role of genetics in insomnia.

There are several risk factors associated with insomnia. While it is possible to develop insomnia without having these risk factors, they greatly increase the likelihood of developing insomnia. For example, about 83% of those diagnosed with depression also suffer from insomnia [7]. Older people are more likely to develop insomnia than younger people due to changes in their bodily functions relating to age and medical conditions [8]. Women are generally more likely to develop insomnia than men, especially those who are pregnant. About 78% of pregnant women experience insomnia at some point during their pregnancy [7]. Other risk factors include activities that confuse the body’s biological rhythms and cause a constant feeling of fatigue, such as working night shifts at a job [8].

Consequences of Insomnia

Acute insomnia is short-term and not likely to have many consequences other than a potentially lower performance at school or work [9]. However, chronic insomnia is a condition that involves many severe repercussions.

A study conducted by a researcher Ellemarije Altena found that the physical appearances and functions of insomniacs’ brains both differ from the brains of healthy sleepers [10]. In this study, Altena separated her sample into two groups. The control group was composed of people who were getting enough sleep, while the experimental group had adults who were suffering from insomnia. She instructed these two groups to complete a few basic tasks in order to find the differences in their brains and abilities. One of the simpler tasks was coming up with as many words as possible that fit into a given category. Those with insomnia were better at this task than the control group. Altena also examined the brain activity of the research participants during the various tasks and found that the insomniacs had lower brain activity than the other group but were still able to perform better.
Their success in these tasks could possibly be attributed to hyperarousal. While hyperarousal can sometimes help improve performance (as shown in this study), it can also cause mental and physical problems.

Furthermore, the brains of people suffering from insomnia are quite different physically from those of healthy sleepers. Some of these differences are highlighted in Figure 1. There is a lower density of gray matter in the brains of insomniacs, but this doesn’t necessarily mean that they don’t function as well. As shown by the study, they can, at times, function better possibly due to hyperarousal. The worsening of insomnia is also associated with the lower density of the orbitofrontal cortex, which deals with the conscious process of decision-making. This suggests that insomniacs might not be able to make sound decisions due to their lack of sleep.

Additionally, a study found that adults who sleep for six hours or less per night as a result of insomnia are at twice the risk for developing cognitive impairment as those who sleep for more than six hours per night. At its most mild stage, cognitive impairment occurs when one is unable to concentrate and remember things. At a more serious stage, it can result in the inability to speak or write. Cognitive impairment increases the risk of developing other neurological conditions, such as Alzheimer’s or dementia. Furthermore, chronic insomniacs are four times more likely to experience psychosis and hallucinations. Another consequence of not being able to focus as a result of insomnia is distracted driving. On average, drivers who suffer from insomnia are twice as likely to cause a car accident than healthy drivers.

Treatment and Prevention

On a more positive note, about three-quarters of people suffering from acute insomnia recover before it becomes chronic. However, when it lasts for over three months, it might be best for an individual to consider pursuing treatment. There are many ways to treat chronic insomnia. The two main goals when attempting to treat insomnia are (1) increasing both the quality and duration of sleep and (2) reducing any daytime impairment.

To treat insomnia, there is usually some kind of psychotherapy, such as cognitive-behavioral therapy for insomnia (CBT-i). CBT-i aims to help individuals overcome whatever the underlying cause of their insomnia is. The cognitive part of the therapy attempts to eliminate any worries or negative thoughts that might be keeping one awake, while the behavioral part helps people create better sleeping habits.

Some CBT-i techniques that a sleep therapist might recommend include stimulus control therapy, sleep restriction, sleep hygiene, biofeedback, and passive wakefulness. Stimulus control aims to get rid of factors that force the mind to refuse sleep, such as avoiding naps. Laying in bed while awake can lead to the inability to sleep well. Therefore, sleep restriction is a method that lessens the amount of time spent in bed. This induces slight sleep deprivation, which makes one more tired in the coming nights. The next possible CBT-i technique is modifying one’s sleep hygiene. This approach involves modifying one’s life habits that affect sleep, such as cutting down
on caffeine later in the day. Biofeedback involves observing and moderating biological signs such as heart rate and noticing patterns in these signs that affect sleep. Finally, another possible form of CBT-i is remaining passively awake. As the name suggests, this is when one avoids falling asleep. The reasoning behind this method is that when one worries about getting enough sleep, it prevents one from being able to fall asleep [14]. When one stops worrying about this, falling asleep becomes an easier task.

Another possible way to treat chronic insomnia is sleep medication. Before taking any sleep medications, one should first ask one’s doctor. Medication is usually the last resort for people when CBT-i methods aren’t working for them. The categories insomnia medication falls under are benzodiazepines, nonbenzodiazepines, melatonin agonists, orexin receptor antagonists, off-label treatments, and over-the-counter medications [15].

Even when one does not have insomnia, it is a good idea to practice behaviors that prevent its development. A good way to prevent insomnia is to make changes to one’s lifestyle, bedtime routine, and bedtime setup. This means putting electronic devices away at least a half-hour before going to bed, reading a book, meditating, or listening to music right before going to sleep [16]. It also means getting rid of harmful habits, such as consuming excessive amounts of caffeine, smoking, and consuming alcohol. Another good way to prevent insomnia is exercising, preferably in an outdoor setting. Since stress is one of the main causes of insomnia, one should try to find ways to reduce the stress in one’s life and find healthy ways to cope with it.

Links Between Insomnia and COVID-19

Getting enough sleep has become more important than ever with the COVID-19 pandemic. During this worldwide health crisis, there have certainly been increased amounts of stress, which is causing people to unexpectedly experience insomnia [17]. The stress of a new deadly virus, as well as shelter in place measures, are an added stressor for people, especially in March and April 2020. Two sleep disorders that are most likely to be developed as a result of the pandemic are insomnia and circadian rhythm sleep-wake disorders [17]. In these uncertain times, it is more important than ever to try to create a good sleeping environment and take preventive measures to avoid insomnia.

Furthermore, an effective method to cope with COVID-19 is to make sure one is getting enough sleep. The human body must have enough sleep to fight the virus, and not getting enough sleep lowers the capabilities of the immune system [18]. Keeping the immune system as strong as possible can help prevent the virus and fight the infection [18].

As stated earlier, melatonin agonists can be used to treat insomnia. Melatonin is a hormone that causes people to feel tired and relaxed. However, new research uncovered by data analyst Feixiong Cheng shows that melatonin may be the key to stopping COVID-19 [19]. Along with the hormone’s effect on sleep, it also helps regulate the immune system’s protective responses. If these responses do not work properly, a mild case of COVID-19 can become life-threatening. Further research found that people who take melatonin have significantly smaller chances of getting
COVID-19, let alone dying from it [20]. Additionally, a study conducted by Columbia University found that patients with COVID-19 have a better survival rate when they take melatonin [21].

Currently, there are eight clinical trials in the world to see whether this hormone is truly an effective cure for COVID-19 [21]. If it is, then it would be the easiest to access, as melatonin is an over-the-counter supplement and relatively inexpensive. Without further research, it is impossible to know if this is truly the way to stop COVID-19. However, melatonin does seem promising, and the link between insomnia and COVID-19 can help researchers develop a cure.

**Conclusion**

Insomnia is a disorder that is receiving increased attention, and understanding its causes while practicing preventive techniques will help people to avoid getting it in the first place [16]. It should not be taken lightly because there can be several consequences, but with the proper treatment, there need not be. Insomnia can be very frustrating, as sleep is a natural function that does not normally require much conscious thought. However, with small changes to one’s lifestyle, a good night’s sleep is achievable.

---

**References**


The Gut in Parkinson’s Disease

Pathogenesis

Richard Zhu

Abstract

Parkinson’s disease (PD) is a prevalent neurodegenerative disease affecting millions globally [1]. Patients with the condition experience neuronal death in the central nervous system and can have both motor and non-motor symptoms. The gut microbiome and intestinal conditions have been shown to be linked to PD through the gut-brain axis. Changes in the gut could result in characteristic aspects of PD pathology, including alpha-synuclein and inflammation [2][3]. The interconnectedness of the two organ systems has resulted in two competing hypotheses for the disease progression [4]. Regardless, this burgeoning field of research will not only greatly improve understanding of a major nervous system condition, but will also lead to better treatments.

Parkinson’s Disease

Parkinson’s disease (PD) is a movement disorder that is the second most prevalent neurodegenerative condition globally [5]. The pathophysiology of this disease is characterized by a loss of dopaminergic neurons in the substantia nigra pars compacta, a structure that is involved in facilitating movement [6][7]. Other pathological hallmarks of PD include neuroinflammation and aggregations of alpha-synuclein (α-Syn) termed Lewy bodies and Lewy neurites present within neurons, which can disrupt cell function [8][9][10]. These pathological changes lead to the symptoms of PD. Classic motor symptoms include bradykinesia, tremors in a relaxed physical position (resting tremor), and rigidity [11]. Changes in an individual’s gait, ability to speak, balance, facial expressions, and handwriting can also be present [10][12]. There are often non-motor consequences of PD as well, such as dementia, depression, constipation, loss of smell (anosmia), and REM sleep behavior disorder [13][14].

Human Gut Microbiome & Gut-Brain Axis

The gut-brain axis (GBA) is a predominantly neural communication system that includes the central nervous system (CNS), enteric nervous system (ENS), and hypothalamic-pituitary-adrenal (HPA) axis [15]. The vagus nerve, in particular, forms a physical link
between the CNS and ENS, allowing the bidirectional transmission of information [16]. The GBA thus provides a pathway for the gut microbiome to influence the nervous and endocrine systems. For example, lack of microbes within the gut is associated with decreased levels of brain-derived neurotrophic factor (BDNF) and increased amounts of adrenocorticotropic hormone, a key component of the HPA stress response [15][17][18]. BDNF, in particular, has been linked to various nervous system diseases, such as PD, multiple sclerosis, and Alzheimer’s disease [19][20]. Given such changes in chemical communication signals, it is reasonable that the GBA is implicated in multiple diseases such as anxiety, major depressive disorder, and autism spectrum disorder (ASD) [21][22].

Increased intestinal permeability to substances within the GI tract, immune dysfunction, and dysbiosis (imbbalances in number and species of gut bacteria) have been specifically associated with ASD patients [23]. There is evidence for shifts in the two dominant gut microbe phyla: Bacteroidetes bacteria are increased, while Firmicutes are present at decreased levels compared to controls [23]. On a genus level, however, Clostridium bacteria (which are part of the Firmicutes phylum) have been shown to increase in patients with ASD and are linked to the gastrointestinal aspects of the disease [23].

The Gut’s Influence on PD

The GBA is thought to play a significant role in PD pathogenesis as well due to a variety of factors. In a retrospective study of PD patients (n=93), it was found that prodromal symptoms—which are symptoms that appear earlier than classical diagnostic symptoms—were present up to twenty-two years before the initial diagnosis [24]. Among these, constipation was present, on average, 16.8 years before the PD diagnosis [24]. This, in association with the greater than 50% prevalence of constipation in PD patients, helps to demonstrate the influence of gut dysfunction on PD [25].

In PD, like in ASD, intestinal permeability is increased compared to control groups. Such permeability is also correlated with the presence of α-Syn, a major pathological hallmark of PD, in the intestinal mucosa, which could point to a link between the gut and PD.

Figure 1. The innervation of the gut by the vagus nerve (highlighted yellow) [32]
A recent study also demonstrated that α-Syn in the intestines of rats can be transported through the vagus nerve (which innervates many abdominal structures) and into the brain stem [26]. The prominent effects of the GBA on PD can be demonstrated by eliminating this connection and observing ensuing changes in the disease. Svensson et al. (2015) analyzed the risk of PD within patients who had superselective vagotomies (where only selected branches of the vagus nerve are severed), truncal vagotomies (where the entire nerve is severed), and no vagotomies. They found that the risk of PD was lower for patients who underwent truncal vagotomy and had their GBA disrupted [27].

Additionally, bacteria are thought to be involved in the increased permeability and development of the disease. E. coli, specifically, has been correlated with the increased gut permeability in those with PD, while a general increase in small intestinal bacterial overgrowths (SIBOs) is linked to PD. The overall gut microbial control of intestinal permeability through tight junction regulation is also well established [28]. Nonetheless, α-Syn and constipation are not the only PD signs linked to gut dysfunction. There is evidence to suggest that the neuroinflammation present in PD patients could also result from intestinal microbiota and inflammation. Studies have shown that inflammatory cytokines are increased in the guts of PD patients and that lipopolysaccharide (LPS), a bacterial endotoxin, in the blood of PD patients is linked to gut permeability [3]. How do these microbial and inflammatory alterations affect neuroinflammation? Studies in rodents have demonstrated that LPS can lead to increases in various cytokines within brain structures [29][30]. Gut inflammation in inflammatory bowel disease (IBD) also influences cognitive problems such as depression, and a similar situation of intestinal inflammation leading to systemic and neural inflammation could be present in PD [31].

Furthermore, the inflammation pathways in IBD are directly applicable to PD patients due to an association between these two diseases, with one study demonstrating that those with IBD have a 28% greater chance of developing PD [33]. Finally, peripheral inflammation has also been shown to increase neuroinflammatory responses in patients with rheumatoid arthritis, further hinting at the influence of inflammation outside the brain on conditions within the nervous system [34].

Evidence has thus demonstrated the influential role of the GBA in PD, with changes within the gut and its neural connections influencing the development of the neurodegenerative condition.

**Controversy Over Hypotheses**

In accordance with the previous discussion on the GBA’s influence on PD, a “gut-first” hypothesis has been proposed where the gut is initially dysfunctional [4]. As described previously, inflammation and α-Syn aggregates then travel via the vagus nerve and other pathways to the brain, where they can influence the development of PD pathology. This hypothesis is further supported by research in REM sleep behavior disorder (RBD), a prodromal and non-motor symptom associated with the gut-first hypothesis of PD development [4]. Patients with RBD are at high risk for neurodegenerative diseases, as over 80% will eventually develop PD or a related condition [35]. Borghammer et al. (2019) thus proposed that peripheral nervous system (PNS) damage should
precede damage in the CNS since the inflammation and α-Syn aggregates are first generated in the periphery. This assertion was supported by their data, which showed that patients with RBD experienced increased damage to sympathetic and parasympathetic neurons (both aspects of the PNS) but decreased damage to the putamen (in the CNS) compared to PD patients [4]. Since the presence of RBD is thought to precede the onset of PD motor symptoms, these results provide evidence for the gut-first hypothesis.

However, other scientists contest the gut-first hypothesis, hypothesizing that the PD pathology first develops in the brain and subsequently spreads to other areas of the body, including the gut. This form of PD development is associated with PD patients without RBD, where there is an initial loss of putaminal dopaminergic neurons and a later increase in parasympathetic damage in the periphery [36].

As described, the precise developmental trajectory of PD is still a controversial topic, with evidence for both brain-first and gut-first hypotheses. Indeed, some scientists have proposed that the two can coexist, predicting that there are multiple subtypes of PD with different directional paths for the propagation of inflammation and α-Syn aggregates [36].

Concluding Remarks

The influence of the gut and intestinal microbiota on PD development is being increasingly investigated. The gut is implicated in a host of PD-related factors, ranging from vagotomies and prodromal symptoms to neuroinflammation and α-Syn. Not only does this increase understanding of the pathogenesis and risk factors for a prevalent and serious disease, but it also contributes to the development of treatments for PD. Probiotics have been shown to ameliorate the condition in animal models, and there is evidence for the benefits of fecal microbiota transplantation in PD patients [37][38]. The burgeoning view of a gut-influenced PD model could thus improve the lives of millions with the disease.

References


Games of Abuse: The Neuroethical Issues of Gaming Addiction

Michael Bai

Introduction

We live in an era where scientific innovation is no longer a generational event; rather, it recurs time and again within a single lifetime. Technological marvels such as automobiles, telephones, and electricity took decades to gain the same popularity that “Pokemon Go” was able to achieve in three weeks. This is in large part due to the widespread use of internet technology [1]. Our ability to stimulate our reward system so quickly and frequently may be harmful for our health, but seeking immediate satisfaction through unhealthy means is not something new. Historically, the most pertinent example of such exploitation is substance abuse, and understandably, it has led to strict legislative control measures. Today, we face novel means through which people are obtaining a rapid sense of reward, but without associated controls, in the form of “reward-based gaming” [2]. Gaming addiction has been a known behavioral problem for over two decades now [3]. While recent neuroscientific evidence strongly analogizes this with substance addiction. This essay aims to compare gaming addiction to other forms of substance abuse while highlighting ethical concerns of the gaming industry’s impacts. If the psychological basis of gaming is indeed similar to other forms of addiction, then regulation is indeed necessary. Without any restrictions, the exploitation of gaming companies, and their subsequent impact on society may run rampant.

Neurological Basis

As a species, human beings are incredibly versatile. Intelligence, spatial memory, and analytical ability are all capabilities that make humans highly adaptable to technological advancements. However, despite this façade, the core essence of human biology remains mostly unchanged, and to a certain extent, abides by the laws of evolution [4]. After all, it took millions of years for the human brain to develop the synaptic connections that drive its ultimate survival.

At the cornerstone of these connections is the dopaminergic system, which mediates the most basic reward pathways of the brain [5]. Dopamine is released from the mesencephalic neurons,
and modulates the striatal, cortical, hypothalamic, and limbic neuronal pathways. These neural circuits constitute the basic framework of motivational and reward pathways in the brain (10.3389/fncir.2013.00152). While these systems have evolved to reward constructive behavior, they can also be abused once they get “hijacked” by those seeking to exploit human nature for financial gains. Research exploring the function of the brain has shown that addictive drugs like cocaine, for example, can trigger these reward mechanisms and tap into compulsion [6]. Gambling also influences reward behaviors by triggering dopaminergic release, which then reinforces pathological behaviors [7,8]. Thankfully, such sources of addiction have been under stringent governmental control with laws and public awareness, which mitigates their harmful effects.

In line with substance abuse disorder, the neuropathogenesis of gaming addiction has also been traced to the same neural circuits that govern reward behavior and compulsion [9–12]. Recent evidence suggests that the ventral tegmental area-nucleus accumbens (VTA-NAc) pathway, a major component of the drug addiction-associated pathways, is strongly implicated in gaming addiction as well, while dopamine plays its role as a key neurotransmitter in these neuronal circuits [13]. Much similar to substance abuse, individuals who report persistent cravings for online gaming, tend to have poor functional connectivity between their VTA and NAc [14]. In addition, the prefrontal cortex (PFC) is also believed to become dysregulated as a direct result of gaming abuse [15]. However, unlike drugs and gambling, gaming is currently not subject to stringent controls, and companies can freely exploit their users for profit.

Psychiatric Basis

Whether purposefully or naturally following market success, gaming companies have clearly been investing in this, with all of the top grossing games having based their income on micro-transactions. They focus on creating and growing a specific collection or in-game aspect, such as evolving a character, thus appealing to the human sense of creation or evolution [16]. The majority of these games also involve multiplayer options, thereby appealing to the human sense of community. In a study of attitude towards video games, 30,000 players indicated that “achievement,” “socializing,” and “immersion” were the factors that motivated them most [17, 18]. Add to that the appeal of exploring one’s identity without real-life ramifications, and the gaming companies have created the perfect simulation of human life. This may very well exploit the human psyche while providing virtual rewards that reinforce the same habits.

Psychiatric studies have suggested that gaming addicts are highly likely to possess an antisocial personality [19]. A trait which is also commonly associated with drug addicts [20]. Moreover, both groups of individuals are also prone to developing a neurotic personality [21]. These characteristic similarities suggest a significant comparability between the victims of internet gaming disorder and substance abuse. In line, the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has already included game addiction in their list of mental disorders [22]. Gaming addicts exhibit the same impulsive behavior as drug abusers, with the only difference being that the substance is replaced by an uncontrolled interaction between the person and machine [23-27]. Individuals who are addicted to gaming squander their valuable time and finances on their gaming
console, and display signs of serious social dysfunction and withdrawal [28]. Moreover, gaming addiction has even been cited as an indirect cause of death [29].

The human mind evolved to reward beneficial behavior, but with the gaming addiction, it has now been tricked into satisfaction with no foreseen evolutionary benefit. Perhaps it is time that behavior-based dependencies, traditionally comprising of eating, gambling, sex, etc., should be redefined to include technological dependencies involving human-machine interaction as suggested by Griffith et al. [30].

Legislative Obligations

The human dependence on technology is undeniable. Technological advances have allowed us to continue functioning even under quarantine situations like the recent COVID-19 lockdown. It also allows for new entertainment and socialization activities. Online gaming has become a $1.1 billion industry through e-sport events alone, and a $139 billion industry overall [27-29]. However, similar to how drugs—which revolutionized medicine—can be abused, so too can reward-based gaming. In this sense, gaming companies could have inevitably become the drug-dealers as they exploit a basic human need. As an ethical issue, legislators should intervene, and set limits to at least some, if not all aspects of this industry. These could encompass restrictions involving age and overall timing of gameplay. Moreover, financial transactions can also be regulated in the online gaming industry.

Recognizing gaming as a potentially harmful activity and restraining its use could help millions of young people in need [29]. Some countries around the world have already set forth plans to counteract its impact on public health [30]. One such example is China where the officials have

![Figure 1. Gaming addiction can be very similar to drug addiction [31].](image-url)
limited the use of online gaming in minors by imposing a restriction over the time spent on playing computer games. However, efforts should be intensified both nationally, and internationally due to the multinational nature of various gaming powerhouses.

Conclusion

Gaming addiction and drug addiction share similar neurochemical bases, psychiatric profiles, and social burdens. Therefore, it is society’s ethical obligation to set laws that regulate the gaming industry such that its adverse sequelae are minimized. From the outset, gaming may not seem as harmful as alcohol or narcotics, but only time will tell how damaging gaming addiction can be to future generations.

References


[9] Weinstein, Aviv. (01/04/2017). New developments in brain...


Consciousness: A Philosophical and Scientific Mystery
Francesca Venditti

Abstract
All humans have a consciousness – a state of awareness when awake that allows us to acknowledge our existence. The debate over consciousness has existed for many years, even centuries, between philosophers and scientists. Qualia, also known as the origin of our consciousness, has been a mystery “from the earliest days of antiquity right up to the present.” Consciousness lets us experience the world interactively, although some believe that our feelings are delusions. New revelations are giving neuroscientists and philosophers a lot to ponder about our consciousness [1].

Background
Consciousness is hard to define. It is the sum of our external and internal experiences but something which, in and of itself, maybe an illusion [1]. Instead of responding automatically to their surroundings, humans are conscious of their actions and decisions. For example, hunger makes people reflexively and unconsciously salivate, but those same people can also choose when or what to eat [2]. Around 400 years ago, Descartes said “cogito, ergo sum,” meaning, “I think, therefore I am,” sparking one of the most long-lasting controversies on a topic that is still vexing scientists and philosophers today. His thesis on mind-body distinction has especially been a subject of inquiry and discussion for centuries. It essentially states that “the nature of the mind (that is, a thinking, non-extended thing) is completely different from that of the body (that is, an extended, non-thinking thing), and therefore it is possible for one to exist

Figure 1. Descartes’s illustration demonstrates the mind-body dualism discussed in his “Treatise of Man” paper. After external stimuli are processed by the sensory organs, the input travels to the pineal gland in the brain and then to the intangible soul [3].
without the other” [3]. Even before Descartes, philosophers like Aristotle and Plato had theories about the origin of consciousness. While these famous people had distinctive views about the soul and its existence, some arguments that they made were disproven. For example, in his advocacy for the existence of a soul, Descartes argued that the brain and soul must be different because “the brain, which is a part of the body, is mortal and divisible—meaning it has different parts—and the soul is eternal and indivisible—meaning it is an inseparable whole.” Roger Sperry, a 1981 Nobel laureate, found that patients with a severed corpus callosum, the area connecting the left and right hemispheres of the brain, could train each hemisphere to complete a task. Thus, a “double consciousness” formed, and Descartes was proven incorrect. Psychologists and neurophilosophers alike have come to the same conclusion that there is no “soul”; our consciousness stems only from our brains [4]. Despite this, consciousness is still a fascinating issue because of the question of what physical systems control it.

Hypothesizing: How It Works

Neuroscientists have turned away from philosophy to seek out the “physical footprints” of consciousness in our brains. Theories about how consciousness is formed in our brains are abundant. One theory about neuronal correlates of consciousness, or NCC, which are “the minimal neuronal mechanisms jointly sufficient for any specific conscious experience” and the subject of much research as the key to understanding consciousness. Specifically, the posterior cortex may be the “seat of consciousness” according to recent research. Causal evidence from studying the effect of “electrical stimulation of cortical tissue” on patients unable to use certain regions of the brain shows that stimulation of the “posterior hot zone” of the brain may trigger a variety of sensations. Studying patients has shown that the loss of a great portion of the frontal lobe tissue does not affect the conscious experience, but removing any portion of the posterior cortex can cause serious issues, such as the inability to recognize faces or “to see motion, color or space” [1].

On the other hand, multiple theories have arisen about consciousness and conscious behavior that are still under debate. One such theory is the global workspace theory (GWT), which states that conscious behavior originates in the “global workspace” of the brain with information broadcasted to specific areas in the brain. Thus, the workspace creates consciousness as “a kind of computation for motivating and guiding actions.” GWT theorists believe that consciousness centers around the prefrontal cortex, which is located in the frontal regions of the brain [2].

Some scientists, though, disagree. Christof Koch and Giulio Tononi developed a different theory called the integrated information theory (IIT). In contrast to the global workspace theory, the IIT theorizes that consciousness is innate given a correct “cognitive network.” Instead of defining how the brain creates consciousness, Koch and Tononi focus on the experience to deduce the “properties that a physical system must possess if it is to have some degree of consciousness” [2]. In other words, the IIT focuses more on tracing conscious experiences to their roots, in line with Descartes’s “cogito, ergo sum.” Tononi-led researchers even created a device to gauge how interrelated the brain’s circuits are by electrical stimulation. Results showed a tendency for brain integration to decrease as people become unconscious [3]. Instead of one level of consciousness,
Koch hypothesizes that consciousness has certain degrees based on the amount of cause-and-effect power in a system [2]. IIT theorists also believe that consciousness centers in the posterior cortex, which is located in the posterior portions of the brain. These two contradicting theories pose the questions that are of more relevance today than ever: What is the difference between humans and AI? Is our consciousness just information processing, or something more?

Humans Versus Computers and Robots

The ability to self-reflect is commonly seen as both unique and advantageous. As an intelligent species that has dominated the world, humans are one of the few to have this ability and are able to be self-aware—an ability referred to as consciousness. With the development of new technology, however, more and more people are starting to wonder about the actual distinction between humans and computers or robots. Koch’s view particularly hits on this point. He says that “systems in which information is merely ‘fed forward’ to convert inputs to outputs, as in digital computers, can only be ‘zombies,’ which might act as if they are conscious but cannot truly possess that property.” Koch likens this kind of processing to simulating gravity in a video game, which is not the true way to produce gravity [2]. The problem that many scientists are facing has been named “The Hard Problem,” which involves the mystery of why we feel sensations like pain if they even exist in the first place, and what differentiates us from hyper-intelligent robots. If humans aren’t as different from computers and robots as some may believe, then what is stopping AI from achieving the same level of consciousness in the future? Humans are complex living creatures, but we all basically function the way that robots or computers do; we are driven by a center of information giving instructions to other parts of the body. The Hard Problem of Consciousness arose in the 1990s and is still unsolved. Among scientists, some had started to delve more deeply into the mechanisms of consciousness at that time. Interestingly, Francis Crick, one of the first to discover the structure of DNA, and Christof Koch co-wrote a paper theorizing that distinct neurons fire at fixed frequencies and may cause humans’ inner awareness [6].

A somewhat unsettling perspective that consciousness is not unique at all to humans or other animals was developed fairly recently. Termed panpsychism is the concept that everything is

Figure 2. With panpsychism, theoretically anything could have consciousness, including computers and robots [10].
or has the ability to be conscious, including technology. The argument for panpsychism is based upon the realizations of physicists in regard to the natural existence and order of things in the universe. Like space, mass, or electrical charge, consciousness could just exist everywhere, without solid explanation [5]. With panpsychism, objects and beings like computers and plants could indeed be conscious of our world in a way we don’t yet understand. Even so, consciousness may be an outcome of something even less understood: quantum mechanics.

The Quantum World

Having existed for only around 100 years, quantum mechanics is a fairly new field. When it comes to explaining consciousness, quantum theory can potentially answer consciousness problems that traditional neuroscience cannot [7]. The Orch-OR theory is one way that describes how quantum mechanics does this. It states that microtubules, or the small protein tubes that are the support structure for neurons, “exploit quantum effects to exist in ‘superpositions’ of two different shapes at once.” The shapes equal classical information, but the shape-shifting properties of microtubules allow storage for "twice as much information as to its classical counterpart" [8].

However, this theory was flawed, as issues like coherence time made this seem impossible. Scientist Matthew Fisher decided to experiment a little. He gave two groups of rats one of two treatments, either lithium-6 or lithium-7, and saw that the group fed lithium-6 was much more active. Lithium-6 is a stable isotope of lithium that normally has a spin of 1. Simply put, spin defines the extent to which a nucleus experiences electric and magnetic fields; higher spins indicate a greater interaction with these fields. Intriguingly, when lithium-6 atoms are placed into an environment like the brain, a water-based salt solution, the additional protons make them seem to be the lowest spin value, $\frac{1}{2}$, and the least interactive with fields. If there were any sort of quantum control in the brain, lithium’s soothing effects could be explained by the coherent nature of lithium-6 atoms in the brain. Fisher, after extensive calculations, came up with a “candidate qubit”: a calcium phosphate structure called the Posner molecule. He identified a chemical reaction that uses the enzyme pyrophosphatase to break down fat and absorb calcium, which he thinks may “naturally manufacture entangled, coherent states between nuclear spins within Posner molecules.” Essentially, structures made of two phosphate ions would be broken down into two entangled ions, which then form Posner molecules when incorporated with calcium ions [8]. The two theories about how quantum mechanics relates to consciousness are fascinating, and more researchers are finding evidence that quantum effects exist in living beings like in plants for photosynthesis or in migratory birds for navigation [9].

Conclusion

Consciousness remains a relatively unsolved mystery in both the philosophical and scientific worlds. Many scientists, physicists, and philosophers have delved, and are delving into this mystery to uncover answers. From the NCC, GWT, and IIT theories to quantum theories to panpsychism, more explanations and arguments for how consciousness works are budding within the scientific community. With the advances in technology, like quantum computers and AI, more and more scientists consider who or what should be treated as having a conscious mind. Who knows—maybe
iPhones have feelings, as Koch conjectures [5]. Hopefully, researchers will continue their efforts to reveal the workings of our minds and make new, revolutionary findings.

References


The Brain, Evolution, and Intelligence: An Overview
Rutvi Vaja

Abstract
Increasing evidence over the past several years of research indicates that multiple structures in the brain are associated with intelligence and cognitive function at the molecular level. The most crucial factors of human intelligence are reasoning, problem-solving, and learning. To further explore the relationship between human brains and intelligence, careful consideration of the structure of human intelligence would be needed. Research over the past years has shown how brain size is also the deciding factor for intelligence in a person. This review paper will explore how the parts of the brain, dopamine receptors, and quantity of white matter along with lobes of the brain play an important role in defining one's intelligence.

Introduction

The human brain is very complex and hence, it is important to learn about the structure of the brain. The brain is one of the most complex parts of the human body. It is known for controlling and coordinating all the functions of the various organ systems. The human brain weighs three pounds and is responsible for functions like memory, behavior, emotional responses, intelligence, speech, movement, control, and coordination. The brain is a part of the central nervous system (CNS) along with the spinal cord, and lies entirely within the skull. The brain can be divided into three main parts: the cerebellum, the cerebrum, and the brain stem.

The cerebellum is the part of the brain associated with control and coordination, that has extensive connections with the cerebrum and the spinal cord. In contrast to the hemispheres of the cerebellum (known as the cerebellar hemispheres), the right cerebellar hemisphere is associated with the movements of the right side of the body, whilst the left side of the cerebral hemispheres is associated with the movement of the left side of the body.

The rostral and largest part of the brain is the cerebrum [2]. In the middle, it is divided into two cerebral hemispheres separated by a deep sagittal fissure. The right cerebellar hemisphere receives sensations from and also controls the total left side of the body, whereas the left cerebral hemisphere is concerned with sensation and movements of the right side of the body. The
remaining part of the brain forms the brain stem. The brain stem forms the stalk from where the cerebral hemispheres and cerebellum rise [3].

The relationship between brain size, the volume of the brain, and intelligence, both in humans and among different species, has never been particularly well-defined until the research published in the last few decades. Humans still believe that they have exceptional cognitive abilities and the highest thinking power among the animalia kingdom in terms of brain size, as well as thinking. Both of these common assumptions are incorrect. Mammals such as blue whales and elephants have bigger brains in size than humans, and humans have an equal brain to body mass ratio as mice[11].

To resolve the brain size and intelligence correlation conflict, scientists have crafted a 3rd measure of brain size known as the encephalization quotient (EQ). Encephalization quotient is the ratio of actual brain mass relative to the anticipated brain mass for an animal's size (based on the thought that larger animals require slightly less brain matter relative to their size compared to very small animals). It also shows the relative brain size based on the ratio of brain mass for a particular size of organism. Humans lead the rankings in EQ, with an EQ of “7.5” far surpassing the dolphin's 5.3 and that of a mice 4.8 [1]. This shows that the humans with the highest brain mass accounts for the highest encephalization quotient.

Regions of the Brain Involved in Intelligence

The development of neuroimaging techniques and other computational software tools have enabled neuroscientists and researchers to investigate the human brain in vivo as well. The evidence obtained from neuroimaging studies and pictures suggests that no single brain region has an exclusive effect on intelligence [4]. Literature Reviews in the previous years have suggested the parieto-frontal cortex theory, which indicates the parietal cortex and frontal cortex as the two regions of the brain involved in intelligence. The parieto-frontal theory has been supported by many neuro-imaging studies.

Out of all the structural neuroimaging studies done previously, 40% of them showed that both frontal and parietal lobes are involved in intelligence [5]. Studies pertaining to the usage of diffusion tensor imaging (DTI) have shown that structural organization of white matter (WM) at the minimal networking level and its developmental trajectory plays an important role in intelligence [5]. However, to date, network-level underlying mechanisms have stated that intelligence is derived from and is also associated with the white matter (WM) structural and functional levels.

There is also proof that gray matter (GM) is also associated with intelligence. The gray matter and its association with the structural framework of intelligence has not been researched in-depth. Other parts of the brain like the cerebellum that could potentially contribute to intelligence are often ignored or overlooked.
The parts of the brain involved in perceiving intelligence usually comprise the cortex, frontal lobe, and parietal lobe, and dopamine receptors. In a study done by Louise Ridley, in which he compares a normal brain and a genius brain, there are certain differences in the above-stated brain regions which distinguish a normal brain from a genius's brain [5]. The studies show:

1. A normal brain has a 50:50 ratio of long and short connections whereas a genius brain has a majority of either type of connections. Short connections indicate an aptitude based on one interest, whereas long connections suggest aptitude in many interests as well as the ability to see problems from new angles and perspectives [5].

2. Minicolumns are present in the frontal lobes of the brain. The genius’s brain has a dense concentration of “minicolumns”, also known as the brain's “microprocessors”, which help in powering the thought processes of the brain. However, the normal brain has an average of 80-120 minicolumns [6].

3. Research through the past several decades shows that the brains of geniuses have fewer dopamine receptors present in the thalamus. Dopamine inhibits neuronal signals, canceling out information it deems worthless. The shortage of receptors such as dopamine receptors in geniuses might mean that they are able to come up with a typical solution to a problem that normal brains tend to disregard [6].

4. The parietal lobe: Einstein’s brain was relatively smaller than a normal brain but the parietal lobe was larger than average. This shows that the parietal role plays an active role in intelligence [7].

Larger Brains Are “Smarter” Across Species and Evolutionary Time

Early evidence has supported the notion that, within the genus Homo, evolutionary constraints have generally been selected for larger brain size relative to body size over time.

Charles Darwin writes in The Descent of Man, “As the various mental faculties gradually developed themselves the brain would almost certainly become larger. No one, I presume, doubts that the large proportion which the size of man’s brain bears to his body, compared to the same proportion in the gorilla or orang, is closely connected with his higher mental powers” (Darwin 1871, p. 37).

For a long time, researchers and scientists have tried to correlate the size of the brain with the level of intelligence. The first of this work was done by Galton in the year 1869, which focused on brain size approximated by measures of head size [7].

Scientists Tramo and Gazzaniga in the year 1999 have found definite and positive correlations between magnetic resonance imaging (MRI) measures of brain volume, and intelligence. 37 neuroimaging studies shown by Mc Daniel in 2005, demonstrates a small, yet
consistent relationship between whole brain volume and psychometric measures of intelligence ($r = .33$). Moreover, the relationship between brain size and IQ appears to be rather equally distributed across tissue types, with unweighted mean correlation values of .31 for white matter volume and .27 for gray matter volume [7].

This relationship between total brain volume and intelligence is emerging through an evolutionary level, basic level, and now also at a nano-level. Two of the prime candidate genes that have been identified so far, microcephalin and ASPM, appear to play an important role in the regulation of brain size [8].

![From Man to Mouse](image)

Figure 1. Over the course of evolution, the brain has taken on many sizes and patterns of surface convolutions to give the neurological variety we see in mammalian species today [10].

It has been proved in research that brain size plays an important role in intelligence. From an evolutionary standpoint, the brain has evolved ranging from organisms such as mice, cat, lion, bear, chimpanzee, and dolphin, until humans. As we have a tendency to see from the tiniest to the biggest primates, for instance from mouse to humans, we are able to see which way the scale of the brain has inflated afterward, defining the amount of intelligence in every of them.
When speaking of the uncertain relationship between brain size and cognitive abilities between different species, a few questions arise. Can brain size predict anything about intelligence amongst humans or is it just a myth? Does having a large brain mean that one is smarter and more intelligent than another human with a smaller brain size?

Some studies suggest that the answer is yes. A recent genome-wide association study, which included around 20,000 human subjects along with their brain scans, was widely reported by the media to have discovered an “IQ gene”. As per the results of the experiment, certain variations in the HMGA2 gene, which is responsible for coding a protein that helps regulate DNA transcription and cell growth, can increase intracranial volume as well as an enhanced IQ [9].

Neuroscientists and researchers also believe that the brain’s computational capacity is determined by the complexity of cellular and molecular organization of neural connections, along with neuronal ends or synapses. This hypothesis is supported by findings and research that shows that intelligence is more correlated with frontal lobe and grey matter volume (denser in neuronal cell bodies and synapses), than sheer brain size.

Conclusion

MRIs and several other technologies have enabled to compare brain sizes of living humans and to find the relationship between brain volume and/or size and IQ [8]. Although having a large brain size is somewhat predictive of having smart thinking, intelligence and higher cognitive abilities probably depend much more on how efficiently different parts of your brain communicate with each other. Researchers generally agree that intelligence involves the ability to learn, survive in the environment, and adapt to changing environments. The studies involved in the past decades indicate that the involvement of the parietal lobe, frontal lobe, and cortex along with dopamine receptors play an important role in determining the intelligence level of the brain. How these parts of the brain communicate with each other and the mass they contain is an important deciding factor for the intelligence any species has.

The term “genius” has come a long way from classifying someone who is particularly innovative or adept, but neuroscientists are still far away from discovering what sets their brains apart from non-geniuses. Differences within the brain and, therefore, the accompanying thought processes, are only a part of the mysterious puzzle. The characteristics of the parietal lobe, frontal lobe, and cortex along with dopamine receptors differentiate a brain of a genius from that of an average human.

References

Geniuses have a denser concentration of thought process on the brain. Research shows that geniuses have fewer dopamine receptors in the thalamus. Retrieved: 01/11/2020.


Towards New, Modified Human Rights in the Era of Neurotechnology: Call for International Human Rights Law

Ehab S. Mohamed

Abstract

Modern advancements in neurotechnology and neuroscience may open unparalleled routes that invade individuals’ personal spheres ranging from collecting and accessing to sharing and even manipulating a person’s brain information. Such implantations pose notable threats to human rights principles; these challenges ought to be addressed to prevent unintended repercussions. This article assesses the implications of the emerging applications of neurotechnology in the context of the human rights framework and suggests, according to several case reports, that existing human rights legislation may not be sufficient to face such emerging circumstances. Finally, after careful interpretations and analysis of these issues, this article identifies four possible new/updated rights that may play a prominent role in covering these issues in the upcoming decades.

Introduction

For a prolonged period of time, the boundaries of the skull have been considered the separation line between the observable and unobservable dimensions of human beings. However, cutting-edge advancements in neuroscience and neurotechnology have progressively revealed the mystery of the human brain and supplied insights into the brain’s processes, as well as their link to mental states and observable behavior, respectively.

Beginning in 1878 by coming across a transmission of electrical signals through an animal’s brain, the practice of brain imaging became a desirable approach. Later on, the first human electroencephalography (EEG) was recorded. Following that, in the 1990s, commonly called ‘the decade of the brain,’ neurobehavioral uses of imaging techniques extended dramatically [i]. Since then, the neurotechnological revolution has taken vital roles inside and outside clinical settings. Nowadays, as a vast and increasingly expanding spectra of neuroimaging technologies has come to be clinically and commercially available, the non-invasive recording and collecting of brain activity
styles have become an accepted contemporary practice (starting from EGG, EPs, and ERP to fMRI and more.)

Furthermore, the capacity of neuroimaging techniques to map the brain's functions and activities has been verified and deemed effective in gaining insights into people's intentions, perspectives, and attitudes. Beyond the clinical and medical uses, a peer-reviewed study used fMRI scans on individuals who significantly drink Coca-Cola against the same individuals drinking unlabeled Cola to display activity differences [2]. The results of this study have pioneered the establishment of a spin-out branch of neuroscience at the intersection with marketing research called “neuro-marketing.” Since then, the concept of neuro-marketing has been expanded dramatically over the past decade, from well-known multinational companies like Google, Disney, CBS, and Frito-Lay to several leading companies in the mobile communication industry, including Apple and Samsung — neuromarketing research services were used to measure consumer preferences and even impressions on their advertisements and products. Namely, Neurofocus, an American multinational neuromarketing company recently acquired by Nielsen, tested subliminal techniques with the purposes of eliciting responses (e.g. preferring item A instead of B) that people cannot consciously register [3].

Predictably, if, within the previous years, neurotechnology has made the human brain an open book for scientists and comprehensible under scientific lenses, the upcoming years will witness neurotechnology becoming more pervasive and embedded in several aspects of our daily lives and swiftly more powerful in modulating the psychological and behavioral neural correlation. Nevertheless, while welcoming progress in the neurotechnology revolution, abuse, and other inappropriate implementations should be considered early and proactively, as it can lead to risks in spawning unauthorized forms of intrusion into people's private sphere, conceivably causing physical or psychological harm, and even allowing unprecedented impacts on people's conduct.

The Era of Neurotechnology

In and outside clinical and research settings, the capacity and range of neurotechnology applications are increasingly expanding. The prospective ubiquitous distribution of cheaper, scalable, and easy-to-use neuro-applications has the potential of opening unprecedented opportunities at the brain-machine interface and making neurotechnology intricately embedded in every aspect of our daily life practices. While these technological trends may generate monumental advantages for society at large in terms of clinical benefit, self-quantification, marketing analysis, personalized technology uses, and even judicial accuracy, its repercussions on the ethical and legal frameworks remain largely ignored by many authorities. In contrast to other biomedical technologies, especially genetic data that has been subjected to standard-setting efforts at the domestic and international levels, yet international human rights laws have not made any explicit references to neuroscience, while neurotechnology undergoes the same scenario that genetics studies have taken earlier [4].
Given the radical changes that neurotechnology imposes in the digital ecosystem, the normative terrain should be urgently prepared to prevent misuse or inappropriate implantations, which may pose amendments to the current human rights frameworks, in turn requiring either a reconceptualization of existing human rights or the creation of new neuro-explicit rights.

The proposal of these rights should be consistent with two fundamental poles: first, Glen Boire’s advocacy of a "jurisprudence of the mind that takes into account the latest understandings of the brain" also, "which situates these within our country’s tradition of embracing individual, self-determination and limited government. [5]" Second, the proposal of genetic-explicit human rights was declared by the Universal Declaration on the Human Genome and Human Rights (UDHGHR) and the International Declaration on Human Genetic Data (IDHGD). Conceivably, four approaches could be developed to prevent the repercussions of neurotechnology: the right to cognitive liberty, the right to mental privacy, the right to psychological continuity, and the right to mental integrity.

The Right to Cognitive Liberty

The recent debate over the notion of cognitive equality was considered a critical first step in establishing a neuro-oriented human rights framework. According to the Cognitive Enhancement book, specifically pages 233-264, this complex notion, often called "mental self-determination," comprises two fundamental, intimately related principles: "the right of individuals to use evolving neurotechnology" and "the protection of individuals from the unconsented and coercive use of such applications. [6]" The benefits of enforcing this notion extend beyond the prohibition of individuals from invading their private sphere, accessing their thoughts, modulating their emotions, or manipulating their personal preferences as it also will prevent social inequality because of the close relation with drug policy reform and the concept of human enhancement. However, in its negative sense of protection from coercive use, cognitive liberty can only partly encompass inappropriate uses of emerging neurotechnology. Indeed, illicit intrusions into a person’s mental privacy may not necessarily involve coercion since it could be performed below the threshold of a persons’ conscious experience. The same principle applies to actions involving harm to a person’s mental wellbeing or unauthorized modifications of a person’s psychological continuity, which are also facilitated by emerging neurotechnologies’ ability to secretly promote interventions into a person’s neural processing in absence of the person’s awareness. In this respect, the right to mental privacy and psychological continuity was proposed as potential complementary solutions.

The Right to Mental Privacy and Psychological Continuity

Today’s info-sphere is more intrusive than at any other time in history. Websites regularly use cookies to record store visitors’ information. Big and small corporations engage in data-mining activities that capture massive amounts of data about users. Email accounts are stuffed with advertisements and unsolicited offers. Video surveillance, facial recognition technology, and
spyware are opening up people’s daily activities for public consumption. As Dr. Adam D. Moore puts it, “informational privacy is everywhere under siege [7].”

Therefore, with more threats hovering over emerging neuro-applications, ranging from “inception problem” to specious EGG use and its linkage with tracing personal identity, it can be argued that current privacy and data protection rights are insufficient to cope with the emerging neurotechnological circumstances. Consequently, the right of mental privacy is highly recommended, as it will protect private and sensitive information in an individual’s brain from unauthorized assortment, storage, hacking, use, or even erasure — in digital form or otherwise. In contrast to existing privacy rights, the right to mental privacy will guarantee the protection of private data before any extra-cranial externalization (e.g., in verbal or printed format) and the generator/source of such data. As such, it will shield a person’s intellectual dimension as the ultimate domain of information privacy in the digital ecosystem. In coordination with that, people’s perception of their own identity may be put at risk through inappropriate uses of emerging neurotechnologies, like the unconscious use of neural devices that not only monitor brain signals but also modulate and process these signals and stimulate brain functions (e.g. tDCS or DBS). According to Dr. Decker & Fleischeret’s research on aspects of a technology assessment of neural implants, any changes in brain functions caused by brain stimulation can generate unexpected consequences on mental states and thus touch an individual’s personal identity [8]. Thus, the right to psychological continuity that will protect the mental substrates of personal identity from uncontrolled and unconsented intrusion/modication by third parties through invasive or non-invasive neurotechnology is necessary.

The Right to Mental Integrity

Finally, in view of the emerging collateral risks associated with the extensive use of pervasive neurotechnology, such as hazardous uses of medical neurotechnology, military applications of BCI as well as malicious brain-hacking, the right to mental integrity may entail reconceptualization. Namely, Dr. Lebedev has described that a neurologically controlled prosthetic could send tactile information back to the brain in nearly real-time by using intracortical microstimulation (ICMS), essentially creating a “brain-machine-brain interface [9].” Indeed, although mental integrity is protected by Article 3 of the EU Charter of Fundamental Rights, this right is conceptualized as a right to accessing and protecting mental health and is complementary to the right to physical integrity. Thus, and with respect to nascent circumstances of the neurotechnology applications, the right to mental integrity should not exclusively guarantee protection from mental illness or traumatic injury, but also from unauthorized intrusions into a person’s mental welfare through the use of such applications, especially if such intrusions result in physical or mental harm to the user [10]. So, for specific action to be counted as a threat to mental integrity, it has to: (I) involve direct access to and processing of neural signaling, (II) be unauthorized –i.e. must occur in absence of the informed consent of the signal generator, (III) result in psychological and/or physical harm. In fact, some may overlap this notion with the right to psychological continuity but the key difference is that
the right to psychological continuity applies to emerging circumstances that do not directly involve neural or mental harm.

Conclusion

Cutting-edge advancements in neurotechnology have opened unprecedented tracks for collecting, accessing, and sharing one's brain information, which in turn may develop as a threat to current human rights. Thus, as neurotechnology evolves, the international human rights law and concerned authorities are required to test the normative solidity of this proposed expansion of the human right frameworks to the neurotechnology dimension in conjunction with investigating the implications of such proposed human rights on other levels of law to offer sustainable censorship and guidance to researchers while providing protection to the public.

References


Contributors Page

IYNA JOURNAL DEPARTMENT STAFF:

Editor-In-Chief: Sojas Wagle

Head of Assembly: Annie Pan

Managing Editor: Shyam Soundararajan

Journal Artist-in-Residence: Jenna Mackenroth

Senior Editors: Kunal Dhirani, Anca-Mihaela Vasilica, Ashvin Kumar, Gasser Alwasify, Sampath Rapuri

Junior Editors: Bhavya Boddu, Haris Rana, Lori Saxena, Rod Moore, Sneha Nadella, Vaishnavi Kode, Johnny Yue

Journalists: Divyash Shah, Mariya Meleganich, Rhea Ray, Sai Snigdha Kodali

CONTRIBUTING AUTHORS:

Featured Writers: Magda Wojtara, Celestine Seyon Reuben, Shruthi Ganesh


IYNA BOARD OF DIRECTORS:

Vice Chair: Nipun Gorantla

Secretary: Sarah Iqbal

Chief Executive Officer: Brian Lee

Board Members: Allen Chau, Sofia Vaca Narvaja, Lara Ressin, Marisol Arau

ADVISORY BOARD:

Advisory Board: Dr. Norbert Myslinski, Dr. Mark Hallett, Dr. Jafri Abdullah, Dr. Olajide Williams, Elaine Snell