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An Introduction to CRISPR in Plants by Nicholas Ellis

Abstract

With an ever growing population on Earth and an ever growing demand for food, scientists have researched alternate ways to improve crops and expand them in number. One of these methods is through CRISPR Cas9 technology, one of the newest technologies in genetic engineering, and the most advanced method to date. Using CRISPR Cas9, scientists can isolate genes and replace them. They are able to alter elements of a plant's DNA, allowing the plants to display certain traits and not express others. This may become critical in the future as climate change forces crops into harsher conditions every year and the demand for food continues to grow.

Introduction

Genetic engineering is a field that has seen much development over the past ten years. CRISPR-Cas9 technology is one example of this that demonstrates the expansion of the technology. Since its founding, CRISPR has become the most advanced system of genetic engineering that exists today, and it has promise in the field of agriculture. This paper aims to introduce and summarize the developments and mechanisms behind CRISPR-Cas9 technology in agriculture, and what that means for the future.

Previous/Current methods

Selective breeding

To better understand the impact of CRISPR in agriculture, one should understand the previous/current methods in use. Selective breeding is a process that dates back thousands of years ago [1]. It is the process where humans will select crops with positive traits and breed them with one another. This leads to those positive traits being expressed more prominently in offspring, and the process continues to create better and better crops. It is an extremely common process, and some staple crops, such as corn, would not even exist without selective breeding [2]. This process has received very little public backlash, likely due to the fact that it involves no artificial processing/chemicals.

GMOs

GMOs are also extremely common in modern times. Genetically modified plants are created by taking a desired gene from a plant with positive traits. Then, the gene is inserted into another plant through a variety of methods [3]. These methods can be a variety of things, but the most common method is using a bacteria that contains the desired gene, and then putting lots of that bacteria onto the plant for it to be genetically modified. The bacteria transfers its DNA into the plant, and the gene is expressed as the plant grows. These expressed traits can be things such as resistance to certain diseases, or increased fruit production. This allows for better crops to be produced in a more precise manner than selective breeding [4]. There exists in many people a fear of GMOs, possibly due to the inclusion of artificial processes and the idea that they hold

some negative side-effects. Although, these supposed side effects have not been observed in clinical trials. A survey performed by the Food Standards Agency found that, in the UK, about 50% of people are either indifferent or against the notion that precision bred foods are safe to eat [5]. Though different from GMOs and CRISPR, studies like this could hint at CRISPR's possible public perception. Additionally, GMOs have been hit with heavy restrictions worldwide, being partially or completely banned in major countries such as France, Italy, Russia, and China [6].

CRISPR and Crops

How CRISPR changes crops

These topics bring us to CRISPR, a recent development in gene editing technology. It functions in a manner that is similar to current genetic modification in plants. The process was initially discovered in 1987, and remains under research today [7]. The process in which CRISPR functions is separated into three distinct phases. The first of these phases is called recognition. During the process, a certain strand of RNA is implanted into cells. This RNA is complementary to a particular gene of interest. The RNA and the Cas9 protein will find the gene of interest and align themselves with it. The next of these phases is called cleavage. This is the phase in which the Cas9 protein will break the bonds holding the particular gene to the rest of the DNA. Finally, the last step is called repair. This is when scientists can permanently alter the DNA of the cell, either implanting new DNA where the old one stood, leaving the slot empty, or other things [8]. This process, therefore, allows scientists to manipulate certain parts of an organism's DNA, including allowing them to remove genes with negative effects and inserting genes with positive ones. This highly precise process could be the future of genetic modification in agriculture. Scientists could one day use CRISPR to stop the creation of enzymes that rot fruit, or boost a certain gene that causes plants to grow large and have large fruit. With CRISPR being the most advanced gene editing technology, there are a myriad of possibilities to create better and more efficient farms and crops.

Different Methods for Delivery

Bacterium-mediated delivery of CRISPR into plants is the primary method of CRISPR delivery. It uses bacteria that contain a certain plasmid that the scientists want inserted into plant cells. The bacteria is shot onto the plant. The bacteria naturally grow ‘needles,’ and through these, the desired plasmid is free to enter the plant cell. The plasmid gets expressed as the CRISPR Cas9 system of interest, and they edit the plant cell's genome. Another method of inserting the CRISPR Cas9 system into plant cells is called protoplast delivery. It is difficult to get the system to enter a plant cell if the cell walls are in the way. So, protoplast delivery uses methods to severely weaken the cell walls of plants, allowing for the CRISPR Cas9 system to be implanted much in a much easier fashion. However, this method is not as popular as the bacterial method, likely due to the fact that plants have a very difficult time growing healthily with weak cell walls. Another method of implanting CRISPR Cas9 systems in plant cells is with the use of a sort of ‘gene gun.’ This is something that would project tiny particles of gold at plants. These pieces of gold would be coated with a substance containing the CRISPR Cas9 systems, and when

the gold pieces are shot at the plant, the pieces of gold would be small enough to enter into the plant cells and change their DNA. However, the primary drawback to this system is that it would be very imprecise [4].

Current Uses and Prospects

CRISPR is still relatively new and it is being heavily researched, so it has not seen any use in large-scale agriculture. However, lots of research has been and will continue to be conducted regarding the effects that the process can have on crops. These tests examine how the process can boost positive traits. For instance, tests have been done on individual wheat plants. These tests have focused on things such as starch quality and heat resistance. These tests have shown that CRISPR can have a tremendous effect on almost all qualities of a plant. Additionally, studies have been conducted into granting rice more thermotolerance. Climate change has led to rising global temperatures, as well as more frequent natural disasters and stronger weather events. CRISPR could have the opportunity to make crops more resilient to these factors, meaning that CRISPR may have to be the future of agriculture. Excitingly, CRISPR-edited crops have already hit grocery store shelves in many areas, including nutrient rich versions of crops and fruits that go bad at slower rates [9].CRISPR can also be used in more playful ways, such as weakening a gene responsible for citric acid production in lemons, which could make them sweeter. Research has been done into removing allergenic proteins from peanuts, making them enjoyable for all [10]. CRISPR does not have to be restrained to agriculture, as well. Many bacteria have evolved to be more resistant to antibiotics and cleaning devices. Using CRISPR, it may be possible for future scientists to locate and remove the genes responsible for this, thus making antibiotics more effective and saving lives, although this is a topic that would require its own paper.

Potential Drawbacks

Despite these positive effects and potential uses in the future, CRISPR does have some drawbacks and difficulties in gaining wide usage. One of these challenges is the challenge of how to deliver the CRISPR in an easy and cheap way. As it remains today, CRISPR is incredibly time consuming to implant into plants, and they may not have particularly strong effects in some cases. Additionally, the fear of unintended consequences remains. When altering the genes of a plant, despite the positive effects likely to come from it, there still exists a fear and possibility for negative effects to take hold. Plants could have their genes altered so that one negative trait may be removed, but it may lead to the creation of a harmful chemical, or some sort of reverse effect of what was intended. These situations are unlikely, but they can easily persist as a fear in the mind of many consumers and scientists alike. Additionally, the processes used to deliver CRISPR to plants, as well as the creation of the CRISPR itself, are expensive. As it stands currently, they take a long time and sometimes have to be done individually for every crop. This expenditure of time and resources could lead to CRISPR-edited plants becoming very expensive, should the practice see wide-scale use in agricultural businesses.

3: Legality and Public Perception

Regulations on CRISPR in Agriculture

Due to its drawbacks, cost, and negatives, CRISPR will likely have to wait quite a while before it sees widespread adoption in agricultural industries, despite the successes it's had in certain towns.. However, should this one day become the case, CRISPR would also soon become heavily regulated internationally. Government agencies, such as the FDA, would likely conduct large-scale testing to ensure that there is an absolute absence of negative side effects in CRISPR-edited crops. Nations that have banned GMOs can be expected to ban CRISPR-edited crops as well. Additionally, CRISPR may bring up other concerns that the government would likely investigate. One of these would be the environmental impact of CRISPR. Farms that implement CRISPR could find themselves facing a large set of guidelines and rules for ensuring that CRISPR-edited crops do not find themselves going wild in nature, since a situation such as this could lead to CRISPR-edited crops almost acting like invasive species to local ecosystems.

3.2 Public Perceptions

Since CRISPR relies on many of the same processes and is overall highly similar to the GMOs of today, it is likely that the two will garner similar reactions from the public. There will exist a large number of people who will trust CRISPR-edited crops, and many will be indifferent. However, there will also likely be many who strongly oppose its use, perhaps even more so than GMOs, due to CRISPR's more recent nature. Many people may fear currently unknown consequences. Theories that CRISPR may cause some sort of disease decades later in someone's life or lead to poorer health will likely pervade spaces of discussion about CRISPR. It remains to be seen if these potential fears will be well-founded or not, but regardless, if scientists hope to persuade the public into viewing CRISPR favorably in food, it may be a long and arduous process.

Conclusion

As CRISPR Cas9 and gene editing technology as a whole becomes more advanced, we must wait and see how it may affect our everyday lives, including what we eat. Despite the setbacks and challenges that many scientists may face to persuade the public, more likely than not, CRISPR is here to stay, altering the crops we eat for what may be a long time. This is likely to bring about great things and remove many problems. It is an exciting time to be a scientist.

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Nothing is more exciting than fresh ideas, so why are areas of knowledge often so slow to adopt them? Discuss with reference to the human sciences and one other area of knowledge
By Justin Kang

Fresh ideas are something that excite all areas of knowledge as they provide progression, discoveries, and new revelations for society. However, the acceptance of ideas can be slow as the knowledge can cause ethical and cultural dilemmas for communities and individuals. Although the role of experts can allow for the acceptance of ideas, it is ultimately the personal and cultural biases that hinder the acceptance of knowledge. The human and natural sciences provide many examples where bias has both prevented and facilitated the adoption of fresh ideas.

Despite the initial excitement fresh ideas bring, they are slowly adopted in the natural sciences due to the dominating role of personal bias. Although knowledge in the natural sciences is largely accepted as an objective telling of reality, personal beliefs create overarching biases that can overwhelm rationality. Personal prejudices that can be created from intuitive, emotional, and religious biases can cloud a knower's objectivity, therefore hindering their receptiveness to new ideas in the field, no matter how "well-researched" they are. This can be seen through the Scopes Trial in 1925, where Professor John Scopes was placed against a jury because he taught evolution to his class.[1] Despite the scientific evidence proving the existence of evolution, religious conservatives were against this knowledge because it went against their personal beliefs. Christians believe in creationism, where one God created all life on Earth.[2] However, evolution argues that all species evolve over time, such as humans from primates. Due to the controversial nature of this claim, in connoting humans to animals, this directly clashed with the deeper personal beliefs of the Christian-dominated government in the United States.[3] This is when one must weigh the objectivity of the natural sciences in comparison to an individual's truth. People will default to their mental paradigm and become reluctant to adopt ideas that are not in line with their "truth"— even if this means rejecting specific ideas in a field that disagrees with their paradigms. The religious prejudices of many experts and government officials overruled the objective knowledge Scopes was teaching, thus, fresh ideas must be filtered through someone's personal biases first, and only then can these ideas become adopted. In the case of the Scopes monkey trial, evolution was highly disregarded and not accepted because it didn't pass through religious believers' personal biases.

However, personal biases can help the acceptance of fresh ideas if the knowledge comes from a well-known expert. An expert has an important role in the natural sciences as they communicate their discoveries and research in a simplified manner to the rest of society. Respected experts in a field positively infiltrate the mental paradigms of the general population, allowing for any fresh ideas from them to be accepted as truth by society—even if the knowledge

[1] Hamilton, David E. "The Scopes Trial." *Bill of Rights Institute*
[2] Downes, Stephen M. "Evolutionary Psychology (Stanford Encyclopedia of Philosophy)." Stanford Encyclopedia of Philosophy, 8 February 2008
[3] Pew Research Center. "How U.S. religious composition has changed in recent decades." *How U.S. religious composition has changed in recent decades*, 13 September 2022

is false. For example, Albert Einstein is a respected figure in physics and has been socialized as one of the smartest mathematicians & physicists of all time. Therefore, society accepted anything Einstein produced despite any errors or false knowledge in his theories. He is famously known for the E=MC^2 formula and Theory of General Relativity proposed in 1905 and 1915 respectively[4], which garnered him a lot of ethos and credibility in the scientific community and made people more accepting of his future theories. However, some of Albert Einstein's research turned out to be incorrect, like his claims against an expanding universe in 1917. To prove that the universe was not expanding, Einstein added the cosmological constant to his equation for General Relativity.[5] Although Einstein was proved to be wrong by 1929, individuals were quick to adopt his knowledge as factual because it came from a credible expert in the field of physics. Therefore, fresh ideas can be accepted by people if they come from a prestigious and respected expert. What's problematic about this is that an expert's claims can frequently be viewed as definite and objective because scientists have lots of ethos garnered, making it difficult for their knowledge to be rejected even if the knowledge is false. Nevertheless, personal biases that favor an expert help facilitate the acceptance of new knowledge.

Although experts play an important role in the acceptance of new ideas, bias is an obstacle that new ideas have to overcome. During the global pandemic, one of the pressing demands was the creation of a vaccine. However, when the COVID-19 vaccine was created, people were hesitant to use the vaccine and raised safety concerns.[6] Although infectious disease expert, Doctor Anthony Fauci took the vaccine and started promoting it, people were still paranoid about taking vaccine shots despite the role of an expert attempting to persuade the public.[7] Even though Facui is a respected and prestigious expert, people would not accept his ideas due to personal biases against vaccines. People have a preconceived notion that vaccines and drugs must take years or decades to create, but when the COVID-19 vaccine was developed in less than a year, individuals were skeptical.[8] This is because most knowers are not knowledgeable about the FDA's guidelines and the methods taken to approve the vaccine. Thus, people's biases took over their understanding of the fresh idea, and they were paranoid about accepting that the vaccine was safely manufactured for people to use.

In the human sciences, experts are slow to adopt fresh ideas because they are culturally disconnected from new knowledge. Compared to the natural sciences, knowledge produced in the human sciences can potentially be more susceptible to bias. For example, in the classification of mental disorders in the 1973 Diagnostic and Statistical Manual (DSM) by the American Psychiatric Association (APA),[9] homosexuality was classified as a disturbance and a mental

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[4]Lu, Donna. "Albert Einstein | World-famous theoretical physicist." *New Scientist*
[5]Mann, Adam. "What is the cosmological constant?" Live Science
[6]"Dr. Anthony Fauci on COVID-19 Vaccines | NIH News in Health." NIH News in Health
[7]Ebbs, Stephanie. "Fauci receives vaccine, has 'extreme confidence' it's safe, effective." ABC News, 22 December 2020
[8]Lance, Rachel. "How COVID-19 vaccines were made so quickly without cutting corners." Science News, 29 June 2021
[9]Drescher, Jack. "Out of DSM: Depathologizing Homosexuality - PMC." NCBI, 4 December 2015,

disorder.[10] However, as more LGBTQ+ activists attended APA conferences, they were able to pressure human scientists to remove the controversial classification of homosexuality within the DSM. The conservative societal values in mid-20th century American culture made many psychiatrists reluctant to adopt fresh ideas regarding homosexuality.[11] However, in the 1970s cultural norms were slowly shifted due to the rise of the counterculture generation. This younger generation pushed back against the more conservative and older generations, putting pressure on psychiatrists to change accordingly. Initially, psychiatrists were more resistant to this change because of the differences between their generation and that of the counterculture generation. Their biases only began to change when the values of the counterculture generation spread to the rest of American society, eliminating the perceived difference. This change in cultural values made the members of the APA more willing to accept the fresh idea proposed by counterculture activists that homosexuality is not a mental disorder and that it should be removed from the DSM.

However, people are more likely to accept fresh ideas if they tie into similar values across cultures. For example, child development psychologists throughout the world are accepting of Kohlberg's theory of moral development as it isn't restricted by certain cultural traditions and laws. In his theory, Kohlberg argues that children learn to follow rules to receive rewards or to avoid punishment.[12] The concept of positive reinforcement and punishment Kohlberg proposed can be universally applied across cultures, as parents can utilize the theory's core principles no matter what environmental circumstance they are in.[13] In Korea, success in education and good grades are highly valued due to its competitive meritocratic society. As a native-born Korean, I was often scolded and punished physically when I failed to meet the threshold of academic excellence that my parents enforced. Furthermore, although Kohlberg's Theory originated in the United States, it proved useful for Korean parents because they could utilize its ideas to ingrain into their children that having good grades is important and having bad grades is something to avoid. This utility allowed his theory to be accepted across cultures and isn't limited to its geographical origins. The knowledge can be accepted despite different cultural circumstances as the concept of punishment is consistent across many cultures. Thus, knowledge in the human sciences can be easily adopted by different cultures when they deem it beneficial and aligns with their beliefs.

Nevertheless, knowledge is mainly contested because cultural differences overpower cultural similarities, leading to the slow adoption of fresh ideas. For example, John Fryer, a leading member of the American Psychological Association, never announced his homosexual orientation because of the cultural hostility towards LGBTQ+ people for most of his life. Even though John Fryer was in the same APA community, his sexual orientation was suppressed

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[10]Spitzer, RL. "The diagnostic status of homosexuality in DSM-III: a reformulation of the issues." PubMed,
[11] Dworkin, Ronald W. "The Fifties Were Awful, But Not the Way You Think." The American Interest, 7 May 2018,
[12]Mcleod, Saul. "Kohlberg's Stages of Moral Development." Simply Psychology, 17 January 2024
[13] Ounjian, Jennifer. "11.2: Cultural Considerations of Kohlberg's Theory - Social Sci LibreTexts." LibreTexts Social Sciences, 14 September 2023

mainly because of the cultural differences he encountered. From this, it can be inferred that the cultural differences he encountered overpowered any similarities he found with his peers. It was only when the counter-generation movement started to shift cultural values and chip away at this difference that John Fryer felt safer to come out and start to advocate for the declassification campaign by identifying himself as a gay psychiatrist.[14] Fryer's courage to go against societal norms played a significant role in the declassification of homosexuality as a mental disorder in the DSM.[15] It was only when the differences in cultural and generational values disappeared that fresh ideas could be adopted quickly.

While fresh ideas can provide a better understanding of our world and give insight into the unknown, due to the complex nature of human biases, these ideas are often diminished and difficult to accept. The subjectivity in individuals and communities makes it especially arduous for areas of knowledge to present fresh ideas due to uncertainty and skepticism surrounding those ideas. People are often discouraged in the adoption of knowledge which leads to the slow recognition of new discoveries that improve society.

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Developing and Utilizing Machine Learning Algorithms to Effectively Assist in Improving the Accessibility of Parkinson's Disease Diagnosis By Varun Hittuvalli

Abstract

Parkinson's Disease (PD) is a complex neurological disorder caused by the loss of dopamine-producing nerve cells in the substantia nigra, leading to effects such as rhythmic shaking, bradykinesia, rigid muscles, and writing changes. As a result of these symptoms, PD patients often develop several abnormalities in their handwriting, known as PD dysgraphia. For this reason, handwriting analysis is becoming an increasingly instrumental factor in PD diagnosis and detection. The primary goal of this project is to create a machine learning algorithm that can collect spiral drawing samples from users in real-time and predict PD dysgraphia. This approach not only enhances the efficiency of PD diagnosis but also offers the convenience of real-time analysis, potentially saving patients large amounts of time and resources.

Introduction

PD occurs when dopaminergic neurons in the basal ganglia, a brain area that plays a vital role in motor control, begin to die, or become impaired (DeMaagd and Philip). Dopamine is a neurotransmitter that controls movement and concentration, as well as emotions such as pleasure and happiness (Juárez Olguín et al.). When dopaminergic neurons are healthy, there is sufficient dopamine production in the brain, but as these neurons deteriorate, the overall dopamine levels decrease significantly, causing widespread issues in balance and coordination in people with PD (Baixauli Gallego ; Meder et al.). The majority of people with PD experience symptoms such as hand and leg tremor, muscle stiffness, and slow movement, which in turn can lead to problems such as depression and difficulty swallowing or chewing (Dauer and Przedborski).

With over 10 million people worldwide affected by PD and approximately 60,000 new cases diagnosed annually in the U.S. (Selvaraj and Piramanayagam), the disease's extensive prevalence, along with a multitude of challenging symptoms, greatly contributes to its significant global impact. Most people affected by PD are 65 years of age or older, and the incidence of PD notably increases with age (DeMaagd and Philip). Despite this general trend, an estimated 5% of people with PD are diagnosed before the age of 50, and in rare instances, symptoms of PD can even be found in juveniles and teenagers (Golbe), highlighting the diverse age range that the disease can impact.

Furthermore, there is no existing cure for PD but there are treatments available that attempt to alleviate the symptoms of PD. Physical therapy, speech therapy, and occupational therapy have been used to ease the quality of life for PD patients, and prescriptions such as levodopa and dopamine agonists help to reduce tremor and increase dopamine levels (Dauer and Przedborski).

Diagnosing PD is challenging because there is no definitive test or exam available. Symptoms of PD can often be mistaken for other Parkinsonian disorders, and vice versa, despite having different causes, disease progressions, and responses to treatment. Instead, doctors and medical professionals must analyze symptoms and medical history to make an official diagnosis.

Doctors often look for symptoms such as shaking/tremor, posture instability, and rigidity as well as other abnormalities that can be detected through a neurological examination. There have been breakthroughs in recent years involving the testing of alpha synuclein levels in cerebrospinal fluid, however, there are many methodological issues related to the quantification and detection of alpha synuclein that have yet to be resolved (Ganguly et al.). In addition to the absence of a conclusive test or exam for diagnosing PD, medical professionals face other significant challenges. The symptoms of PD often vary considerably from person to person, which can complicate the diagnostic process. Furthermore, the early stages of PD may present symptoms that are subtle and easily overlooked, making early diagnosis particularly challenging (Dauer and Przedborski).

To overcome the obstacles of PD diagnosis, a variety of machine learning models have been deployed to assist in diagnosing PD using data such as voice recordings (Tracy et al.), MRI scans (Abos et al.), and movement samples (Djurić-Jovičić et al.). However, these models often require large amounts of time and resources to collect the data necessary to make a diagnosis, and frequently, the data can only be collected in a hospital environment.

In this project, I aim to develop a machine learning model that predicts the likelihood of PD based on analyses of spiral drawing samples, where individuals will be tracing an Archimedean spiral with a pen or stylus. Spiral drawings are a recognized diagnostic tool in clinical settings, used to assess motor control and the presence of characteristic PD symptoms such as tremors, bradykinesia, and rigidity. These motor deficits can significantly impact a person's drawing abilities, making spiral tests a valuable method for evaluating the severity of these symptoms. By translating the nuances of spiral drawings—such as line consistency, tremor presence, and overall fluidity—into quantifiable data, this model seeks to harness the diagnostic capabilities of this method, offering objective insights for the early detection and monitoring of PD. With this project, I hope to increase the accessibility of PD diagnoses, and to create a sustainable tool which can be used without obstacles or hindrances.

Methods–Dataset

For the machine learning model, I used the Parkinson Disease Spiral Drawings Using Digitized Graphics Tablet dataset from the UCI Machine Learning Repository (Isenkul et al.), which consists of handwriting data from 62 people with PD and 15 healthy individuals. The handwriting data used for assessment is categorized into three distinct groups. The first is the Static Spiral Test, where each patient traces Archimedean spirals. The second, known as the Dynamic Spiral Test, involves tracing an Archimedean spiral that appears and disappears at specific time intervals. Lastly, there's the Stability Test on a Certain Point, where subjects are asked to hold a digital pen on a red point in the middle of the screen without touching the screen for a certain duration. As shown in Figure 1, I chose to use only the data from the Static Spiral Test, which contained the x-coordinates, y-coordinates, z-coordinates, pressure, grip angle, timestamp, and test ID of each Archimedean Spiral Drawing done by the one of the 77 people from the original study, as it provided the best representation of a person’s hand movements in

relation to the context of this project. I further processed this data by only using the x-coordinates, y-coordinates, and timestamp data to extract the features for the model.

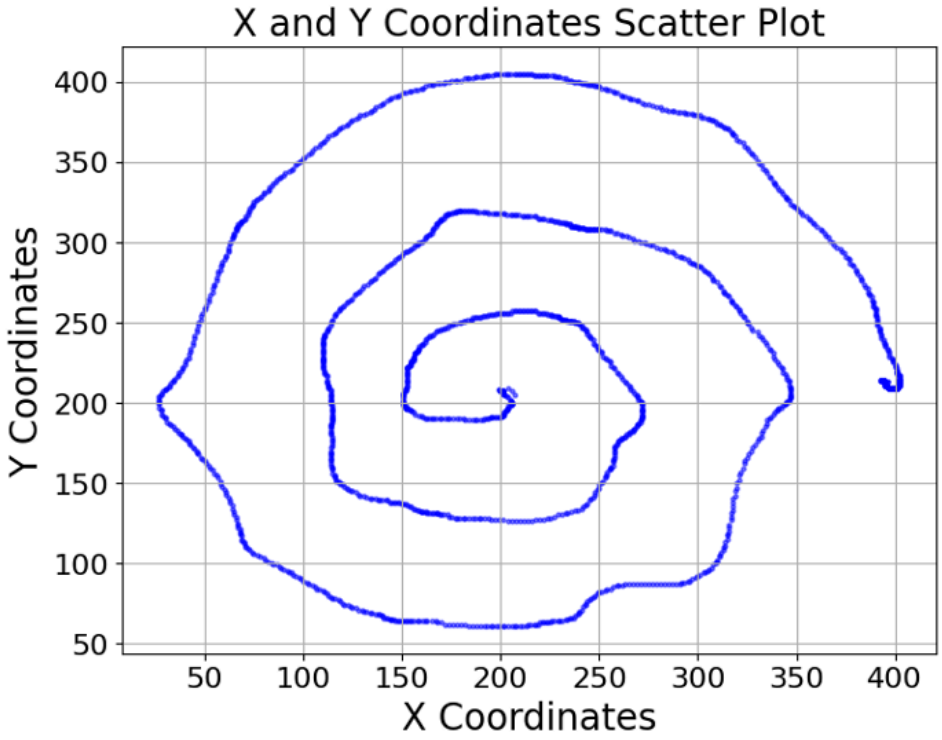


Fig 1: Plot of X and Y coordinates of spiral drawing of PD Patient from Dataset

Feature Extraction

I extracted 22 dynamic and kinematic features using the x-coordinates, y-coordinates, and timestamp (in milliseconds), for each drawing:

- Range: I calculate the difference between the smallest x-coordinate and the largest x-coordinate (x-range), as well as the difference between the smallest y-coordinate and largest y-coordinate (y-range).
- Velocity: In addition to extracting the speed, I calculate X-Velocity, $V_x = \frac{\Delta x}{\Delta t}$, every 20 points and find the average of all the X-velocities. I also calculate the Y-Velocity, $V_y = \frac{\Delta y}{\Delta t}$, every 20 points and find the average of all the Y-velocities.
- Acceleration: In addition to calculating the magnitude of acceleration at each time point, I calculate the x and y components of acceleration. X-Acceleration, $A_x = \frac{\Delta V_x}{\Delta t}$, every 2 points and find the average of all the X-accelerations. I also calculate the Y-Acceleration, $A_y = \frac{\Delta V_y}{\Delta t}$, every 2 points and find the average of all the Y-accelerations.

- Distance from mean coordinate: I calculate the mean x coordinate and mean y coordinate for each drawing, then iterate through each coordinate in the drawing and find the distance between the mean coordinate and the actual coordinate.
- Distance from moving average: I calculate the moving average of the x and y coordinates over a window of 10 points, and then I find the distance from the average x and y coordinates to the corresponding point on the spiral (Fig 2).
- Average angle: I calculate the angle of the spiral in radians between intervals of 20 points using math.atan and convert the radians to degrees. I then calculate the consecutive difference between the angles I found.
- Jitter: I start at the 10th coordinate of every drawing and iterate 10 points forward each time. If the x-coordinate is greater than or less than both the x-coordinate 10 points before and 10 points after, I increment the jitter count. The jitter count is also incremented every time the y-coordinate is greater than or less than both the y-coordinate 10 points before and 10 points after. If the jitter condition is satisfied, I calculate the distance between the current point and the point 10 points before and append the distance to a list.
- Amplitude: After applying Fast Fourier Transform to the time series, I take the absolute value of the result and divide it by the length of the data to get the amplitude components.
- Frequency: After calculating the periodogram for the time series, I determine the dominant frequency by identifying the frequency at the index where the power density is the highest.

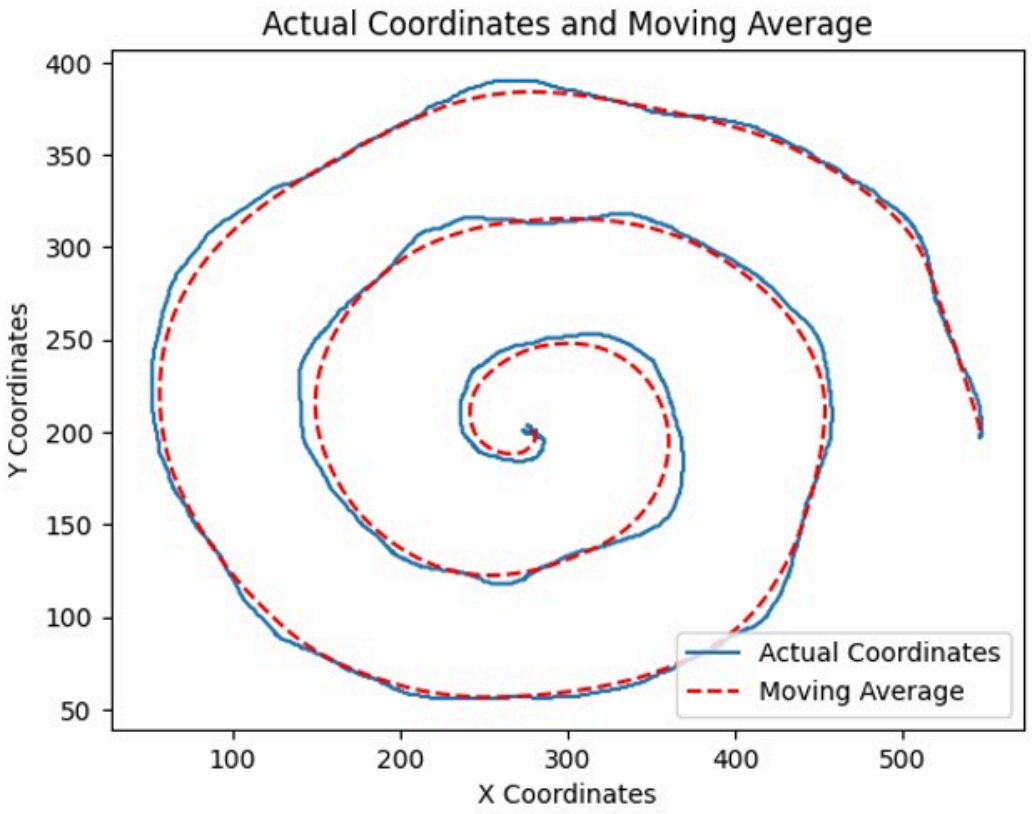


Fig 2: Moving Average Plotted Over Actual Spiral Drawing

Model

After successfully collecting all the relevant features for the model, there was a significant class imbalance as there were 61 instances of people with PD in the new dataset but only 15 instances of healthy people in the new dataset. I split the data into 80% training sets and 20% testing sets, and I employed the Synthetic Minority Oversampling Technique (Chawla et al., 2002) to make the dataset balanced by artificially creating extra feature vectors of healthy people in the new training set. Then, I created the model, an ensemble Adaboost Classifier with a base estimator of a Random Forest Classifier (Biau & Fr, 2012). Next, I chose to perform Recursive Feature Elimination with Cross Validation to select the features for the model that produced the optimal sensitivity. I found that out of the original 20 features, 10 features (X-range, Y-range, Y-Average-Velocity, X-Average-Acceleration, Average-Acceleration, Maximum Distance from Moving Average, Average-Angle, Average-Angle-Change, Jitter, Maximum Deviation of an Oscillation, Maximum Amplitude, Average Amplitude, and Minimum Amplitude) provided us with the optimum model performance. Finally, I performed hyperparameter tuning using GridSearchCV with a parameter grid including the number of estimators and the learning rate.

Application

The envisioned application, upon full development, could serve as a potential tool for enhancing the diagnostic process of Parkinson's disease (PD). By leveraging a machine learning model, encapsulated within a Python Tkinter GUI, it aims to provide a novel approach to PD diagnosis. The application is designed to offer an accurate template for users to trace—a moving average of the coordinates from the most accurately drawn spiral in the dataset. This not only aids users in creating their own spiral drawings but also ensures consistency and accuracy in the data collected. As users trace the template on a touchscreen, the GUI is planned to dynamically respond, capturing the x-coordinates, y-coordinates, and timestamps of their drawings in a CSV file for further analysis. Upon completion of the drawing, users would be prompted to initiate the prediction process with a simple click, leading to the extraction of relevant features and their evaluation by the pretrained model. The application's goal is to output the model's confidence in the PD diagnosis, providing users with immediate feedback in the form of a probability score alongside a detailed data frame of their drawing metrics. Additionally, a feedback mechanism, through a link to a Google Form, is proposed to gather user input, further refining the tool's effectiveness and user experience. This approach has the potential to revolutionize early PD detection and monitoring by making it more accessible and interactive.

Results

Table 1: Comparison of Machine Learning Model Performance on Testing Set: Specificity (True Negative Rate), Sensitivity (True Positive Rate), Positive Predictive Value (PPV), Negative Predictive Value (NPV)

Model	Accuracy	Specificity	Sensitivity	PPV	NPV
Adaboosting Classifier	96.94%	95.78%	98%	96.36%	98.18%
Logistic Regression	93.89%	100%	87.55%	100%	90.23%
Support Vector Machine	93.84%	98%	90%	98%	90.55%
Decision Tree Classifier	91.9%	93.56%	90%	94.17%	91.67%

Gaussian Naive Bayes	87.68%	98%	78%	98%	81.65%

Since the context of the project is related to disease diagnosis, it is imperative that the model is best at identifying true positives, which is measured by the performance metric sensitivity. Because of this, I used RFECV, a feature selection algorithm, and GridSearchCV, an algorithm which finds the best parameters for the model, to significantly improve the overall performance and maximize sensitivity.

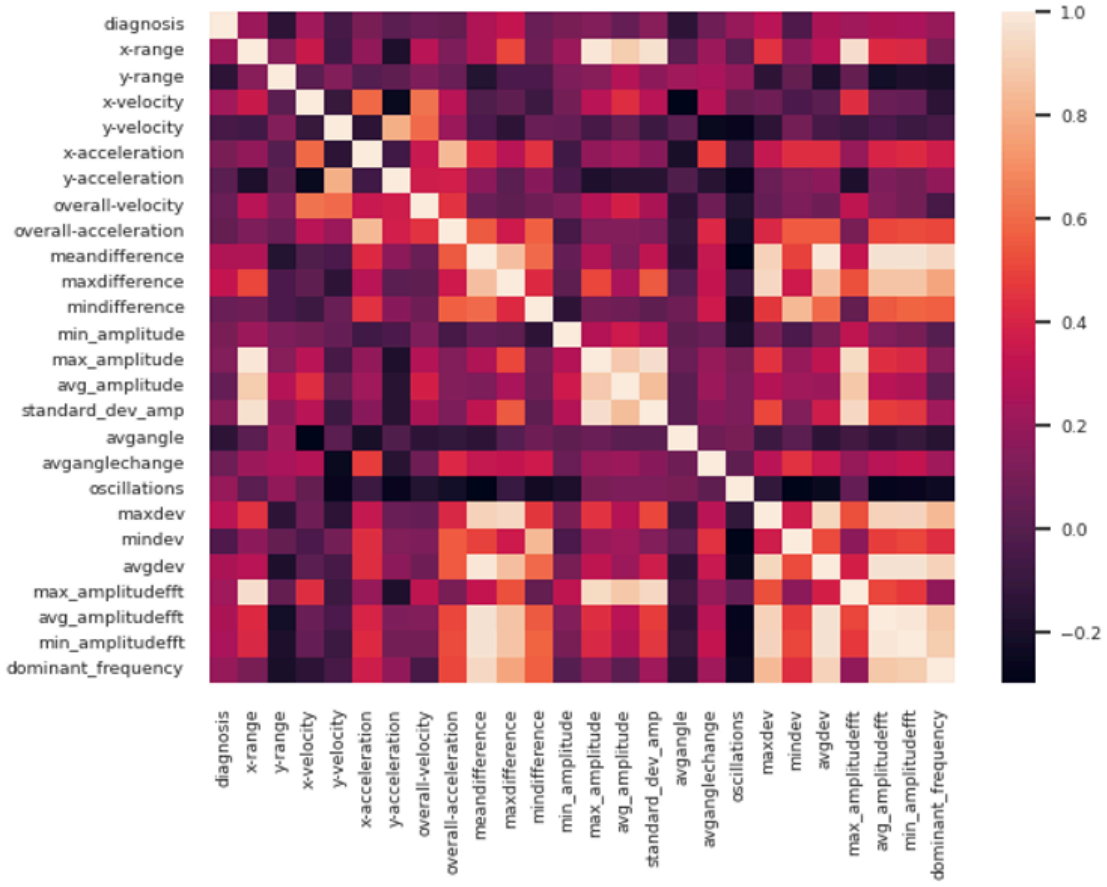
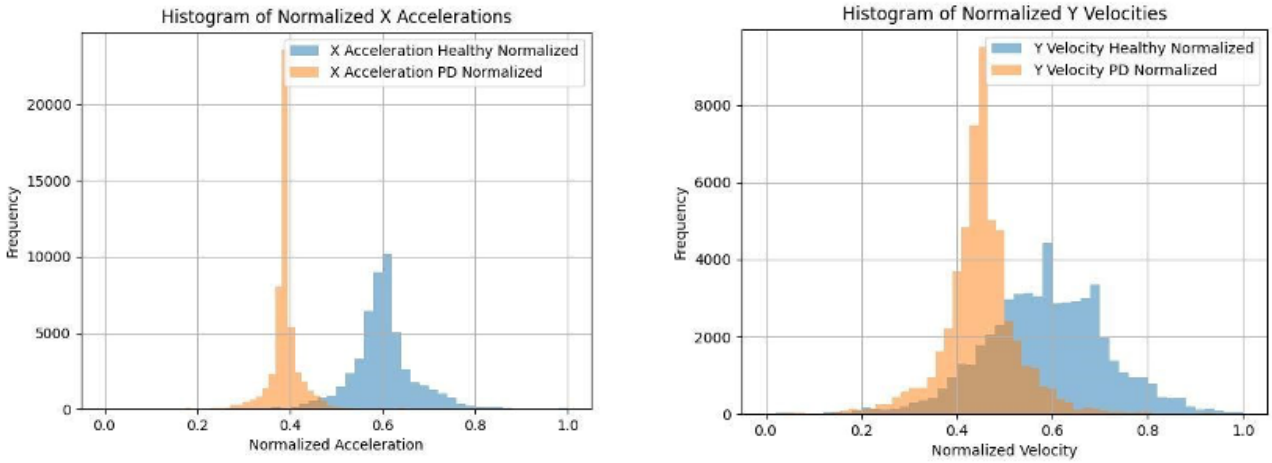


Fig 3: Correlation Plot For All Features Extracted From Original Dataset



Figs 4 and 5: Histograms of Normalized X Accelerations and Normalized Y Velocities

Analyzing Acceleration and Velocity in PD vs. Control

Figure 4 and Figure 5 illustrate the distribution of two key kinematic features, highlighting how they differ between populations. The observed gap in these histograms may be attributed to the symptoms of PD dysgraphia. For example, PD patients often display significantly slower starts in their spiral drawings compared to their healthy counterparts, a finding that is consistent with the observed slower acceleration rates in our study. This slower initiation of movement is a characteristic manifestation of PD, deeply rooted in symptoms like bradykinesia, which involves slowness of movement, and micrographia, where handwriting becomes small and cramped. The presence of these symptoms in PD patients can lead to more constrained and weaker movements, further evidenced by the slower acceleration patterns in their kinematic profiles. Thus, our findings not only highlight these well-known challenges in PD but also quantitatively confirm them through the analysis of kinematic features. The distinct differences in the X acceleration and Y velocity levels of PD patients and healthy people provide valuable data to the machine learning model, and provide quantitative insights into the motor characteristics of PD. Utilizing this data in the model allows for more accurate and reliable predictions of PD diagnoses as the model is able to better determine patterns in movement data and drawing samples.

Discussion

The results of the study demonstrate the successful development of a machine model for PD diagnosis through the analysis of handwriting features. The model showed promising performance metrics, with a focus on optimizing sensitivity, which is crucial in the context of disease diagnosis. Additionally, the accuracy of 96.94% and the specificity of 95.78% shows that the model is not just good at predicting positive cases, but can predict cases well overall,

regardless of class. These results have profound implications for the accessibility of PD diagnosis, as users of the digital application from around the world will be able to access the model, without interference from other factors such as location or cost.

Pros and Cons of the Model

Overall, there are various benefits of the model such as high sensitivity, which is the most important metric in disease diagnosis, as it measures a model's effectiveness in detecting positive cases of a disease. Equally important is the model's high specificity, at 95.78%, which plays a vital role in reducing false positives. This high specificity means that the model is adept at correctly identifying individuals who do not have the disease, thereby preventing unnecessary medical interventions and associated costs. This aspect is particularly crucial as it can help protect individuals from the financial and emotional burdens of unwarranted medical procedures and treatments, ensuring a more targeted and efficient healthcare approach. Additionally, the model increases accessibility to all with a touchscreen device, creating convenience and ease for people who wish to perform a diagnosis test without needing money and resources. Finally, the model uses real-time analysis to allow users to provide live spiral drawing samples and receive instantaneous results.

However, there are a few problems that I encountered during the process of building the model, which include class imbalance, as the dataset used for the model contained samples from 62 PD patients and only 15 healthy people, and limited interpretability as the Adaboost model I used is considered a "black box" as its inner workings are complex and hard to understand. To prevent the model overfitting and complexity caused by these problems, more varied forms of data could be collected and used in the future to retrain the model to account for differences in the type of device that people may perform their spiral tests on, as all the current training data comes from only one specific device.

Project Improvement

In addition, some possible ways the model can be improved is through retraining the model on data collected from healthcare professionals or medical organizations, as this eliminates the disconnect between the data collected in the dataset and the data collected from the application. Also, I plan to alter the model so that it collects multiple types of data such as voice and movement recordings to develop an even more comprehensive and complete PD diagnosis tool. Similarly, I plan to make the model capable of analyzing the success of different treatments of PD, through extracting the relevant kinematic and dynamic features, and tracking the change in the extracted features over time as a user provides more and more spiral drawings. Finally, I hope to incorporate deep learning into my project, possibly including a neural network which can produce PD diagnoses based on spiral drawing images, as this would eliminate the need for manual feature extraction and allow for the model to improve and learn from its errors.

Broader Impacts of the Model and Application:

The broader impacts of the model and application include improved quality of life as early diagnosis of PD can provide timely access to the necessary treatments and medication, as well as reduced healthcare costs. Additionally, the user feedback feature of the application offers users the chance to voice their concerns and suggestions, encouraging user engagement and continuous model improvement. In the future, I plan to distribute this resource through partnering with various healthcare providers as well as companies dedicated to creating artificial intelligence solutions for medical problems. I also plan to release this app on various platforms such as the app store and the chrome web store so that I could have the opportunity to foster a community of various users and healthcare professionals.

In conclusion, the machine learning model for PD diagnosis offers an array of benefits in terms of accessibility, cost-efficiency, and early detection. The model's strong performance and real-time analysis capabilities make it a valuable tool for both users and medical professionals. While there are areas for improvement, future research directions and broader impacts hold great promise for enhancing the diagnosis and management of PD.

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Function as a Driving Force of Romanesque Architectural Evolution By Rhea Menon

Abstract

In the 11th century, St. Michael's Church was completed in the Romanesque style, though some consider the building to be pre-Romanesque. The Richardsonian variation of this style is an American adaptation of the ancient Romanesque style of the early 11th century, which experiencedmajor changes during the Romanesque Revival, nearly 700 years later and on the other side of the world. Charles F. Haglin and Charles Morse designed Minneapolis City Hall in 1888 in the Richardsonian Romanesque style, and the construction completed in the early twentieth century I chose to further my knowledge on the evolution of geometric rationale and design aspects over time and how societal influences may have impacted this style... In this paper, I will be addressing the evolution of the Romanesque style through a comparison of two buildings created in the periods which these styles were most prevalent. My primary investigation into the architecture of these structures is through plan drawings made by analyzing images, existing drawings, and visiting sites when possible, the first being St. Michael's Church in Hildesheim, Germany, and the second being the Minneapolis City Hall Building, in Minnesota, U.S. Using historical analysis, I will further this research by analyzing how different issues and societal values arose over time and how this may have impacted the architectural styles of the time. Throughout this paper I hope to better understand both the Romanesque and Richardsonian Romanesque styles, as well as how each style functionally evolved, analyzing their characteristics and purposes through research and drawing.

Introduction

The Ancient Romans are well known for their intricate and fanciful art and design styles. One of these styles which is most prevalent in modern society, especially in the United States, is the Romanesque architectural style. This style has greatly evolved over time and has led to the creation of many different building styles, the main two being the Gothic and Richardsonian Romanesque styles. While both are quite different from the original, the Richardsonian Romanesque style shares more similar functions to its predecessor and is the style that this paper will focus on. The Richardsonian Romanesque style is not very well known but is commonly used across the country in public buildings. This, along with other historical evidence, shows that the driving force for the evolution of the Romanesque style was function.

The Origins of the Romanesque Style

The romanesque style of architecture, prevalent from 800-1100s A.D., utilized elements created by the ancient Romans (History of Romanesque Architecture, n.d.). Three main elements which make this style distinct are round arches, symmetry, and an emphasis on biblical design aspects. The style was created around 800 C.E. when Charlemagne, the emperor of the Holy Roman Empire, began creating churches in the Roman style, specifically the style from the rule of the first Holy Roman Emperor, Constantine (Spanswick, n.d.). He did so in order to validate

his rule by connecting it with that of Constantine, as well as connecting it to the church. Soon it was realized that the Romanesque style was advantageous for constructing large structures because it had a practical system of stresses and buttressing. The style was then utilized in gatehouses, chapels, and churches within Europe (Spanswick, n.d.).

Some refer to the style in this period as pre-Romanesque, as the Romanesque style saw growth between the 9th-12th centuries when it was prevalent. As knowledge about this style of architecture spread, due to the expansion of monasticism, the buildings created in the Romanesque style became larger and more imposing. The Romanesque style spread mainly throughout Europe, mainly in countries which were part of the Roman Empire, such as France, Germany, Italy, Spain, Britain and Scandinavia. The Romanesque style spread to Britain, though in Britain it became known as "Norman" because the use of this style within the country was initiated by William the Conqueror, who had invaded Britain from Normandy (Spanswick, n.d.).

The Romanesque style at its peak utilized repeating shapes and proportions, rows of sturdy piers or columns with arches connecting them, simple geometric designs rather than floral or curvilinear patterns, and painted ceilings(Spanswick, n.d.). One effective example of this is St. Michael's Church in Hildesheim, Germany.

St. Michael's Church

St. Michael's church was constructed between 1010 and 1022; the building is still in use to this day (Michigan State University [MSU], n.d.). Since the structure has been damaged and rebuilt since its creation, I will be analyzing the original building rather than the present day structure. As with most Romanesque structures, St. Michael's Church is characterized by its symmetrical layout, with the east mirroring the west, which can be seen in the plan below.

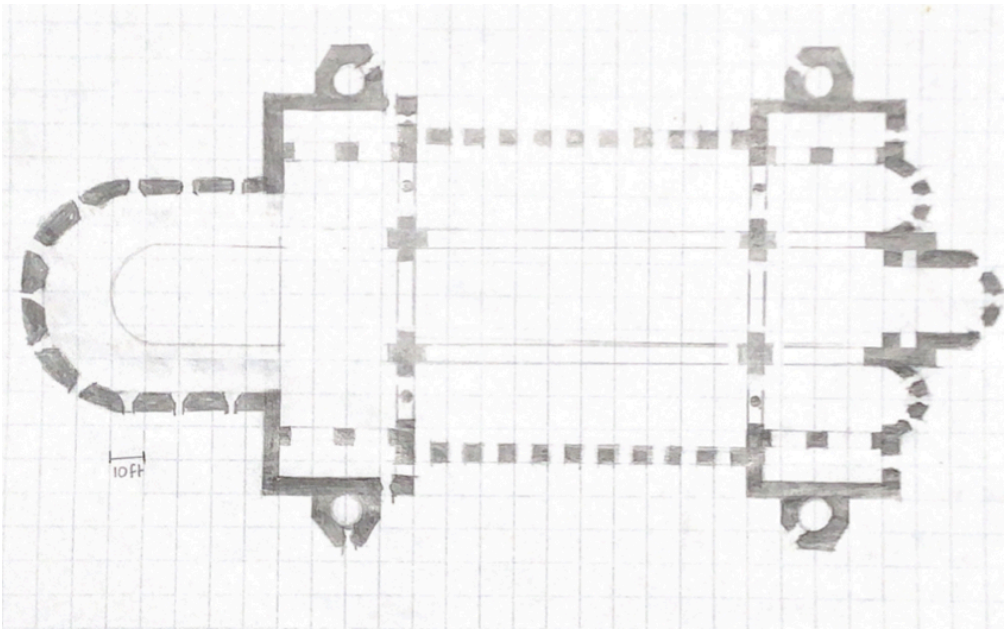


Fig. 1: Plan of St. Michael's[1]

The interior of the church also has a painted wooden ceiling and large arcades. Due to the time of its creation, the building lacked strong buttresses; since a stone roof would be too heavy for the structure's walls alone to support, a light yet durable wooden roof was used instead. However, its most prominent feature would be the doors. The bronze Bernward doors were commissioned by Bishop Bernward of Hildesheim and are over sixteen feet in height. Each was made as a single piece and is known as the most complex bronze-casting project undertaken since antiquity (St. Michael's Church, n.d.). The doors portray biblical tales with immense detail and precision.

The Romanesque Revival

Centuries after the time of Romanesque architecture, key pieces of the style began being incorporated into American architecture. This period, from 1840-1900, was known as the Romanesque Revival. Few buildings were built in the early revival styles until 1870, when a new Romanesque Revival style was created (Architecture Styles, 2011).

This unique style was created by Henry Hobson Richardson, a Harvard graduate who had studied architecture in Europe. Richardson combined French, Spanish, and Italian Romanesque features in order to create what is now referred to as the Richardsonian Romanesque style. This style quickly grew in popularity, mainly being used in public buildings due to the size and building requirements, and Henry Hobson Richardson became known as the father of the Romanesque Revival (Finn Macleod, 2017). Similar to the Roman style of its origins, the Richardsonian Romanesque style of architecture includes many arches and thick stone or brick walls. However, the style now had one main difference to its predecessor: walls pierced by large and multiple coursed arches. These arches are layered and often around windows and door frames as decorative elements for the building.

Minneapolis City Hall

The current Minneapolis City Hall building was created in 1888 and completed in 1906, with the addition of the clock tower. The structure was designed by Long and Kees, which was an architecture firm that mainly worked on structures in the Richardsonian Romanesque style. The building has gone through one major change since its creation, which was the necessary replacement of the original terracotta roof, as the tiles would fall and become a safety hazard. These ceiling tiles were replaced with the current copper roof (Minnesota Government, 2007). The Minneapolis City Hall building includes four symmetrical parts, with each of the corners being equivalent to the one shown in the sketch below.

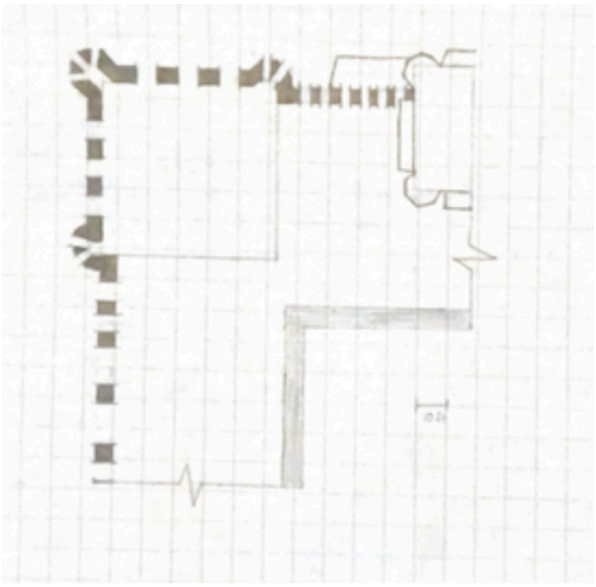


Fig. 2: Plan of Minneapolis City Hall

The structure also includes three large arches, which pierce the wall by the main entrance, as well as arched cutouts on the walls of the clock tower's balconies.

Comparisons

Since the time of its creation, the Romanesque style has seen major changes, the main reason for them being function. Since the style began, it has been used to create large buildings that are important to society. In the time of the Romans, those buildings were churches. However, as time passed and the style spread, religion lost importance with the government putting more emphasis on government and public buildings. This was the reason for the loss of one crucial aspect of the original style: the biblical designs. While many aspects of the style remained the same, such as wall thickness, materials, and arches, the buildings also gained new structural aspects such as buttresses in order to make them sturdier, larger, and allow for heavier roofs rather than the wood ones of the past.

Conclusion

Romanesque buildings have always maintained a powerful and strong image, which has been a main reason that the buildings tend to be places of power and at the center of society. As time changed societal values did the same, switching from a strong church to a strong government, with building style following. With adaptations such as height and size—which were partially due to technological advancement—the style has grown more prevalent and is often seen around the country in public buildings, usually involved with the government rather than a specific religion. This is due to the fact that the size and material cost of the Richardsonian Romanesque style is not often affordable by private groups.

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The Protagonist: A Journey of Narrativization By Nathan Wang

Abstract

The concept of narrativization has been argued about in philosophy for centuries. However, scant attention has been given to its applicability to our daily lives when considering it as an approach to life. This paper contrasts numerous arguments from philosophers and contemporary professors to arrive at a conclusion regarding narrativization. As an optimistic byproduct, I aim to assist anyone struggling with finding a sense of identity by providing individuals with a more holistic perspective.

Introduction

Nihilism has increased in prevalence among teenagers and young adults in recent decades. Simultaneously, the new 'YOLO' motto has gained popularity among youth. One reason for this trend could be the oversaturation of markets and the influx of talent and competition, where one's future seems ever so opaque. It is easy to doubt oneself, one's abilities, and the aspects that make one fundamentally unique. The question surrounding purpose and meaning seems more relevant than ever, yet it has been debated for thousands of years in the philosophical world. The solution? Meditation? Constant self-exploration? Discovering nature? Believing that every step of life has already been determined for you? Self-help books about Stoicism? Philosophers, psychologists, journalists, and even non-expert self-enthusiasts have all attempted to address this one question. This paper argues against one such approach to living a meaningful life: Narrativizing your life. In short, narrativizing one's life is the perception that you, as an individual, are the protagonist of a story that lasts your entire life. Like any narrative, your primary objective is to reach a particular climax, which is synonymous with an individual's life goal. In the past, narratives have been related to the feminist movement, and the notion of individuality has been at the crux of the topic. Feminists made arguments against narrativizing one's life on the basis that narratives prolonged harmful gender roles. Seyla Benhabib, a Turkish-born American Philosopher, introduces us to a few of these narratives —familial narratives, gender narratives, linguistic narratives, and narratives regarding our own identity. Essentially, these narratives make up the norms and moral codes within any given society and may limit one's ability to tell one's life story. One of the most discussed issues was the effects of such gender and familial roles, where they were born into positions of obedience and labeled as future mothers from the moment they were born(Benhabib, n.d., p. pg 344). These very narratives severely impacted the decisions women were (and were not) allowed to make related to the careers they wanted to pursue, their education, and a large portion of issues pertaining to their selfhood.

Although a core aspect of what narrativization is, the role narratives played in feminism is not the core idea of my paper, and I will not be discussing particularly harmful narratives. My paper begs the question of whether narratives are principally good in nature, even if there is

nothing uniquely wrong about the narratives in question and we are only concerned with ideal narratives.

Paul Ricoeur, a prominent 20th-century philosopher, contributed to one of the central debates within philosophy: the meaning of life (Fieser). In the status quo, where people are as polarised and divided as ever, Ricoeur offers the narrative theory as the solution to living a life of purpose, or the good life as he calls it. From another perspective, as mainstream media diffuses globally, numerous individuals have begun narrativizing their lives to discover a sense of direction or have been influenced by mass media. Narrativization of life can be defined as individuals perceiving themselves as the protagonist in their own stories. These narratives follow the typical storybook arc with one or two climactic points involving a prominent element of purpose, life goal, or common theme that ties things together, creating a coherent narrative. Recently, narrativization has expanded beyond the realm of philosophy, and psychologists have entered the debate on the narrativization of life. In an article written by Julie Beck of The Atlantic, she draws upon an argument made by psychologist Jonathan Adler. He argues that by narrativizing our lives, we can better cherish and hold onto the countless experiences we face in our mundane, repetitive lives(Beck). Conversely, Beck makes an essential point regarding the limitations of narrativizing one's life. She states that one's life hardly ever follows the chronological order of a storybook narrative, "so narrative seems like an incongruous framing method for life's chaos(Beck)."

Throughout this paper, I will address whether, even in the best-case scenario, it is the right decision for you to narrativize one's life. Nevertheless, to understand the best-case, it is essential first to visualize the worst-case scenarios when narrativizing one's life. The first case is one where the narrative directly harms the individual, where such harm can materialize through prejudice or oppression. The second case can occur when there is a sudden, unanticipated change in life for the worse, skewing or entirely derailing you from the course of your narrative, and you never reach the climax. The third possibility is that the narrative you envision yourself as the protagonist of does not match up with the steps of progression along the narrative arc; hence, the framework of your self-proclaimed story crumbles completely. In the rest of the paper, I will disregard the worst-case scenarios and contemplate whether, even if there is nothing intrinsically objectionable about the narratives, narrativizing one's life is the right decision. I will argue against the detrimental effects of perceiving one's life as a one single narrative and present rebuttals against proponents of the narrative approach. Specifically, I will defend the following premises:

P1: Storybook narrative arcs are hyperfocused around a particular climax or theme.
P2: You should not want to dramatically downgrade the importance of most moments/aspects of your life.
P3: Hyperfocusing on one specific climax in life will cause you to downgrade the importance of other moments/aspects dramatically
P4: If you narrativize your life into one single storybook narrative, then you will dramatically downgrade most moments of your life.

C: You should not narrativize your life into a single storybook narrative.

Narrative Arc of Life

In this section, I will provide further background information about narrativizing one's life. First of all, the nature of the narrative approach to life essentially is a process of linking our daily experiences into a larger story we can articulate and reflect who we are as individuals. As philosophy professor Marya Schechtman writes, "In some essence, this is how experiences come to have any real meaning at all —rather than merely isolated events— by being part of a larger story that relates them to one another within the context of one life (Schechtman 1996, 96-99)". It is reasonable to assume that storybook narrative arcs revolve around a particular climax or theme. The modern-day narrative arc commonly taught in most educational institutions was created by Gustav Freytag, a German novelist and playwright. According to Freytag's pyramid, narratives have five key stages:

1. The Exposition. The introduction of background information, characters, setting, time, and anything else necessary to understand the story.
2. Rising action. This is where signs of an imminent conflict begin to arise. Usually, this kickstarts the "action" of your story and sets up the central conflict within the story.
3. Climax. This is the point everything was leading up to, where "all the different subplots and characters converge(Blume)." In other words, this is the "big moment" the protagonist was waiting for and will require them to make a decision that could change the course of the entire story.
4. Falling action. This is the result of the climax and the fall of tension. Essentially, the falling action is the opposite of the rising action and precursor of the resolution.
5. Resolution. This is where your story ends. In numerous fairy tales, the ending is sweet, and it seems like the protagonist will 'live happily ever after.' However, that outcome is usually overly idealistic and rarely the truth.

Applying Freytag's pyramid to our daily lives, the narrative arc may manifest in two ways. Firstly, narrativizing one's life most prominently manifests in career endeavors (e.g., doctors, athletes, philosophers). For others, it may be displayed less professionally and in a more ambiguous role (e.g., being a father, mother, or romantic partner). Either way, the natural byproduct of narrativizing one's life is that you will subconsciously (or consciously) hyperfocus your life around one particular climax or theme, as that is the final destination you are striving towards. Contrary to our first intuition, the narrative approach to life can be applied to everyone, ranging from the aristocratic elites of the social hierarchy to the middle and lower social classes. For example, one's narrative might revolve around becoming the world champion of a particular sport. For others, it may be becoming the CEO of a world-renowned bank. In other words, the aspect of life one chooses to narrativize will usually be closely connected to one's professional career.

Downgrading the Mundane

Having contextualized and established the definition of life's narrative arc, I will now argue that you should not want to dramatically downgrade the importance of most moments and aspects of your life. By concentrating your life around one specific target, it is undeniable that you will be rather disconnected from the other significant aspects of your life(e.g., friends, family, and other goals) because of our limited capacity, as humans, to partake in activities endlessly. As a contributing member of society, it is a given that one has obligations to tend to. However, when one's intuition is to utilize everything within one's power to reach the climax ceaselessly, there is a high likelihood that one will exhaust one's capacity to function at all.

Another downside of the narrative approach to life is the overreliance of an individual eventually reaching the so-called climax. In career fields requiring immense talent and specialization on the individual's end, climbing the ladder is no menial task. Take an Olympian as an example(assuming you have never come across a career-ending injury). Your entire life and identity are essentially the product of one sport. Especially in the case of Olympians, they tend to devote all their time and effort to their chosen sport at an incredibly young age. They recognize that if they want to accomplish something everyone tells them is practically impossible, they will willingly make sacrifices and work vigorously to prove them wrong. There are infinite challenges they will encounter along their journey to the top and never-ending obstacles they need to maneuver around.

Nevertheless, they stay driven because of their one goal in mind. At last, after pouring your heart out to reach the climax of your narrative, the stars seem to align, and you have finally reached the final goal. The current situation begs the question of what happens in the best-case scenario after reaching the climax.

Looking back, although having accomplished the supposedly most meaningful event in their life, they feel more vulnerable than ever. After being part of the most exhilarating work one could have dreamed of, a spontaneous loss of meaning accumulates. At this moment, the surge of hopelessness we experience post-climax is a term Harvard lecturer of positive psychology Dr.Ben-Shahar calls the *arrival fallacy*. In his words, "The arrival fallacy is this illusion that once we make it, once we attain our goal or reach our destination, we will reach lasting happiness(Ben-Shahar)." The arrival fallacy is analogous to certain individuals' resilience in intense grief. We expect a specific reaction of overwhelming agony from ourselves, but surprisingly, some cope much better than expected. This is the same case here when we expect a specific emotion to arise after the occurrence of an important event, yet the emotions that engulf us are not what we imagined. In a separate study conducted in 1988 in the Journal of Personality and Social Psychology, assistant professors who had yet to be considered for tenure repeatedly displayed results of overly inflating the happiness they would experience once they finally reached the position(Ben-Shahar). Individuals perceive this lifelong accomplishment as something that will bring them extreme gratification for an extended period, but once again, they end up disappointed.

A contentious element to consider within the framework of this premise is one's identity. After experiencing the arrival fallacy and its repercussions, one should note that emptiness is not

the only feeling one may endure. It is highly probable to immediately lose direction, having been hyperfocused on one part of life for so long. After achieving this big goal, the subsequent likely outcome is a mid-life identity crisis, a term we hear all too often nowadays. To have an 'identity crisis' is to become unsure of my most characteristic properties—of what sort of person I am in some deep and fundamental sense (Roughley). Such uncertainty would be amplified dramatically, especially for individuals who have narrativized their lives. Although one's identity can vary over time, for certain individuals, there may only be a small handful of components that define them as a person; when one becomes uncertain about those specific traits, then it could cause them to spiral into a cycle of questioning themselves and undergoing existential dread.

Paul Ricoeur, a 20th-century philosopher concerned with the meaning of life, proposes another argument supporting narrativization. He argues that the only model that can accurately encapsulate the complexity of life is the narrative model. In his book *Time and Narrative*, he emphasizes that in the fragile nature of life, if the "narrative coherence" of one's life crumbles, it could potentially lead to an identity crisis where one feels undeserving of a net good life and lacks self-worth. He elaborates on this point by utilizing a metaphor that compares us, humans, to be the 'writer' and 'reader' of our life narratives(Fieser). As the principal author of our own life story, we essentially write our narrative through the actions we carry out on a day-to-day basis. Similarly, we are also the 'readers' of our own life story, where we constantly observe our own life story in retrospect and build our narrative(Fieser). Then, using that life story, we can influence how we think about ourselves, affecting our future decisions regarding how they fulfill this element of coherence. Ricoeur argues that we are especially susceptible to identity crises if we do not have a life story that makes sense to ourselves. His point concerns the importance of narrativization, where one must have a life that revolves around a climax. The decisions we make must all interconnect, directed towards the one objective we want to fulfill so that we can live knowing we have a greater purpose in life to achieve(Fieser). However, the main flaw with his point is that it presumes that everyone knows what they want to pursue as their climax in life. For most teenagers and adolescents, self-exploration and understanding oneself are still the priority during this stage of life. Therefore, other than a minority of individuals with their entire careers mapped out ahead of them, narrativization would be mostly inapplicable to others.

Furthermore, it is also conflicting that even Ricoeur acknowledges that if one's life story is not coherent and does not make sense to oneself, one could fall into an identity crisis. It is conflicting because, typically, most individuals are the most driven in their youth and lack the maturity to decide on one life goal. Hence, even if it is prevalent among adolescents to narrativize their lives, the probability of an individual switching careers and life goals later in life is incredibly high. Consequently, the narrative would not coherently develop towards the climax and change entirely, causing the individual to fall into an identity crisis. Ricoeur's arguments are unpragmatic, and rather than preventing individuals from losing purpose, the result will likely be the opposite.

Additionally, Alasdair MacIntyre, a Scottish-American philosopher, further offers an argument supporting narrativizing one's life. MacIntyre argues that when someone is unhappy

with their life and complains that his or her life is meaningless, then it signals that they are complaining that life has become unintelligible to them or it has become meaningless, and there is no motion towards a "climax or telos" (MacIntyre 2007, 217). The argument is that having a sole goal in life is the motivation we need to continue progressing. Without it, we succumb to despair and lose ourselves in this complacency, analogous to a rock floating in space with no velocity. Our physical body is present, but the mind is entirely vacant, having all the freedom in the world to dictate the trajectory of one's life but missing a compass for guidance.

MacIntyre presents a well-grounded argument, but let us analyze another case to further engage with his point. Let us examine a scholar writing his or her dissertation in philosophy. As an undergraduate student, writing one's dissertation is a prerequisite to continue studying a subject at a higher level. For those working in academia, writing a dissertation is one of several integral steps in working towards the pinnacle of their career. For some, it may be working toward the position of tenure that is the highlight of one's career or even successfully publishing literature or research that has significantly contributed to a particular field. In the eyes of many scholars, "tenure is the golden snitch of academia: It grants job security, prestige and, usually, a bump in pay (Shilton)."

Further analyzing the example of a scholar, let us assume this individual working in academia has successfully established themselves as a credible source of information in the eyes of many. They are renowned by scholars worldwide for their work, and they have either been nominated for or have won several academic awards. It is reasonable to assume that any individual would be euphoric if they have accomplished their life goal. However, in actuality, the celebration is over within just a few days. All adrenaline and ecstasy they may have experienced will diminish exponentially, and the future becomes daunting: What is next?

With all factors considered, the mismatch between one's expectations and the reality of reaching their goals leads to an identity crisis and loss of purpose in life. Although the narrative approach fuels individuals with an intrinsic drive to reach the climax, the realistic outcome and repercussions cause individuals to ponder whether fixating one's life around a specific goal was even worth it.

Hyperfocus

In conjunction with the argumentation presented in the first two premises, my third premise is that hyperfocusing on one specific climax in life will cause you to downgrade the importance of other moments and aspects dramatically. When one is fixated on one particular goal in life, you are naturally less attentive to the different parts of life. As MacIntyre, Rosalind Hurtshouse, and Martha Nussbaum argue, this idea of rationality separates humans from other organisms: evaluating the motives behind our actions and the ability to separate oneself from one's desires. In the case of narrativization, if delegating your time to specific tasks best appeals to your hierarchy of priorities, then those are the tasks you will naturally delegate more of your time to. One is rational because you are a fully autonomous being with the most accurate understanding of your values and priorities. However, accurately understanding yourself does not

directly translate to the highest subjective happiness or the best outcomes. Often, the unfortunate reality of our decision-making is that we will neglect the granularities of life —moments that may eventually blossom into core, lifelong memories. As elucidated in the second premise, any given individual only has a limited capacity to complete tasks; if they delegate a large portion of it to this one goal, they will be disinterested or lack the energy to worry about the desires of others. In these circumstances, an individual becomes disconnected from those around them. In nearly every study regarding happiness, the top source of happiness is one's relationships with family and friends. Those relationships can only be fostered through learning to appreciate the present, focusing on the little things, and maximizing every opportunity you have, which builds the foundation for a more sustainable life. The argument here is not that one should live one's life on a day-to-day basis where one is predominantly focused on the 'granularities of life.' Instead, the argument is that one should partially shift the focus of one's priorities away from this single objective in life to the other, less eventful moments.

Contrarily, psychology professor Johnathan Adler presents an opposing perspective. Adles argues that storybook narratives help provide us with a sense of purpose, stating that life is simply too complex for humans to hold onto simultaneously and appreciate the infinite experiences around us. Hence, by structuring our lives into stories, we can better hold onto our experiences and make meaning from them(Beck). The problem with Adler's argument is that when one chooses to perceive their life as a narrative where the end goal is to reach the climax, the "infinite experiences" Adler refers to will be the very experiences one gives up. As mentioned in the first premise, for individuals narrativizing their lives, there will always be a primary theme(typically career-related) that interconnects different events in life that guide you towards a climax in any coherent narrative. Thus, unless the infinite experiences around an individual all miraculously relate to their journey of reaching the climax, the likelihood of genuinely appreciating those moments is close to zero because they deem them irrelevant and counterproductive to their ambitions.

The unfortunate consequence of hyperfocusing one's life is that the seemingly unimportant and uneventful aspects of life that build up the foundation of one's happiness are often abandoned. We become detached from the rest of our lives and gradually grow distant from those closest to us.

Repercussions and Alternatives

In this final premise, I will argue that if your life makes for a good, single storybook narrative, you will dramatically downgrade most moments and propose another alternative to the narrative model of life. Firstly, it is imperative to note that my first premise is not that you should completely steer clear of pursuing your dreams because success may be unlikely in some scenarios. The argument is that we should not hinge our happiness and illusions of our envisioned so-called good life on one determinant. When considering the climax of our lives, we should also remember that life goals are usually not as fulfilling as we perceive. Even in the absolute best-case scenario after achieving one's sole goal in life, the reality in front of you

probably does not meet the expectations you initially had in mind of the good life that was supposed to be everlasting.

I will now propose an alternative to narrativizing one's life. You can narrativize multiple goals or aspirations rather than encompassing your entire life in one cohesive narrative. Note that this alternative is not the same as having one narrative dictate your life; you are not fitting your entire life into one narrative. The benefit of having multiple narratives is that you are still motivated enough to get things done. It means you can have a purpose in life derived from several sources instead of one primary source. As Julie Beck writes, "Someone might have an overarching narrative for her whole life, and different narratives for different realms of her life—career, romance, family, faith (Beck)." With multiple goals occurring concurrently, one's identity becomes multifaceted, meaning that one is less vulnerable to the harms posed by one single narrative. There will be safeguards and other goals to fall back on if you cannot achieve your goals. Alternatively, even if you do achieve them and are left feeling unfulfilled, you can turn to other objectives in life that are meaningful to them.

Due to the fundamental definition of the narrative approach to life, anyone who consciously(or subconsciously) narrativizes their life will ultimately hyperfocus their life around a telos. The subconscious(or conscious) hyper-focusing on one life goal will naturally lead to the dramatic downgrading of other moments and aspects of life.

Conclusion

In my paper, I have argued why one should not narrativize one's life. Though narrativizing one's life around a particular goal poses a degree of validity, it is in one's best interest to abstain from a life that makes for a single storybook narrative. In the first premise, I argued that storybook narratives focus on a particular climax. In the following premise, I argued why you should not want to dramatically downgrade the importance of most moments or aspects of your life. In the third premise, I argued that hyper-focusing on one specific climax in life will cause one to downgrade the importance of other moments or aspects dramatically. Lastly, if your life makes for a good, single storybook narrative, you will dramatically downgrade most moments of your life, which is a logical step following the previous premise.

In the end, is the conclusion that we should all just be nihilists and live life with the 'YOLO' mindset? Does it mean that you should give up in the face of hardships? Not at all. Throughout this paper, I have argued that one's life should not rotate around a single narrative. Instead, it is a better alternative to care about multiple things simultaneously. If you think the way to live a grandiose life is to narrativize your life, that is not the case, as I have shown. Life does not stop once you have accomplished your one life goal, so even if every step to reach the climax was successful, narrativizing your life is not a good recipe in the long run and the grand scheme of life.

As a reader, the paper could have caused you to contemplate life further and find it depressing. On one hand, this grand life we envisioned is a utopia that can never be fulfilled. On the other hand, if we do not narrativize our lives, many live a day-to-day lifestyle where we

simply just exist. However, it does not have to be this way. In my final premise, I argued that setting multiple goals is essential to our happiness and that problems arise only when we revolve our lives around one goal. It is crucial to work towards our different goals, acknowledge that they can overlap in the long-term or short-term, and embrace that every human is complex and unique on a multitude of levels. Allow yourself to enjoy the pride of achieving a goal, but always have other goals you continue to progress towards.

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Do the Results of Elections Adequately Reflect the Will of the People? By Aidan Lo

Abstract

The following paper explores the notion of whether election results truly reflect the will of the people. It argues that elections are influenced by various factors, such as the concept of "the will of the people" being a political fiction, campaign tactics employed by politicians, different electoral systems, and the potential for a tyranny of the majority. The paper examines the origins of the concept of "general will" as popularized by Jean-Jaques Rousseau and critiques its application in modern democracies. It also explores the impact of campaign tactics, including political advertisements, endorsements, and manipulation of data, on election results. Furthermore, the paper examines different electoral systems and their impact on representing the population's preferences. Additionally, it highlights the potential dangers of a tyranny of the majority. The paper concludes that while election results may indicate the popularity of candidates, they do not necessarily represent the true will of the people. It suggests that alternative mechanisms should be considered to ensure a more comprehensive and representative reflection of the people's desires.

Introduction

Those that are popular get their way. This is a trope that has been seared into the public consciousness, be it through experiences of stereotypical adolescent cliques or the apparent impunity of celebrities and public figures. But in the real world, this logic is also often how leaders are chosen and major decisions are made.

When a candidate wins an election, they do so because the majority of voters selected them on their ballot, be it because of support for their policies or belief in their person. On the surface level, this appears to be a fair process, where political leaders are selected by the population rather than an elite class. As such, one would presume that the outcomes of elections are representative of what everyone, “the people”, want. However, time and again the results of elections have often proven contentious, to the point of sparking outrage, all because the chosen candidate was not unanimously accepted by the population as a whole. One of the most recent and heavily publicised examples of this is the results of the 2020 United States Presidential Election, wherein Joe Biden won against the then-incumbent Donald Trump. This sparked widespread election denialism and conspiratorial fury amongst the latter’s supporters, eventually resulting in a large-scale storming of the Capitol building.

This is an obvious case where the results of an election, though vetted countless times, was not accepted as “the will of the people” by a large segment of voters. This brings us back to the question; do elections and their results actually reflect the will of the people? To answer the question, this essay will argue that the results of elections do not adequately reflect the will of the people, since electoral results are influenced by a variety of factors, as is the definition of will of the people, which may not even exist.

Firstly, election results are not representative of the wishes of the population, because "the will of the people" is a political fiction, and attempts to clump the entirety of a population together as an entity creates the false illusion of unity, removing the fact that a wide variety of people will have a wide variety of beliefs, wants, and needs. Moreover, the will, or rather the wants and needs of "the people" are not necessarily the deciding factor in an election. Rather, electoral and media tactics used by politicians and campaign managers frequently have as great, if not an even greater effect on the voting population. Additionally, the various electoral systems that exist worldwide must also be noted for how they factor in the citizens. Finally, the majority is not representative of the whole electorate, and as such a singular elected candidate cannot represent the wishes of the entire population. It is these points that will demonstrate why the results of elections are influenced by factors beyond general will, and that in fact the will of the people is a potentially non-existent concept.

Rousseau's General Will

To understand why the will of the people does not exist, there first needs to be understanding of the origin of this concept. The notion of "the will of the people" was popularised by Genevan philosopher Jean-Jaques Rousseau as the "general will". Rousseau believed that "the law is the expression of general will", and distinguished it from the particular and often contradictory wills of individuals and groups (Munro). As such, it can be interpreted that general will as a concept is meant to remove the many distinctive opinions that exist in the spectrum of a population, in favour of a unified vision that supposedly appeases all.

There is also the population itself to consider, as in cases including but not limited to city, county, state, and nation-wide elections, the population becomes increasingly quite vast and multi-faceted, making the collective will of the people ever-harder to define. 19th century German philosopher Georg Wilhelm Friedrich Hegel was a contemporary of Rousseau, and he argued that because it did not possess any grounding in an objective ideal of reason, Rousseau's vision for the general will inevitably led to the Reign of Terror of 1793 and 1794 during the French Revolution (Bevir 553). Likewise, modern scholars closer to our time have criticised and reevaluated Rousseau's philosophies. In 1952, Professor Jacob Talmon argued that Rousseau's general will would lead to what he described as a "totalitarian democracy", where elected representatives would carry out decision making without any input from the citizens (Talmon 2). This would leave regular citizens vulnerable to the actions of the state, backed by the supposedly infallible will of the majority (Williams 110).

The false equivalency that is created between the majority and "the people" as a whole is evident when politicians illegitimately claim they succeeded thanks to "the people" (Balkin), as elections are won with majority votes (and, given the voting system, sometimes not even the majority of the popular vote), not unanimity. As such, this practice creates a false equivalency that removes the minority of the voting population from the discussion, and by doing so the "general will" is by strict definition not representative of the whole population.

Campaign Tactics

Another major determinant of electoral results are the tactics employed by politicians and their campaign managers to influence the voting population. Politicians often employ methods such as identifying a figure or group as an enemy, gathering endorsements from influential establishments or people to build more trust, brandishing favourably manipulated data, and having supporters build outreach through word of mouth (Sivaraj). One technique to convey these messages is political advertisements, which will deliberately utilise pathos to convince voters to be on their side (Grüning and Schubert), hampering their right to think for themselves. Additionally, in her book "Primary Politics", Elaine Kamarck argues that money, media coverage, and voter suppression influence the electoral process, and in turn lead to election results that are not representative of what the public want. Oftentimes, everything from heavily biased media coverage to suppression of minority voter blocs can be used to ensure that a candidate supported by only a minority of voters is ultimately elected.

By using these tactics to bring more voters to a certain candidate, an imbalance is created, one that inevitably taints the ability of many election results to truly represent "the will of the people", even assuming that only means a majority. For example, from 2000 to 2016, more than 80% of candidates who spent the most on their campaign won in the midterm elections for the US House of Representatives (Koreth). What this demonstrates is that generally speaking, candidates who spend more on their campaign will yield greater success. This means that candidates who do not have as much financial backing or donors will suffer in elections, and the issues they seek to address or mend will be overlooked and de-prioritised. A fundamental pillar of the claim that election results represent the will of the people is that every person has one, equal vote; however, in many of today's democracies, those with existing massive resources, fame, and networks at their disposal can leverage them to increase the power of their "singular vote" manyfold.

Different Electoral Systems

One more reason why elections often do not express the will of the people is due to the varying electoral systems that exist internationally. The most commonly known system is First-Past-the-Post voting, or plurality voting, where the voters select a single candidate, and the candidate with the most votes wins (New Zealand History). Having said that, various other systems exist, including the Two Round System, which as the name implies, has two rounds. In the second round, candidates with the least votes are eliminated and only the ones with the most votes remain, ensuring a majoritarian result (Electoral Reform Society). Systems also exist which do not require citizen participation, such as the election of the Chief Executive of Hong Kong, where the candidates and the winner are both chosen by an Election Committee of 1,500 chosen from without much citizen input, even though these members are supposed to represent all citizens. (Reinfrank et al.) The Two Round System is also not without issues, as it reduces the power of the voter, as those who vote for a dark horse candidate with fewer supporters and a smaller political party are likely to have their vote not matter, and be forced to vote for a larger

candidate in the second round anyways. This has the effect of discouraging the voting population from casting a ballot, as the candidates they are forced to pick from may not accurately represent their wishes and needs, leading to poor voter turnout. As such, defining the will of the people from these elections is a pointless task, since the voters had no other options, as the candidate that they may have supported is out of the equation.

Tyranny of the Majority

Finally, as previously mentioned, even though an election can tell the world which person or which party has the most supporters, it cannot be said that this candidate represents everyone, as the majority is not representative of the whole electorate, and a singular candidate cannot represent the wishes of the entire population. The danger of letting the majority of a population get their way every time through elections is that it could lead to a tyranny of the majority (McGann). Another issue is that small gains to the majority will outweigh large losses to the minority (Heckelman). What this means is that the suffering of minorities may be "justified" as long as the wants and needs of the majority are addressed.

Such was the case during the aforementioned French Revolution, when Maximillien Robespierre and the Committee of Public Safety, following the deposition and execution of King Louis XVI during the French Revolution, instituted harsh policies that would become known as the Reign of Terror. In this period, 35,000 French citizens were accused of royalist or anti-revolutionary loyalties (Martin 191-192), convicted as traitors by the Revolutionary Tribunal (Duclaux 239), and executed by guillotine. This was enacted in the immediate aftermath of the overthrow of the King, when a new government was established by revolutionaries and radical sans-culottes enforced their new policies, creating an environment which was highly anti-royalist and pro-revolutionary. As such, it was easy for Robespierre to conduct such violent actions under the pretence of carrying out "the will of the people", when it carried immense harm to a sizable segment of the civilian population, with up to 10,000 people dying without even a trial (Britannica), for "crimes" as simple as saying anything that could be considered passingly anti-revolutionary. This is a clear display of the threat that the tyranny of the majority poses, and is the ultimate example of what happens if you manipulate what the will of the people means.

Conclusion

Because of the falsity of the concept of general will, tactics used to influence voters, varied electoral systems with different levels of citizen effect, and the fact that the wishes of the majority cannot represent the wishes of the whole, the results of elections do not reflect what scholars define as "the will of the people". Instead, what election results express is merely the popularity of the candidates. And with the way elections work, the most popular gets their way. However, that being said, the imperfect image of the will of the people projected by most electoral democracies is usually still preferable to the straight-up aristocratic tyranny of many autocratic states. Though it is clear that electoral democracies present many benefits compared to the dictatorial regimes preceding them, this essay has robustly illustrated that elections are still a

deeply flawed mechanism, and we must move beyond a narrow view of voting as the only means to reflect the so-called “will of the people”.

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The Revocation of Article 370 By Aarushi Deswal

"August 5th, 2019 will be written in golden letters. It was the end of terrorism, nepotism, [and] corruption" announced Amit Shah, Home Minister of India, to the Jammu and Kashmir youth club.[16] However, former chief minister of Jammu and Kashmir, Mehbooba Mufti, said August 5 was "the blackest day of Indian democracy when its Parliament, like thieves, snatched away everything from the people of Jammu and Kashmir."[17] Polar opinions on the BJP's revocation of Article 370, whether August 5 was the "end of terrorism" and "corruption" or indeed the "blackest day of Indian democracy" remains a serious debate throughout the world.

Established in 1952, Article 370 allowed Jammu and Kashmir's local government to make laws on all aspects of the state except for foreign relations, defense, and communications, which were under federal government jurisdiction. Additionally, it served as a constitutional safeguard that prohibited non-Kashmiris from acquiring land or jobs in the area or from voting or running for office in state elections.[18] When revoked, Kashmiris lost these special privileges and Kashmir lost its status as a state, becoming a union territory. Despite Article 370's protections, extreme violence has plagued Kashmir for 30 years. Most of this violence falls into one of two categories: religious communalism against minority Hindu Kashmiri Pandits committed by Kashmiri Muslims, or Muslim insurgency against federal government involvement in Kashmir. The most recent effort to quell this violence was the government's revocation of Article 370.

Although the federal government claims that it was intended to bring peace to the area and has successfully helped bring prosperity to Kashmir, they have not been truthful about the revocation's impact. In gaining a more holistic understanding of the impacts of this abrogation, one can see that this action was not truly beneficial for Kashmiris. The Indian government has promised and publicized the revocation's "success," downplayed the violence still afflicting the area, and censored Kashmiri voices that stand as evidence against its success. Furthermore, in claiming that this abrogation was constitutional with its December 11 ruling, the Supreme Court failed to protect the best interests of the Kashmiri people and compounded the revocation's impact.

Article 370 originated from a treaty called the Instrument of Accession, signed by Raja Hari Singh, princely ruler of Kashmir, during Partition. With this treaty, he set preconditions to Kashmir's joining of India, the most significant of which stated that Jammu and Kashmir's local government would make laws on all aspects of the state except for foreign relations, defense, and

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[16] "Aug 5, 2019 Marked End of Terror, Corruption, Nepotism in Valley: Amit Shah to J&K Youth," *Times of India*, October 23, 2021, https://timesofindia.indiatimes.com/india/aug-5-2019-marked-end-of-terror-corruption-nepotism-in-valley-amit-shah-to-jk-youth/articleshow/87224988.cms.

[17] Jeffrey Gettleman, Raj Suhasini, Hari Kumar, "India Revokes Kashmir's Special Status, Raising Fears of Unrest," *New York Times*, August 5, 2019, https://www.nytimes.com/2019/08/05/world/asia/india-pakistan-kashmir-jammu.html.

[18] "Article 370 Revoked in J&K: A Look Back at Its History and What Now," *Hindustan Times*, September 22, 2020, https://www.hindustantimes.com/india-news/article-370-revoked-in-j-k-a-look-back-at-its-history-and-what-now/story-56pEY6h2tGSgRbPMt05PdJ.html.

communications.[19] Article 35A, a provision under Article 370, encouraged Kashmiris to remain in the area for generations by reserving land and jobs for locals, thus eliminating foreign competition in these matters and strengthening the population's shared cultural identity.[20]

The BJP claims to only have Kashmir's prosperity in mind when revoking Article 370, and within it, Article 35A. In justifying the revocation, the BJP insisted that all issues in Kashmir stemmed from its partial autonomy and thus that eliminating this special status would provide the logical solution. Amit Shah stated his desire "to tell the people of Jammu and Kashmir what damage Articles 370 and 35A did to the state." He claims that "it's because of these sections that democracy was never fully implemented, corruption increased in the state, that no development could take place."[21] The issues Shah identifies can also be attributed to the government's heavy militarization, extensive intervention, and Islamophobic measures taken in Kashmir. Yet, Shah's firm stance that Articles 370 and 35A are to blame removes all culpability from the government in the BJP's narrative. Prime Minister Narendra Modi also announced that this abrogation would "pave the way to peace and development," further condoning the government's decision.[22] If one does not look beyond this surface-level explanation and is only told that Article 370 caused these issues, then it's reasonable to conclude that its revocation was an appropriate decision.

Yet, one may argue that an unspoken motive for the revocation had to do with a broader governmental strategic initiative. The BJP government united Kashmir with India in an effort to return to its nationalist agenda by revoking Article 370 and stripping Kashmir of its status as an independent territory. Firstly, leading up to the August revocation, India was struggling with a weak, turbulent economy and rising unemployment. As Kashmir began to dominate the media because of its major change in status, the revocation provided a perfect distraction from the struggling economy – a necessary one after the media leveled major criticism at Modi for his handling of India's weak economy. Additionally, uniting Kashmir with India added strength to the country considering India's ongoing dispute with Pakistan over Kashmiri territory. Thus, this revocation allowed India to show Pakistan and the world that it remained the more powerful nation in South Asia. Although nationalism can be powerful in uniting a country, it has actually proved divisive in Kashmir because the BJP's nationalist agenda involved, and continues to involve, a strong tie to Hindu nationalism. With Kashmir being the only Muslim-majority state, many Kashmiris fear that the government is trying to change the demography of the area by now allowing foreigners to move there as well as by encouraging Hindu Pandits to return to the

[19] "Article 370 Revoked in J&K."

[20] Sameer P. Lalwani, Gillian Gayner, "India's Kashmir Conundrum: Before and after the Abrogation of Article 370," US Institute of Peace, no. 473 (Fall 2020): https://www.jstor.org/stable/resrep25405

[21] "Article 370: What Happened with Kashmir and Why It Matters," *BBC*, August 5, 2019, https://www.bbc.com/news/world-asia-india-49234708.

[22] Praveen Donthi, "Violence in Kashmir: Why a Spike in Killings Signals an Ominous New Trend," *International Crisis Group*, June 28, 2022, https://www.crisisgroup.org/asia/south-asia/india-pakistan-kashmir/violence-kashmir-why-spike-killings-signals-ominous-new-trend.

area.[23] Considering the BJP's actions post-revocation, these Kashmiris' fear has some reasonable basis.

After government initiatives to support Hindus moving into Kashmir, a local terrorist group threatened violence against all foreigners moving in – a safety issue that the government refuses to address because it suggests that the revocation led to increased terrorist activity. Once non-permanent residents gained the right to own land in the area through Article 370's revocation, the government established new land laws to support non-locals in purchasing property in Kashmir. However, afraid of government efforts to change the cultural demographics of Kashmir, a Muslim terrorist organization called The Resistance Front (TRF) publicly threatened to harm all foreigners attempting to move to Kashmir. In particular, Satpal Nischal, a 70-year-old Indian jeweler, was murdered on December 31, 2020, shortly after receiving his domicile certificate. TRF, a group that formed after Kashmir's 2019 change in status, posted on Facebook claiming responsibility for the murder. The group alleged that Nischal was an agent of the BJP's parent organization, the RSS, and that he "was an active participant in the demographic change and settler colony project run by Hindutva fascists to alter the demography of Kashmir."[24] That a man in his 70's with no known connection to the RSS was claimed to be an "active participant" in this "Hindutva fascist" initiative demonstrates that all Hindus moving into Kashmir were and remain at risk. The post went on to ominously clarify that this murder would not be an isolated incident as the TRF said "For a long time, we warned and now the time has come when we shall warn no more. We know your names, we know where you live and we know what you do and we are coming for you."[25] In essence, this terrorist organization intended to take back power from the government by harming civilians moving into Kashmir. Despite terrorist threats and danger to incoming Hindus, the government has not backed down either, continuing to support Hindus from other Indian states in settling in Kashmir and refusing to address the security issues involved. Overall, the new ability for non-permanent residents to purchase immovable property is currently benefiting no one but the federal government by supporting the BJP in changing Kashmir's religious demographic. Meanwhile, the BJP stands firm in their claim of the revocation's success, ignoring its role in increasing terrorist activity, in order to maintain a strong reputation with other parts of India and the rest of the world.

In further efforts to downplay violence and project normalcy in Kashmir after the revocation of Article 370, the government refused to help relocate Hindu Kashmiris fearing for their safety and prevented civilians in relocation camps from leaving the region. In 2022, a large group of minority Kashmiri Pandits raised concerns to the government about their safety in Muslim-majority Kashmir Valley and pleaded for government assistance in relocating to Hindu-majority Jammu. Since a relocation of this magnitude would attract media attention and

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[23] Gettleman, Suhasini, Kumar, "India Revokes Kashmir's Special Status."

[24] Praveen Donthi, "Violence in Kashmir."

[25] Mir Ehsan, "Police Probe Srinagar Jeweller's Murder as Little-known Group Claims Responsibility," *Hindustan Times*, January 2, 2021, https://www.hindustantimes.com/india-news/police-probe-srinagar-jeweller-s-murder-as-little-known-group-claims-responsibility/story-MPumjuc0LOsyduwzMNRriN.html.

contradict their downplaying of religious communal violence post-revocation, the government denied this request. However, that the government was forced to choose between civilians' safety and maintaining a certain public image by standing by their claims of the revocation's success makes clear that these claims are not entirely true. Further, if the government is forced to make such choices, then the revocation is not only less successful than alleged, but is, in fact, actively harming Kashmiris. In additional efforts to prevent Hindus from relocating and the world from finding out that a move was necessary, federally appointed security forces have been barricading relocation camps to stop people from leaving Kashmir. A Kashmiri Pandit organization brought to public attention that relocation camps designed to help foreign Hindus move to Kashmir are now serving the government's agenda rather than these people's.[26] Treated as puppets rather than humans in governmental efforts to downplay violence and project normalcy, Hindu civilians are evidently being harmed by the government to try and pass the revocation off as a success.

Kashmiri jobs being now open to non-permanent residents has also given rise to fear and uncertainty among many Kashmiri residents regarding losing their jobs and opportunities to foreign competitors. Government intervention in the Kashmiri job market has further heightened these fears. Governor Satya Pal Malik investigated the hiring process, for example, of the Jammu & Kashmir bank – a highly influential bank in which the state government holds a large stake – after incidents of reported discrimination. Upon investigating, Governor Malik found that the entire list of 258 local Kashmiri applicants were rejected to fill all open positions with political affiliates of the BJP.[27] While helping the BJP gain more inside control over Kashmiri financial affairs, this intervention only confirmed Muslim fears of discrimination and domination in the workforce by government-aligned candidates. Further, it is reasonable to assume that these fears could also lead to more violence against Hindus who are unfairly perceived as agents of the BJP.

Moving from fundamental questions of land rights and job opportunities in the state to propaganda campaigns supporting a Hindu nationalist agenda, the BJP promoted an exaggerated narrative of Kashmir's history of religious communalism. In doing so, Modi's government further inflamed a hatred of Kashmiri Muslims and presented the revocation as successful in decreasing violence. A movie released on March 11, 2022, *The Kashmir Files* describes the religious communal violence in Kashmir, focusing on the exodus of Hindu Pandits as pressured by Kashmiri Muslims in 1990. Kashmir's local police department estimates that about 89 Kashmiri Pandits were killed in the conflict that this film covered. However, *The Kashmir Files* presents a figure of about 4,000. The film's opening credits clarify that it "does not claim accurateness or factuality of historic events", explaining its inaccuracies. Yet, the BJP and Modi have presented the film as a " truth which has been suppressed for years", exaggerating the truth of the violence to further villainize Muslims. Falsely presenting these statistics as true also

[26] Praveen Donthi, "Violence in Kashmir."

[27] *The Kashmir Today*, ""PDP-BJP Changed Entire Select List of J&K Bank to Appoint Favorites." October 28, 2018, https://m.facebook.com/TodayInKashmir/photos/a.513239938732590/2045236915532877/?type=3&eid=ARCXVw4e6qM2SqNq3i0-wufGqg3XFTZ7-4zG43z1Z0NG6-c5nTBPfJRXJnaQvzo3VmImAG7nMM2-51IC.

provides a more stark contrast between violence pre- and post-revocation so that the revocation appears to be a greater success in bringing peace to Kashmir.

The BJP's support for *The Kashmir Files*' Islamophobic storytelling similarly alienated, and continues to estrange, Muslims while promoting a Hindu nationalist agenda. In further support of the film, the BJP waived entertainment taxes on its distribution and even gave government employees a day off to go watch it. After these actions, in addition to describing it as a suppressed truth and as a "very good movie" in a Parliamentary meeting, the BJP made it very clear that they wholeheartedly support this movie. The anti-Muslim message of the film is also transparent enough that it has made many Muslim viewers uncomfortable and kindled extreme Hindu nationalism. For example, Rana Ayyub, Muslim journalist for the *Washington Post,* described having to leave the theater 30 minutes into the movie because she felt "humiliated and physically unsafe" while other viewers screamed "Ja Pakistan!" (Go to Pakistan) at her.[28] Additionally, a viral video circulated the internet in which a viewer gestures to the movie theater screen after the film ended, shouting, "That is why Hindus must protect themselves against the treachery of Muslims and prepare to take up arms. If a Hindu's blood does not boil, that's not blood – it's water!"[29] Not only does this reaction clarify that the Islamophobic propaganda in the movie is obvious to its viewers, it also serves as a dangerous call to arms against Muslims by suggesting that a Hindu's blood is "water" if they are not ready to "take up arms" against Muslims. The demonization of Kashmiri Muslims present in this BJP-supported film strongly suggests that the government does not truly have the best interests of Kashmiri Muslims in mind, and only seeks to promote Hindu nationalism and to defend its claim of the revocation's success.

The government's efforts to further its Hindu nationalist agenda in Kashmir did not cease with Article 370's revocation, labor practices favoring Hindus, and new regulations regarding Hindu migrants to the region. The BJP also suppressed independent dissenting voices regarding its Kashmir policies. By regularly restricting and blocking internet access in Kashmir after the revocation, the government prevented the spread of opposing opinions and controlled the narrative. In 2022, Kashmir had more internet shutdowns than any other region of the world, with more than one fifth of all web blackouts happening in Kashmir. Moreover, the longest blackout lasted for over 6 months, from August 5, 2019 to January 25, 2020. This block's start date was no coincidence as the government purposefully restricted internet access as soon as Article 370 was revoked in order to control the narrative from the beginning. When asked to explain these restrictions, authorities assert that their goal was simply to prevent dissemination of "misinformation and [to] maintain public order."[30] However, it is clear that the BJP characterized any opinion not aligned with its own narrative as "misinformation" in attempts to suppress

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[28] Rana Ayyub, "I Tried Watching 'The Kashmir Files.' I Left the Theater to Screams of 'Go to Pakistan," *Washington Post*, March 29, 2022, https://www.washingtonpost.com/opinions/2022/03/29/india-movie-kashmir-files-screams-go-to-pakistan/.

[29] Sanjay Kak, "The Dangerous 'truth' of the Kashmir Files," *Al Jazeera*, April 13, 2022, https://www.aljazeera.com/opinions/2022/4/13/the-dangerous-truth-of-the-kashmiri-files.

[30] Bilal Hussain, "Kashmir Registers Highest Number of Internet Restrictions Globally," *VOA News*, February 11, 2023, https://www.voanews.com/a/kashmir-registers-highest-number-of-internet-restrictions-globally-/6958516.html.

backlash. Unconstitutionally taking away civilians' right to express themselves and share their opinions, the government once again protected its own reputation by harming its people.

In further attempts to suppress dissent, the government detained several thousand influential Kashmiris in order to avoid an organized rally of opposition to the revocation. As of August 29, 2019, over 3000 were detained, including local politicians, opposition activists, and civilian protesters.[31] The BJP's public statement on this matter claimed that they only had Kashmir's peace and the containing of unrest in mind when detaining these people. By painting all opposition as a threat to Kashmir's peace, the government villainized all protesters and once again took control of the narrative. Additionally, all detainees were either known separatists, proponents of Article 370, or both.[32] Thus, the government specifically placed those who opposed its agenda under house arrest indefinitely in order to ensure that all information on the revocation would emanate exclusively from the BJP during this critical time. As Adnan Ashraf Mir, spokesman for the Jammu and Kashmir's People's conference articulated, the government aimed to "silence every voice they [thought] would be able to mobilize opinion on the ground."[33]

On December 11, 2023, the Indian Supreme Court found no fault in the 2019 abrogation of Article 370, despite the BJP's use of a constitutional loophole to revoke it. Regarding any change to Article 370, the Indian Constitution states that the President may declare it to be void only if he has "the recommendation of the Constituent Assembly of the State."[34] Essentially, the Jammu and Kashmir Constituent Assembly must recommend a dissolution of Article 370 before the President can declare it inoperative. However, since the Constituent Assembly dissolved in 1957 and was not replaced with an equivalent governing body, the BJP's legal team asserts that it was within Modi's power to revoke the Article on his own.

Although the BJP and Supreme Court's stance does not contradict the letter of the law, it fails to abide by the law's intent. That this law has not been updated after the Assembly's dissolution leaves the appropriate process of revoking Article 370 up to interpretation. Thus, there is little legal basis for challenging the BJP's decision or the Supreme Court's ruling. The intent of the law, however, is clear: the President can revoke Article 370 only if he has the Kashmiri peoples' support. If Modi truly intended to go about revoking the Article as owed to Raja Hari Singh and the Kashmiri people, he would have sought Kashmiri support for his plan. Yet, it is reasonable to assume that he ignored the will of the people and unjustly revoked Article 370 because he anticipated that a popular vote would not have resulted in his desired outcome.

Although presented as a means of bringing peace and prosperity to Kashmir, the 2019 abrogation of Article 370 did not truly benefit Kashmiris – Muslim or Hindu – and, rather,

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[31] Niha Masih, Joanna Slater, "Among the 3,000 Detained by Indian Authorities in Kashmir: Children," *Washington Post*, August 29, 2019, https://www.washingtonpost.com/world/asia_pacific/among-the-3000-detained-by-indian-authorities-in-kashmir-children/2019/08/29/1616b5c0-c91c-11e9-9615-8f1a32962e04_story.html.

[32] Anjana Pasricha, "India Frees Top Kashmiri Leader," *VOA News*, October 14, 2020, https://www.voanews.com/a/south-central-asia_india-frees-top-kashmiri-leader/6197115.html.

[33] Masih, Slater, "Among the 3000 Detained."

[34] Indian Const., art. CCCLXX, cl. 3, https://cdnbbsr.s3waas.gov.in/s380537a945c7aaa788ccfcdf1b99b5d8f/uploads/2023/05/2023050195.pdf.

selfishly served the government's Hindu nationalist agenda. Modi and the BJP truly remain "a sign of the times" on the world stage. Around the world today, one can see democratic norms, constitutional guarantees, and the rules (legal or customary) that undergird democratic governments all under incremental assault. Modi's efforts in Kashmir are part of this process. Whereas Modi's approach is ostensibly "Hindu Nationalist," like Putin's is "All Russia," the fact remains clear that in both cases these incremental efforts to consolidate power all over their respective countries serve the leader more than anyone else. And the BJP policies for Kashmir, especially including those surrounding Article 370's revocation, are a case in point of what Modi is trying to consolidate for himself and his allies. That even Kashmiri Hindus did not benefit from initiatives taken "on their behalf" in New Delhi strongly suggests the salience of this point: Modi moves inexorably toward authoritarian rule, setting aside statutes, precedents, and norms wherever he can to consolidate his hold over this vast nation.

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Strategies for Mitigating and Remediating Space Debris in the Geostationary Orbit by Arin Magesh

Abstract

As space exploration continues to grow, there is a problem halting its development: space debris. Since 2019, an average of 2,500 pieces of space debris have accumulated in Earth's orbit[31]. It is becoming a hazard for spacecraft to enter Earth's geostationary orbit (GEO), a circular orbit 35,800 km above the Earth's equator, without contacting space debris[16,31]. Pieces of debris less than 2mm long, often referred to as micrometeorites[30], complicate this matter further, as they cannot be seen with current detection technology and, when coming into contact with spacecraft, can cause immense damage. Here, we investigate current engineering solutions for this problem. The presented solutions range in readiness from near-market to beta-testing. The solutions presented in this paper also fall under two broad categories: mitigation and remediation. Mitigation focuses on new engineering designs to aid spacecraft in avoiding and surviving collisions with space debris, i.e., motion tracking technology, heat-sensing cameras, and a stronger body. Contrastingly, remediation aims to clean Earth's orbit of debris to make spacecraft less likely to ever encounter debris while in GEO, i.e., adding a docking station for spacecraft low on fuel, sending spacecraft with the sole mission of collecting debris, robotic arms to pick up the debris, and the elimination of the practice of abandoning spacecraft[29]. A combination of strategies from both these approaches can secure spacecraft missions in the future and enable humanity to reach new limits in space exploration.

Introduction

Geostationary orbit, or GEO, is a vital region where 590 satellites currently orbit Earth at about 35,800 kilometers above the equator[27,3]. Satellites in this orbit contribute to essential parts for day-to-day life, modern communication, Earth observation, and various other space-based activities[4]. Thus, these satellites must be safeguarded from damage, as their malfunction could lead to massive societal harm.

However, a looming threat puts these imperative satellites at risk: space debris. Some objects can be up to 20m long, whilst others, micrometeorites, can be as small as 50 micrometers in length – but in essence, it encompasses a wide array of objects that float around space[15]. Some of these fragments can be characterized as natural debris, which implies an origin from an asteroid or a meteor; most debris in GEO (95% of it), however, is human-made, which can include fragments from disintegration, collisions, abandoned spacecraft and paint chippings[11, 25]. Research has established that when space debris collides with satellites, the outcome is usually terrible for the satellite, and he suggests that the likelihood of this contact has exponentially risen over the past couple of decades[17].

This paper also refers to the phenomenon known as Kessler Syndrome, first stated by Donald Kessler in 1978, who said that there is an immense multiplication of space debris due to debris colliding into each other, causing more and that in GEO, this syndrome seems to worsen[2].

Currently, the total weight of debris in Earth's atmosphere is estimated to be over 9 thousand metric tons[1]. This space debris can travel up to 15 km/s, which is 10x the speed of a bullet[9]. At this speed, immense damage to the spacecraft is highly likely.

Barriers

Solutions must be implemented as soon as possible to mitigate these challenges and ensure spacecraft safety in future space missions[29].

Although scientists have been aware of space debris for some time, no space missions have successfully removed space debris. This is because reliably capturing debris without creating more is a daunting task for most agencies, as when these clean-up spacecraft come into contact with the debris, they must not be hit by debris, causing even more particles to enter GEO. Evidence supports the urgency of these missions, adding that the space industry has all the technology and resources needed to mitigate this crisis effectively; however, having that might not be enough[7]. One of the most significant factors that seems to be holding space exploration back is the economics and whether debris mitigation can be financially viable for companies in the space debris mitigation business.

Given the challenges expressed in the literature, to prevent smaller debris from hitting satellites in GEO, it is crucial to implement solutions to this problem.

Through exploring these solutions, this paper intends to inform space agencies and industries alike on how we can ensure that space is a safe environment for years to come. By addressing the issue of space debris, we can contribute to the longevity and safety of spacecraft and ensure that future space missions go smoothly without any worry of a possible collision.

Evidence

Currently, there are many engineering solutions to this issue, and they can be split into two categories: mitigation and remediation. Solutions under mitigation are mostly engineering-related and include innovative shielding materials to protect spacecraft, collision avoidance systems, i.e., motion tracking sensors, and total debris avoidance through creating a debris landfill and programming spacecraft to avoid those areas. This paper's second section will focus on the solutions that fall under remediation. This includes the implementation of robotic arms to pick up the trash, missions involving launching spacecraft to pick up debris, docking stations so spacecraft can refuel, and reducing the abandonment of spacecraft.

Mitigation

One solution we can implement is the use of motion-tracking sensors. A Belgian space company called Arcsec has been developing these sensors to put on spacecraft in the future[23]. When this tracker detects an object that does not look like a shining star or planet in the backdrop of the cosmos, it immediately flags it as potentially being debris. It then calculates the object's trajectory, which space situational awareness companies (organizations that monitor hazards in space and determine their risk) can use to assess the likelihood of that debris hitting the

spacecraft[22]. By utilizing these sensors, spacecraft can detect and monitor pieces of debris in real time. This heightened sense of awareness can allow them to maneuver the spacecraft autonomously away from the debris, thus evading a potential collision.

Another solution is that pyrotechnic elements, particularly pyrotechnic bolts, must be protected. These elements are imperative in separating spacecraft when launched into space, and when a piece of space debris hits them at the wrong time, they can be triggered. The spacecraft will separate prematurely, thus ruining the space mission and causing further debris from the failed rocket. Therefore, we ought to protect these bolts to ensure that the breaking process goes smoothly and that the spacecraft successfully launches into space.

In addition, the body of the spacecraft should be thickened. This is the solution that is easiest to implement and understand. By fortifying the outer structure of the spacecraft, it will be much easier to withstand the impacts from smaller space debris and other particles in GEO, reducing damage[19].

A lab test was done by the European Space Agency (ESA) where a 1.2cm diameter aluminum sphere was fired at 6.8 km/s (15210 mph) into a block of aluminum about 18cm thick[14]. The results of this test are shown in Figure 1.

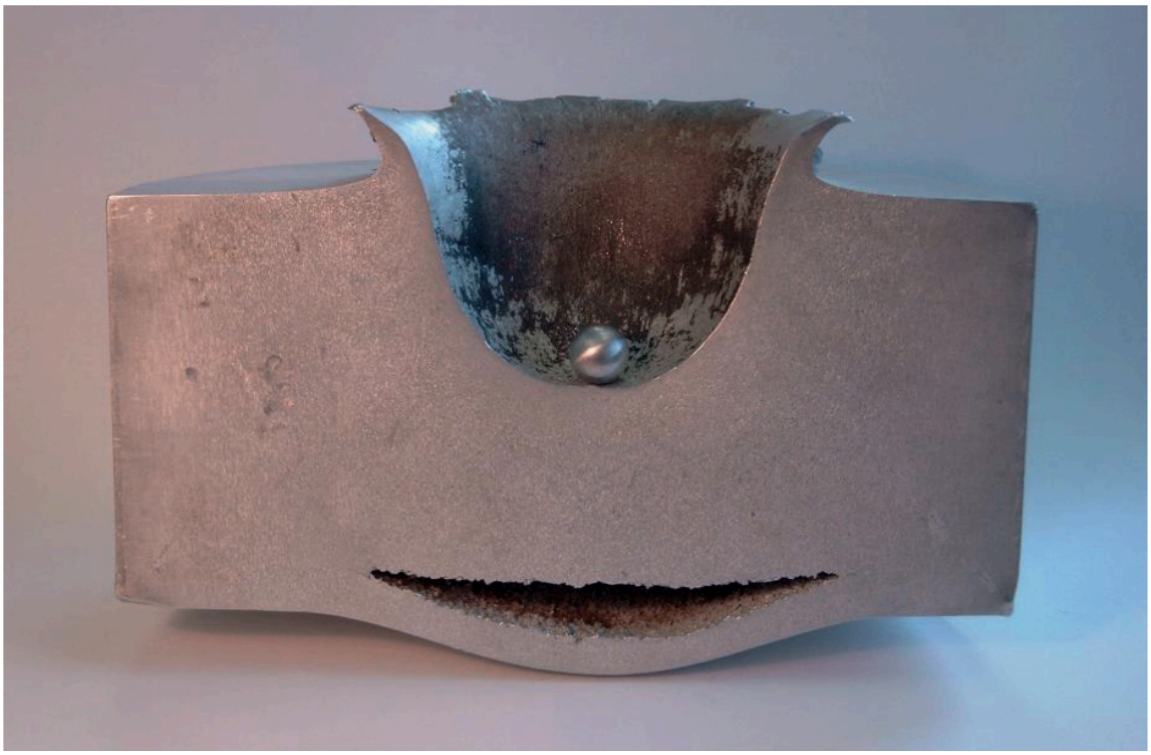


Figure 1: Results of the experiment conducted by the ESA on the power of Space Debris

The average spacecraft's walls are only about 1 cm thick[18]. This means that at least 7-8 cm of aluminum must be added to ensure safety. However, this would increase the spacecraft's

mass, which could lead to greater financial responsibility for those launching and owning the spacecraft[19].

Finally, an unconventional solution is aggregation. There have been proposals to aggregate all the debris in GEO into one giant "trash pile" in space. This could be done by towing, sending a spacecraft to remove defunct satellites, and dumping them all in the same place. Space debris can avoid these locations by centralizing all the debris in specific areas.

Thus, all these solutions aim to aid spacecraft in avoiding the current space debris present in GEO.

Remediation

The first solution involves removal missions. This requires spacecraft to be sent out solely for debris and defunct satellite removal. Spacecraft can remove debris by docking it to the defunct satellite and using propulsion systems to move it to where it needs to be. Alternatively, the satellite can be moved to the lower atmosphere, where it can burn up. Through this process, space debris in GEO can be reduced[8].

The second solution is the use of robotic arms. The development of these devices can be used for the retrieval and securement of space debris. These arms can latch onto debris objects and remove them from GEO, thus reducing collision risks[26]. The third solution is docking stations for spacecraft. Refueling and servicing stations in GEO are essential for spacecraft that are low on fuel. These stations can help reduce the likelihood of the abandonment of aging spacecraft, thus reducing space debris caused by defunct satellites.

Finally, there needs to be a reduction in the abandonment of spacecraft. This is because when dead spacecraft are left to float out in space with no purpose, it leads to additional space debris from the residue of the destruction[7]. Thus, by reducing the number of abandoned spacecraft, we would also decrease the amount of extra debris.

By implementing solutions from this category, there is a lower chance of spacecraft meeting debris in the first place, thus reducing the risk of collision.

While solutions from both categories are crucial, the solutions under the remediation category are more vital regarding effectiveness in space debris removal. This is primarily because preventing the accumulation of debris is more effective than dealing with the aftermath. Even with the engineering modifications from the mitigation category, the existence and volume of debris will still be an issue and a burden for space agencies. However, mitigation is a better solution for the short term and is much cheaper, as most solutions that fall under mitigation cost less to implement than the latter since strategies under remediation demand greater resources and usually result in greater changes to the spacecraft and space industry.

Engaging with Space Policy

The increase in space debris can hurt the world economy. A study estimates that the presence of space debris alone can drop the global GDP by almost 2%[20], and as of January 2022, the IMF forecasts that the global GDP is at 85 trillion dollars, and a 2% loss is equivalent to

around 1.7 trillion dollars[10]. Since most debris is man-made, imposing fines on countries and companies that fail to take precautions can also be a way to help combat space debris.

These fines have been shown to have an impact. Companies have started getting fined for negligent practices leading to the abandonment of satellites in orbit. Notably, in 2023, Dish, a satellite television company, was fined $150,000 by the FCC for failing to remove a satellite from GEO properly. As a result, their share price fell 4%, causing the company's valuation to drop by about 100 million dollars, according to the MIT tech review[21]. This incident emphasizes the growing importance of responsible satellite management. This shows that companies simply cannot be negligent over their satellites, and thus, they will likely employ strategies to ensure they do not spill excess debris in the Earth's orbit. Therefore, this incident would motivate companies to not be irresponsible with their satellites. This situation also emphasizes that it would be much wiser for companies to spend money on space debris mitigation than to be fined for contributing to it, facing a drop in valuation.

In the future, the question arises of who will enforce these fines. Firstly, it should be established that contributing to space debris is unethical, as in the Outer Space Treaty, a foundational document in space law that prohibits the active contamination of celestial bodies and their surroundings[28]. Fines related to GEO littering require greater enforcement. This kind of policy enforcement most naturally comes from a body like the UN. Subsequently, the UN has a committee dedicated to the ethical use of space called the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). This organization mainly focuses on ensuring peace in outer space and preventing competition between countries[6]. While it might seem a bit out of the scope for this topic, the UN does have the biggest scope regarding how many countries will be affected by a law they propose[24]. Thus, if this committee could come together to create a law, it would be the most legitimate. In order for a law to be established and a fine to be mandated, it would require the nations in COPOUS to cooperate and reach a final agreement. Thus, while no laws are set in stone, COPOUS can change that to prevent companies from carelessly mishandling their satellites.

Engaging with Alternative Perspectives

Critics make a couple of arguments against efforts to combat space debris.
Some argue about the issues of docking stations, stating that they are way too expensive to implement and that we are better off not investing in them. While it might seem costly, the reality is that it would cost more money not to implement docking. While it usually depends, most satellites launched cost anywhere north of 100 million dollars[12]. While there are currently no stand-alone docking stations in space right now, the fact of the matter is that over time, having one docking station serving satellites multiple times would save agencies millions in having to buy new satellites. This would be because docking stations act as refuel and repair stations, prolonging the life of a satellite. One challenge with docking stations is that it is hard to design a single station that can fit with every satellite, considering that every satellite is unique and

different manufacturers make each[13]. Adapters can help with that. In 2019, NASA spent 22.5 million dollars on their docking adapter IDA-3[5].

Others argue that implementing solutions that lessen space debris costs too much money. However, as stated earlier, the rapid proliferation of debris caused by the Kessler syndrome is expected to cause a 2% drop in the global GDP. Thus, doing something about this crisis could save the world over a trillion dollars. Furthermore, this paper's solutions (specifically under mitigation), which are similar in scope and resource use to the NASA IDA 3, are in the same ballpark price-wise. This would mean that the average cost of mitigation strategies presented in this paper is tens of millions per solution. Thus, ignoration will hurt the economy much more than implementing solutions to alleviate this crisis.

Conclusion

In conclusion, Earth's geostationary orbit (GEO) is a crucial area for satellites that power our day-to-day lives. However, a new problem is emerging that could disturb these satellites: space debris. With 9000 metric tons of debris already in the atmosphere, the numbers are only surging. Collisions and their likelihood are increasing along with the amount of debris, necessitating urgent solutions. Most of these solutions fall under one of two categories: mitigation and remediation. Mitigation focuses on avoidance, while remediation focuses on removing and preventing further debris. The exploration of these solutions aims to educate space agencies and organizations about the need to create a safe space in GEO. By addressing the ongoing challenges posed by space debris, we are taking one step closer to ensuring that Earth's GEO is a safe place for our satellites to continue operating.

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Is the electron rotating? A dive into the Stern-Gerlach experiment and the nature of electron spin By Iraklis Kantzelis

Abstract

The Stern-Gerlach experiment is among the most revealing quantum mechanics experiments of the 20th century, providing insights that remain at the cornerstone of the particle theory. The experiment's paradigm-shifting results set the foundation for the critical discovery of intrinsic angular momentum (spin) and its eventual contribution to the development of the quantum model of the atom and Pauli's exclusion principle. This review article intends to summarize the design, results, and mathematical explanations of the experiment. The article aims to inform its readers by presenting a comparison between the Stern-Gerlach experiment's expected and true results, as well as underscoring a significant sequential extension of the experiment that sheds light on the nature of quantum mechanics as a whole. This article offers a foundational compilation of the most important components of the experiment and its later contributions to the formalism of particle physics.

Introduction

To begin understanding the fundamentals of quantum mechanics, we may first address a few qualitative properties of this subset of physics. When discussing quantum mechanics, we naturally look at objects at the smallest scales measurable so far. From experience of classical mechanics on a daily basis, we intuitively imagine a particle behaving as we would expect any other object on our scale of existence. Yet, particles behave in a very different way than we would expect. Whether we are talking about electrons, protons, or any other particle of that scale, we often use the term particle-wave duality to express their behavior.

Fundamentally, any object at the quantum level is neither a particle nor a wave; it is intermediate to the two. Another significant difference between classical mechanics and quantum mechanics is that the latter is probabilistic in nature. In other words, classical mechanics suggests that the behavior of a particle is deterministic, whereas quantum mechanics suggests that the state of a particle can only be considered as a probability. In other words, if the present state of a particle is known, calculating the future state of the particle is impossible; however, it is possible to find the probability of the particle being in any given state. Hence, the particle is assumed to be in a multitude of different states simultaneously with varying probabilities. Another difference between the two fields of physics is that in quantum mechanics, not all the classical variables of the particle can be known with certainty. For example, greater certainty in a particle's position implies more limited certainty in its momentum. This is known as the Heisenberg uncertainty principle [4].

The scope of this paper is to describe the experiment that guided the discovery of a fundamental property of all particles at the quantum level and demonstrate the quantum behavior of this property. By discussing the results of the Stern-Gerlach experiment in comparison to what classical physics would anticipate, the paper will provide a connection between the observed spin

and the mathematics describing it. Furthermore, the paper will also look at the unique characteristics of spin behavior in the sequential Stern-Gerlach to discuss properties rooted in the difference between quantum and classical physics.

History of the Stern-Gerlach Experiment

The Stern-Gerlach (SG) experiment [3] was originally designed by Otto Stern in 1921 and undertaken by him and Walther Gerlach in 1922 in Frankfurt, Germany. The experiment itself is considered one of physics's historic greats. It is still praised for its conceptual simplicity yet striking contribution to understanding the quantum world, particularly through the lens of space quantization. The experiment's unique findings led to a significant departure from traditional interpretations of the atom and paved the way for the formalism of the quantum model of the atom taught in schools across the world today. It is worth noting that Stern and Gerlach were aiming to validate the quantization of the orbital angular momentum [2]. It was later understood that the intrinsic angular momentum, which explains the results of the experiment, is fundamentally different from what Stern and Gerlach expected.

Orbital angular momentum is a result of the electron orbiting the nucleus of an atom, whereas intrinsic angular momentum refers to an electron spinning around itself. The total angular momentum would be the sum of the orbital and intrinsic angular momenta. It must be emphasized that the electron does not truly rotate around itself; rather, the mathematics that explains the phenomenon warrants the physical analogy to classical mechanics. Although it would seem logical for the electron to spin around itself when considering that magnetic fields, such as that of the electron, arise from rotating bodies, the electron would have to rotate around itself at rates exceeding the speed of light to commensurate with experimental values of intrinsic angular momentum [1].

Experimental Design

Stern and Gerlach began by heating silver (Ag) in an electric furnace. The furnace has a small opening with a circular area of 1 mm^2 through which energized silver atoms flow into a collimator, which forms an unpolarized parallel beam. The beam is then thrust into an inhomogeneous magnetic field generated by a pair of parallel magnetic poles, one flat and the other with an edge oriented toward the opposite plate. The beam finally exits the space between the two magnets and hits the photographic plate. The most important components of the experiment are schematically shown in Figure 1 [5][7].

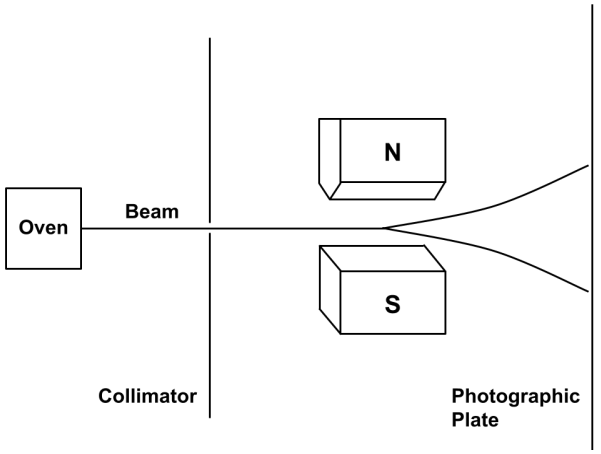


Figure 1: Design and Set-up of the Stern-Gerlach Experiment

Note that the use of silver atoms is particularly useful as they only have one unpaired electron in the 5s orbital. This means that the next intrinsic angular momentum of all other atoms is zero, allowing for each atom to be treated as an electron. From this point on in this paper, the words atom and electron will be used interchangeably when referring to the beam. It is also important to note the significance of an inhomogeneous magnetic field as it allows a net force to act on the electrons and deflect them. In other words, it would have been impossible to observe any variations in angular momentum had the field been homogeneous. It is equally important to understand that the beam must have been unpolarized, meaning the beam contains particles with spin in all possible orientations with equal probability; otherwise, the results of the experiment would have been trivial.

Expected Results

To begin discussing the approach to determining the expected results, we will use a simplified interpretation of the silver atoms. Silver is composed of 47 electrons, 46 are paired, filling up to and including the 4d orbital, indicating that they generate zero net angular momentum within the atom. The remaining electron is unpaired in the 5s orbital. This electron's spin is the sole source of the atom's total magnetic moment μ. Reiterating the above sentence, we get $\vec{\mu} \propto \vec{\mathrm{S}}$.

We shall now take the magnetic potential energy between the magnetic field and magnetic moment $-\vec{\mu} \cdot \vec{\mathrm{S}}$ to determine the force acting on the atom in a specific direction.

$$F_z = \frac{\partial}{\partial z}(\vec{\mu} \cdot \vec{\mathrm{B}}) \simeq \mu_z \frac{\partial \mathrm{B}_z}{\partial z}$$

In making the above calculation, we disregard all components of $\vec{\mathrm{B}}$ that are not in the z-direction. Here, it would seem appropriate to use principles of trajectory from classical dynamics to indicate that atoms with $\mu_z < 0$ would be subject to a downward force; whereas atoms with $\mu_z > 0$ would be subjected to an upward force [5]. The orientations of each atom's respective $\vec{\mu}$ are entirely arbitrary when the atoms come out of the oven; hence, a substantial

sample should create a continuous distribution on the photographic plate, as illustrated in Figure 2.

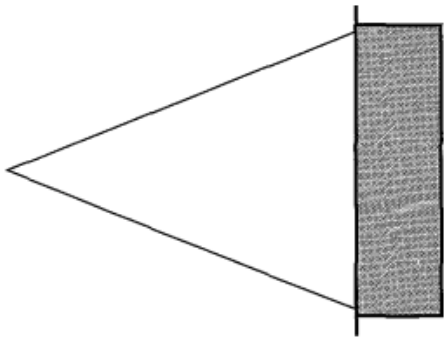


Figure 2: Neglecting the initial small divergence of the beam, a smooth distribution is expected on the photographic plate.

Experimental Results

Unlike what would be expected from a classical interpretation, Stern and Gerlach observed two uniform bundles of spots on opposite ends of the photographic plate. One bundle correlates to an "up" orientation, while the other correlates to a "down" orientation. Put more simply, the SG apparatus distinguishes the beams into two possible components, which generate two separate peaks along the photographic plate, as seen in Figure 3, a phenomenon commonly referred to as spin quantization.

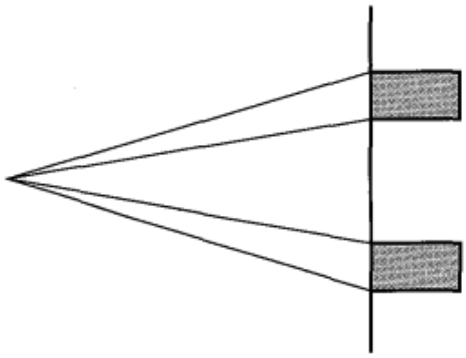


Figure 3: The experimental distribution on the photographic plate is two smooth peaks separated by a small distance.

At this time, it is important to stop and reflect on the significance of these results. Classical physics would describe the above result as impossible, with no mechanisms or theory suggesting that any form of quantization would have been possible. It becomes once again evident that the laws governing this behavior are fundamentally different than what can be observed at the macroscopic scale.

It is also important to note that the "up" and "down" quantization of electron spin is completely arbitrary, and quantization can be observed in any direction. For example, had the magnetic poles been oriented horizontally, the quantization observed could be described as "right" and "left."

Since the magnetic moment, $\vec{\mu}$, is observed to appertain to one of two distinct configurations, the same can be said about $\vec{S}$ when considering $\vec{\mu} \propto \vec{S}$. Thus, it is possible to define the two possible values of electron spin as $S_z +$ and $S_z -$, denoting spin up and spin down, respectively. The fact that the peaks are spatially separated led to the original cumbersome name of "space quantization". The Stern-Gerlach experiment demonstrates the quantization of the dipole moment and theoretical inference of the quantization of spin.

Stern-Gerlach Experiments in Sequence

It is possible to set up a sequence of SG apparatuses in a variety of ways. Suppose two SG$\hat{z}$ experiments are done in series with the same orientation. The first experiment is completed by filtering the electrons into two bundles, where the bundle of electrons with down spin is removed entirely from the apparatus. In the second experiment, the electrons with up spin are shot through the SG$\hat{z}$ apparatus, and the electrons received on the other end have only up spin. Figure 4 illustrates this scenario, where each rectangular box represents an SG apparatus labeled with the axis it acts on. The checkered square represents a filter that removes one of the resulting beams, in this case, the beam with spin down [5].

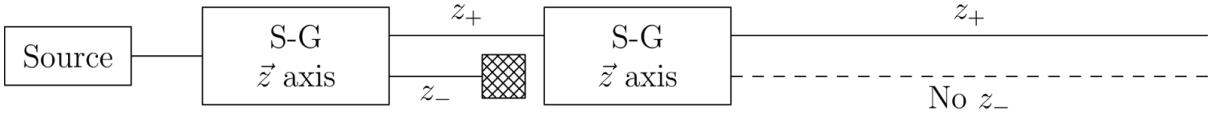


Figure 4: First Iteration of Sequential Experiments

In another iteration of sequential Stern-Gerlach Experiments, the electrons with up spin are once again removed and then thrust through an SG$\hat{x}$ apparatus, which filters them on a different orientation. By deflection, the electrons are filtered into two distinct beams based on their spin on the x-axis. For the sake of contextualization, it can be thought of as right and left. It is worth noting that at this stage, from a classical standpoint and with reference to the first iteration of sequential SG experiments, we would expect the beams resulting from the deflection to have spin components $S_z +$ and $S_x +$ or $S_z +$ and $S_x -$ [5].

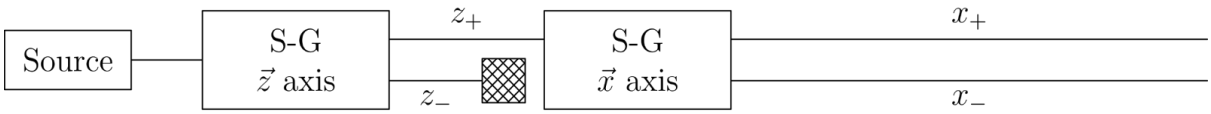


Figure 5: Second Iteration of Sequential Experiments

Finally, another iteration of the sequential SG can be made with three experiments. The initial beam passes through an SG$\hat{z}$ apparatus, and the resulting spin-down beam is removed. The spin-up beam passes through an SG$\hat{x}$ apparatus where the spin-down electrons are again filtered out. The beam with spin-up in both directions is sent through another SG$\hat{z}$ apparatus, and the resulting beam is expected to be entirely spin-up since all atoms with spin-down were removed

in the first SG$\hat{z}$ run-through. Surprisingly, the apparatus releases two beams, one with $S_z +$ spin and one with $S_z -$ spin. Figure 6 illustrates the set of the final sequential experiment [5].

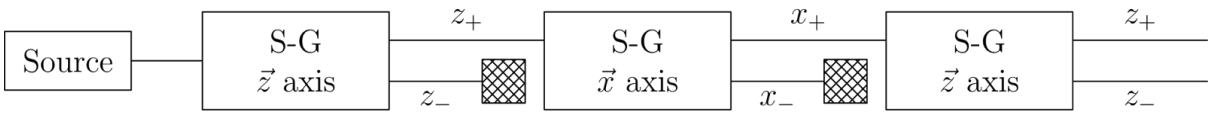


Figure 6: Third Iteration of Sequential Experiments

This is fundamentally different from what would be deduced in classical physics, which would suggest that the resulting beam would only contain spin $S_z +$ atoms. We may deduce that shooting the atoms through the SG$\hat{x}$ apparatus destroys any information about the spin in the $\hat{z}$ direction. Thus, it is critical to realize that the method by which this reset occurs can only be described by a thoery different in principle from what has already been considered.

Bra and Ket Notation

Prior to moving into the mathematical components derived from the result of the Stern-Gerlach experiment, it is imperative to define the mathematical domain in which the quantum phenomenon occurs. The experiment is defined in a complex vector space with dimensionality two. Dimensionality refers to the number of components of the vector systems that describe the physical scenario. Since the Spin can be described by either up or down, the dimensionality in the Stern-Gerlach experiment is two. The state vector defining the spin of the electron is called a **Ket** and is denoted $|S\rangle$. Note that kets are column vectors and can be added together to form a new vector. In the context of the experiment, a ket can be multiplied by a complex constant; however, the constant does not matter to physical considerations since we are only interested in the direction of the vector. As such, $|S\rangle$ will be dealt with as a ray.

Observables, including spin, are represented by **matrix operators** such as A. These operators act on vectors from left to right, resulting in a new vector. In ket notation, the new vector is represented as A$|S\rangle$. In general, the matrix operator does not act as a constant unless $|S\rangle$ is an **eigenket**. In this case, the resulting constant is referred to as the **eigenvalue**.

A matrix operator can be transposed, meaning the columns and rows of the matrix are inverted. One such example is

$$A = \begin{pmatrix} a & b & c \\ d & e & f \end{pmatrix}$$

where

$$A^T = \begin{pmatrix} a & d \\ b & e \\ c & f \end{pmatrix}$$

Thus, it can also be shown that the Ket can be transposed into a `horizontal' vector (row vector) known as a **Bra** and is denoted $\langle S|$. Note that Bras and Kets are essentially matrices with one row or column, respectively.

Spin 1/2 Systems

Through the singular run of the SG experiment, it can be observed that approximately half of the electrons have spin up and the other half have spin down. Considering that quantum mechanics is a theory founded on physical probabilities, it is imperative that the mathematics that describes the behavior of the electrons in this system is also probabilistic in nature.

The deflections caused by the magnetic field are equivalent to $S_z = \frac{\hbar}{2}$, hence the name spin one-half system. Since the spin of the atom is quantized into either up or down, the state that describes the spin, also referred to as the spinor (in general, not just for the state of the spin), can be defined as

$$S = \begin{pmatrix} S_\uparrow \\ S_\downarrow \end{pmatrix}$$

where $|S_\uparrow|^2$ and $|S_\downarrow|^2$ are the probabilities of the electrons having spin up and spin down, respectively. It follows that a spinor $S = \binom{1}{0}$ denotes an electron with spin up, and spinor $S = \binom{0}{1}$ denotes an electron with spin down. If we rewrite the spinor as

$$S = S_\uparrow|\uparrow\rangle + S_\downarrow|\downarrow\rangle$$

where $|\uparrow\rangle$ and $|\downarrow\rangle$ are defined as $\binom{1}{0}$ and $\binom{1}{0}$. Recall that $S_\uparrow$ and $S_\downarrow$ are complex. Since the total probability of the electron spin state should amount to 1, the inner product of the spinor will also be equal to 1. Hence, it can be shown that $|S_\uparrow|^2 + |S_\downarrow|^2 = 1$.

The behavior of the systems is naturally dependent on the direction in which the magnetic field acts on the electrons. This effect is determined by the Hermitian operator corresponding to each directional application of the magnetic field. Each of these operators can be represented as a matrix. For instance, the spin operator in the z direction is

$$\hat{S}_z = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

These operators, which are also referred to as observables, act on an eigenvector resulting in an eigen equation that is simply the original eigenvector multiplied by some eigenvalue.

By acting $\hat{S}_z$ on up-spin and down-spin components of the spinor S_z, it is possible to verify that the operator gives out the one-half spin deflections observed in the SG experiment.

$$\hat{S}_z|z_\uparrow\rangle = +\frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} 1 \\ 0 \end{pmatrix} = +\frac{\hbar}{2}\begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\hat{S}_z|z_\downarrow\rangle = +\frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} 0 \\ 1 \end{pmatrix} = -\frac{\hbar}{2}\begin{pmatrix} 0 \\ 1 \end{pmatrix}.$$

The behavior of the above operators simply means that if the electron was to have spin state $|x_\uparrow\rangle$ or $|x_\downarrow\rangle$, the action of the operator would simply result in the electron having intrinsic angular momentum $S_z = \pm\frac{\hbar}{2}$ according to the original spin state.

Spin Operations in Sequential Experiments

Before delving into the mathematics of the sequential experiments is it is critical to set forth two mathematical results that are critical to analyzing the experiment. Firstly, suppose there are two ket spinors $\vec{z}$ and $\vec{x}$ in a complex vector space. The scalar product of the two spinors is defined as

$$\langle z|x\rangle = z_\uparrow^* x_\uparrow + z_\downarrow^* x_\downarrow$$

Secondly, up and down spin states are orthogonal to each other; hence the scalar product between two opposite states will always equal zero.

$$\langle z_\uparrow|z_\downarrow\rangle = 0 \qquad\qquad \langle z_\downarrow|z_\uparrow\rangle = 0$$

Naturally, the scalar product of the same spin state will always be equal to one.

$$\langle z_\uparrow|z_\uparrow\rangle = 1 \qquad\qquad \langle z_\downarrow|z_\downarrow\rangle = 1$$

In the case of sequential SG experiments, the first run-through is identical in properties to what is described in the previous section. The electrons with spin down are removed from the system, and the electrons with spin up are then shot through an SG$\hat{x}$ apparatus. The eigenstates in the SG$\hat{x}$ experiment are simply

$$\hat{S}_x|x_\uparrow\rangle = \frac{\hbar}{2}|x_\uparrow\rangle$$

and

$$\hat{S}_x|x_\downarrow\rangle = -\frac{\hbar}{2}|x_\downarrow\rangle.$$

Notably, the eigenstates of the $\hat{S}_x$ operator can also be expressed in terms of the eigenstates of the eigenstates of the $\hat{S}_z$ operator. This relation is often expressed in Dirac notation, as shown below.

$$|x_\uparrow\rangle = \frac{1}{\sqrt{2}}|z_\uparrow\rangle + \frac{1}{\sqrt{2}}|z_\downarrow\rangle$$
$$|x_\downarrow\rangle = \frac{1}{\sqrt{2}}|z_\uparrow\rangle - \frac{1}{\sqrt{2}}|z_\downarrow\rangle$$

The above equation can also be added to express the eigenstates of the $\hat{S}_z$ operator in terms of the eigenstates of the $\hat{S}_x$ operator.

$$|z_\uparrow\rangle = \frac{1}{\sqrt{2}}|x_\uparrow\rangle + \frac{1}{\sqrt{2}}|x_\downarrow\rangle$$
$$|z_\downarrow\rangle = \frac{1}{\sqrt{2}}|x_\uparrow\rangle - \frac{1}{\sqrt{2}}|x_\downarrow\rangle$$

Recall that the electron being shot through the $\hat{S}_x$ will result in having either $|x_\uparrow\rangle$ or $|x_\downarrow\rangle$ spin state and that all electrons with spin state $|x_\downarrow\rangle$ are then removed from the system. Hence, the spin state $|x_\downarrow\rangle$ shall not be considered from this point on. By multiplying the $|x_\uparrow\rangle$state by the $\hat{S}_z$ operator, we may demonstrate the effect the second run through the SG$\hat{z}$ apparatus will have on the spin state of the electrons. In matrix notation, this can be represented as

$$\hat{S}_z|x_\uparrow\rangle = \frac{1}{\sqrt{2}}\frac{\hbar}{\sqrt{2}}\begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}\begin{pmatrix}1\\0\end{pmatrix} + \frac{1}{\sqrt{2}}\frac{\hbar}{\sqrt{2}}\begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}\begin{pmatrix}0\\1\end{pmatrix}$$

which equates to

$$\hat{S}_z|x_\uparrow\rangle = \frac{\hbar}{2}\begin{pmatrix}1\\0\end{pmatrix} - \frac{\hbar}{2}\begin{pmatrix}0\\1\end{pmatrix}.$$

The above result is equivalent to the state in the $\hat{z}$ direction, thus providing a mathematical explanation for the sequential phenomenon observed in Figure 5.

Alternatively, the above calculation can be demonstrated using Dirac operator notation [6], which defines $\hat{S}_x$ and $\hat{S}_z$ as

$$\hat{S}_z = \frac{\hbar}{2}|z_\uparrow\rangle\langle z_\uparrow| - \frac{\hbar}{2}|z_\downarrow\rangle\langle z_\downarrow|.$$

In the passage through the $\hat{z}$-filter, the $\hat{S}_z$ operator acts on an $|x_\uparrow\rangle$ state. This calculation can be shown as

$$\hat{S}_z|x_\uparrow\rangle = \hat{S}_z|z_\uparrow\rangle + \hat{S}_z|z_\downarrow\rangle$$
$$\hat{S}_z|x_\uparrow\rangle = \frac{\hbar}{2}|z_\uparrow\rangle\langle z_\uparrow|z_\uparrow\rangle - \frac{\hbar}{2}|z_\downarrow\rangle\langle z_\downarrow|z_\uparrow\rangle + \frac{\hbar}{2}|z_\uparrow\rangle\langle z_\uparrow|z_\downarrow\rangle - \frac{\hbar}{2}|z_\downarrow\rangle\langle z_\downarrow|z_\downarrow\rangle$$
$$\hat{S}_z|x_\uparrow\rangle = \frac{\hbar}{2}|z_\uparrow\rangle + \frac{\hbar}{2}|z_\downarrow\rangle$$

where

$$\langle z_\uparrow|z_\uparrow\rangle = \langle z_\downarrow|z_\downarrow\rangle = 1 \text{ and } \langle z_\downarrow|z_\uparrow\rangle = \langle z_\uparrow|z_\downarrow\rangle = 0.$$

Again, it becomes evident how the acting of the third apparatus allows for the quantization of spin in the $\hat{z}$ direction despite the removal of all electrons with spin up from the first apparatus.

Uncertainty Principle Interpretation of the Sequential Experiments

The results of the final iteration of the Stern-Gerlach experiment can also be interpreted using Heisenberg's uncertainty principle. As stated in previous sections, the Heisenberg uncertainty principle asserts that in quantum physics, no two characteristics of a particle can be known with total certainty; rather, the certainty of one characteristic is inversely proportional of the certainty on another characteristic, the most common example being the relation between position and momentum:

$$\Delta x \Delta p \geq \frac{\hbar}{2}.$$

In the context of the experiment, the two characteristics of the electron are taken as the spin in directions $\hat{z}$ and $\hat{x}$. Crucially, this interpretation relies on the fact that the two directions

are orthogonal; hence, the spin in each direction is entirely independent of the spin in the other direction. Since the two directions are orthogonal, it then follows that spin in the $\hat{z}$ direction, for example, cannot be known if the spin in the $\hat{x}$ is known with complete certainty. In other words, running the silver atoms through an apparatus oriented in the $\hat{x}$ direction destroys any information from any previous experiment in the $\hat{z}$ direction. Ultimately this allows the electrons to take up any spin in the $\hat{z}$ direction, hence the 50-50 split between spin-up and spin-down atoms.

Conclusion

This article has provided a textbook-level discussion of the experimental setup, expectations, and outcomes of the Stern-Gerlach experiment. The article has subsequently demonstrated the mathematical and physical explanations for the phenomenon observed in the experiment. This work discussed the existence of quantum operators and their relevance in not only characterizing the quantization of spin but also in illustrating the results of the sequential Stern-Gerlach experiments. Finally, the work has presented a qualitative explanation of the uncertainty principle interpretation of the experiments that supports the deduction that can be made from the quantum operator approach.

It is worth reminding that the experiment introduced concepts that had never been considered previously, especially on the difference between orbital and intrinsic angular momentum. Furthermore, the experiment has had a significant influence on the discovery of quantum mechanics and many significant concepts such as the Pauli exclusion principle which are integral in the understanding of the micro-scale of our universe.

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Neutrinos: Physics Beyond the Standard Model Through Multi Messenger Astronomy and Lessons from IceCube y Avni Iyer

Abstract

Neutrinos, a class of nearly massless elementary particles that interact with only the weak nuclear and gravitational forces, possess a remarkable ability to traverse enormous distances without interference. Originating from processes like nuclear fusion in stars, supernova explosions, supermassive blackholes and radioactive decay, neutrinos are unique in their capacity to journey through space largely undisturbed. This characteristic helps answer some of the most fundamental questions about the universe such as the inner workings of astrophysical bodies and potentially the matter-antimatter asymmetry in the universe. By reviewing data from IceCube, the world's largest optical Cherenkov telescope, this paper presents a critical evaluation of the information from a major identified source of astrophysical neutrinos: blazars. This paper also evaluates and discusses the importance of multi messenger astronomy and the need to go beyond the standard model to understand the complex nature of neutrino emissions, antineutrino characteristics, and blazars.

Introduction

Neutrinos are part of the standard model, a theoretical framework for particle physics (Figure 1). The model consists of fermions (leptons and quarks), bosons, and the Higgs boson. Fermions are matter-carrying particles made up of two subclasses: quarks and leptons. The particles in the class of leptons include the electron, muon, and tau particles as well as the electron neutrino, muon neutrino, and tau neutrino. Bosons on the other hand are force-carrying particles and include the photon, gluon, W boson, and Z boson. The Higgs boson is a particle that creates the Higgs field, which fermions such as electrons and quarks interact with to obtain mass.

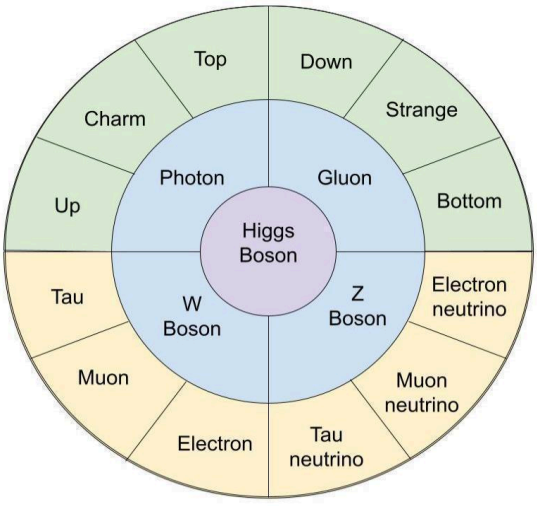


Figure 1: A simplified representation showing matter carrying particles (leptons: yellow; quarks: green) and force-carrying particles (bosons: blue; Higgs boson: innermost circle). (Author)

Neutrinos:

For neutrinos, the standard model has generated limited theories. Initially, scientists postulated, based on the standard model, that neutrinos possess no mass and consequently do not engage with the Higgs Boson in the same manner as other fermions. A second hypothesis was that neutrinos travel at the speed of light, in turn indicating that they are massless. However, Super-Kamiokande and the Sudbury Neutrino Observatory conducted experiments that prove neutrinos do have mass, though it is very close to zero, and were also shown to oscillate between 3 known flavors, the muon neutrino, tau neutrino, and electron neutrino respectively oscillating into a muon, tau, or electron upon interaction with matter.[1] These discoveries provide the foundation for our exploration of neutrinos from astrophysical sources.

Neutrinos are unique as they have a neutral charge, almost no mass, and travel close to the speed of light. Though neutrinos rarely interact with matter and only interact via the weak or gravitational forces, they are the most abundant particle with mass in the universe. They are produced during nuclear fission and fusion as well as during radioactive decay.[2]

Despite being the most abundant of all particles in the universe, detecting a neutrino is extremely rare. This makes them a challenge to study and for years the astrophysical sources of these high-speed neutrinos were not determined. Astrophysical neutrinos are of particular relevance due to their exceedingly high energies. These extreme energy neutrinos are produced only from interactions near supermassive black holes, which is why they provide insight to the unique processes within them.[3]

CP Violation:

Another major question within the realm of neutrinos and astrophysics is the question of why the current universe has an abundance of matter over antimatter. Scientists' current model of the Big Bang includes matter and antimatter being formed in equal amounts. This also suggests that all the matter and antimatter annihilate each other, leaving nothing but light and radiation.

However, we know the universe contains an abundance of matter in comparison to antimatter. Charge-parity symmetry is when the charge can be inverted and coordinate directions mirrored without altering any other properties.Charge-parity violation, or CP violation, however, is a phenomenon where a particle and an antiparticle differ in their fundamental characteristics.[4] This is a key pathway to explain why matter can outweigh antimatter.

While scientists are exploring CP violation within quarks and their antiparticles, understanding neutrinos is also essential to this mystery. Their very low mass indicates that they might be the relatives of very heavy particles that formed near the Big Bang: undiscovered, right-handed particles that obtained mass from a method other than the Higgs field. Right-handed particles are those whose spin, or amount of angular momentum, aligns with their direction of motion. The disintegration of these particles may have led to CP violation that should be observed in neutrinos and antineutrinos today. The hypothesized process that neutrinos went through to cause an excess of matter over antimatter is known as leptogenesis.

By studying neutrinos and antineutrinos, scientists hope to understand more about CP violation and the matter-antimatter imbalance in the universe.

Why Neutrinos are Key:

Particle physics encompasses 36 different fundamental particles, but neutrinos, and especially astrophysical neutrinos, are unique to our understanding of the universe.

Astrophysical neutrinos are released in the decay process of particles ejected by blazars. They are key in providing information about blazars because they only interact with gravity and the weak force, therefore traveling large distances without being affected by magnetic fields.[5] Astrophysical neutrinos provide a major source of information to answer key questions about the universe because of the large distance in space and time they travel. Once traced back to their sources, they give scientists information about processes that occur within blazars and characteristics of these cosmic bodies.

Background

Sources of Astrophysical Neutrinos:

Possible sources of cosmic neutrinos include black holes, pulsars, the remnants of supernovae, energetic explosions called gamma-ray bursts, and active galactic nuclei (AGNs).[6] Blazars are the main source of interest for this paper as they have been shown to be a primary source of astrophysical neutrinos.

Blazars are the active cores, or black holes, of giant galaxies. Because they are so bright, we can see them at very great distances. Thus, we can also see far back in time because of the amount of time it takes light to travel from a far away source to our detectors. The difference between blazars and other active galactic nuclei is that the jets of particles (cosmic rays) ricocheting from the blazar are directed towards Earth. These jets are formed as gasses around the active black hole rub against each other, losing kinetic energy in the process. This causes them to fall into the black hole and release visible heat and light. As the plasma moves faster, there is less space available, resulting in a crowding effect that causes the plasma to ricochet away from the blackhole. Due to the irradiation of radio, optical, x-ray, gamma-ray, and neutrino emissions, blazars open the door for multiwavelength astrophysics.[7]

Two major subclasses of blazars have been identified: Flat-spectrum radio quasars (FSRQs) and Broad Line Lacertae Objects (BL Lac Objects). FSRQs are characterized by powerful GeV gamma rays and strong emission lines (lines of radiation produced by highly excited electrons). Emission lines are typically produced in the broad-line region (BLR) of a blazar, which is a region of dense gas and dust that is located close to the supermassive black hole at the center of the blazar. On the other hand, BL Lac Objects are less powerful with weaker emission lines, but the presence of Radiatively Inefficient Accretion Flows (RIAFs) near their nuclei cause them to be a point of intrigue for astrophysical neutrino sources, as is discussed later in the paper.

Neutrino Fluxes - Photohadronic and Hadronuclear Interactions:

Understanding photohadronic and hadronuclear interactions that produce neutrinos is crucial to understanding more about the role of blazars in neutrino production covered later in this paper.

When cosmic rays from blazars interact with gasses or photons, they generate high-energy neutrino and gamma rays. Both hadronuclear (interaction with ambient matter in gasses) and photohadronic interactions (interaction with photons) produce charged and neutral pions (particles made up of a quark and antiquark) which play a significant role in the strong nuclear force.

Neutral pions decay into two gamma ray photons, contributing to the gamma-ray flux. Charged pions (π) produce neutrinos (n) along their decay chain. Neutrino flux refers to the rate at which neutrinos pass through a unit area. It's essentially a measure of the number of neutrinos per unit area, per unit time. Gamma rays are produced alongside high-energy neutrinos (ν or $\bar{\nu}$) and cascade down to lower energies. These gamma rays then lose energy over time, undergoing a process known as 'cascading,' ultimately resulting in the production of lower-energy photons.[8] These are explained by these equations:

Photo Hadronic interactions:

p + γ --> n + π(+ or -)

A high-energy proton (p) collides with a photon (γ), typically a gamma-ray photon. This interaction results in the creation of a neutron (n) and a charged pion (π+, if the original proton was positive, or π-, if the proton was negative).

π(+ or -) --> μ(+ or -) + ν (or anti-neutrino $\bar{\nu}$))

A charged pion (π+) or (π-) undergoes a process known as pion decay. The charged pion transforms into a muon (μ) of the same charge, along with the corresponding neutrino (ν) or antineutrino ($\bar{\nu}$).

Hadronuclear interactions:

$p + p \rightarrow \pi^0 \rightarrow \gamma + \gamma$

Two protons interact to form a neutral pion that cascades into two gamma ray photons.

$p + p \rightarrow \pi^+ \rightarrow \nu_\mu + \mu^+ \rightarrow \nu_\mu + e^+ + \nu_e + \bar{\nu}_\mu$

Since a pion is made up of three particles: neutral, positively charged, and negatively charged, the pion produced decays in three stages. The first, as shown above, eventually releases a muon neutrino, poitron, electron neutrino, and muon antineutrino .

$p + p \rightarrow \pi^- \rightarrow \bar{\nu}_\mu + \mu^- \rightarrow \bar{\nu}_\mu + e^- + \bar{\nu}_e + \nu_\mu$

The third stage results in a muon antineutrino, electron, electron antineutrino, and muon neutrino.

Compton and Synchrotron Scattering:

Along with neutrino emissions, photons of various frequencies are emitted. There are two main processes that contribute to the energy of photons released by blazars:

First, Inverse Compton scattering occurs when a high-energy charged particle, usually an electron, interacts with a photon and transfers its energy to the photon (typically X-rays or gamma rays), resulting in a recoiling electron with diminished energy.[9] Second, synchrotron radiation which occurs as a charged particle is accelerated in a circle by magnetic fields. The charged particle, usually an electron again, releases a photon.[10] Detecting these photons in parallel with neutrino emissions gives scientists a way to correlate wavelengths such as X-rays, gamma rays, and radio waves with neutrino fluxes.

Glashow Resonance:

Tying together the concepts of neutrinos and antineutrinos as well as neutrino production by astrophysical sources is a phenomenon called Glashow Resonance, a concept with more implications that are covered later in the paper.

Glashow resonance is a phenomenon predicted 60 years ago by Nobel laureate physicist Sheldon Glashow.[11] It explains that a high-energy electron antineutrino, with estimated energy above 6.3 PeV, can produce a W- boson when it interacts with an electron. No terrestrial accelerators can accelerate neutrinos to such high energies. This resonance is significant in the context of neutrino detection from BL Lac and FSRQ blazars due to the potential production of these high-energy antineutrinos in such environments. This means that only astrophysical neutrinos such as those created by blazars are capable of causing Glashow resonance. Secondary muons that cascade from the W- boson are what IceCube detects after Glashow resonance.

Glashow resonance provides validation of the standard model, a method of distinguishing neutrinos from antineutrinos, and a way to identify astronomical accelerators that produce neutrinos via hadronuclear or photohadronic interactions, with or without strong magnetic fields.

IceCube - The World's Largest Cherenkov Telescope:

Detecting neutrinos is no simple feat. This is where the IceCube Detector comes in, the world's largest optical Cherenkov telescope. It is located in the Amundsen-Scott South Pole Station, made of one cubic kilometer of Antarctic ice. IceCube is designed to detect astrophysical and atmospheric neutrinos. Neutrinos have to interact with matter in order to be detected, a phenomenon that is very rare, given that neutrinos do not interact with the electromagnetic and strong force. To maximize the chance of a neutrino interacting with matter, IceCube encompasses a huge area of 250 acres. A billion metric tons of clear ice with 5000 detectors allows huge amounts of light to be taken in.[12]

To ensure that sunlight cannot reach the sensors and prevent photon interference from any light that does not come from neutrinos, IceCube is also drilled 2.5 km deep. It is made up of 86 strings, 60 phototubes, and 5160 optical sensors.

When high energy particles interact with the ice, they create a shower of particles that travel faster than the speed of light in ice, though slower than the speed of light in a vacuum. Similar to a supersonic spacecraft emitting a sonic boom, these electrically charged particles release a cone of light known as Cherenkov radiation. This radiation is useful as it tells how much energy was deposited, which indicates how much energy the particle had, roughly where

the particle came from, the type of particle, and possibly even the type of collision. In the ice, digital optical molecules (DOMs) designed as strings form much of the detector. With a photomultiplier and electronics, the DOMs detect Cherenkov light. Sensors collect the light, which is digitalized and time stamped.

The surface array of IceCube, called IceTop, is made up of a veto and calibration detector. IceTop detects neutrino air showers from cosmic rays in the energy range from 300 TeV to 1 EeV. Eight DOM strings packed more compactly within the ice are known as DeepCore. This component lowers the neutrino energy threshold to 10 GeV for closer atmospheric neutrinos. The IceCube lab processes data from the DOMs for information on what direction the neutrinos arrived from.

IceCube is not designed for low-energy neutrinos such as ones from the radioactive decay of rock, from sun, and from supernovae explosions. These all fall in the energy spectrum of thousandths GeV to a few hundredths GeV. Instead, IceCube commonly observes atmospheric neutrinos created by high energy particles that collide with nuclei and create a shower of hadrons that decay into neutrinos, as well as astrophysical neutrinos.

To contribute to multi-messenger astrophysics and validate the discoveries of IceCube, other telescopes are used to detect optical, radio wave, or gamma ray fluxes at the same time an astrophysical neutrino is detected. IceCube's most important collaborations include Laser Interferometer Gravitational-wave Observatory (LIGO), NASA's Fermi-gamma telescope, Major Atmospheric Gamma Imaging Cherenkov Telescope (MAGIC), Max Planck Institute for Radio astrophysics (MPIfR) in Germany, and Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry (TANAMI).[13]

IceCube Historical Data:

Since 2010, IceCube has made several groundbreaking discoveries in the realm of neutrino physics. Between 2010 and 2012, IceCube detected 26 high energy particles.[14] Their energies were more than one million times greater than those from supernovae in the Magellanic Cloud detected in 1987. These particles first indicated the possibility of neutrinos from outside the solar system.

Soon after, in April of 2012, a pair of neutrinos nicknamed Bert and Ernie were detected. Each one had an energy of above one PeV. This provided confirmation for neutrinos from outside the solar system and earned the Physics World 2013 Breakthrough of the Year.

In December of 2012, Big Bird was detected: a neutrino with less than a millionth the mass of an electron but energies a million million times that of an X-ray With the energy of 2 quadrillion EeV, Big Bird was the highest energy neutrino of its time and now still stands as the second most energetic. IceCube collaborated with scientists from the Fermi-Gamma ray telescope to connect Big Bird to the blazar PKS B1424-418. Observations showed that the blazar shone 15 to 30 times brighter than normal during the neutrino flare.

In July of 2018, IceCube for the first time confirmed the source of a high energy neutrino. By turning telescopes to observe the unusually bright bursts of energy from the blazar TXS 0506+056, scientists tied this blazar to the high energy neutrino event, named IceCube-170922A.

Results and Discussion

In this section, we discuss more specific data from IceCube and other multi-messenger sources that demonstrate the importance of blazars in neutrino physics and implications of the data we receive from them.

Proof that Neutrinos Originate from Blazars:

On September 22, 2017, IceCube detected a high-energy neutrino (estimated to be ~290 tera-electron volts (TeV), and sent messages to other observatories around the globe. The Fermi Large Area Telescope Collaboration observed and identified a gamma ray source 0.1 degrees from the direction of the neutrino. The source, blazar TXS 0506+056, was observed to be in a flaring state. (The emission of neutrinos can be linked to gamma ray radiation, as explored later in this paper).[15]

The MAGIC Telescope Collaborations observed that the gamma-ray flux reached 400 GeV at times. TXS 0506+056 has a redshift of 0.34[14]. As depicted in Figure 2, the regions containing 50% and 90% of the neutrino event IceCube-170922A (indicated by dashed red and solid gray contours, respectively) are superimposed on an optical V-band sky image. Known gamma-ray sources within this area, previously identified by the Fermi spacecraft, are denoted by blue circles. The size of the circles corresponds to the 95% positional uncertainty of each source, and they are labeled with their respective names.

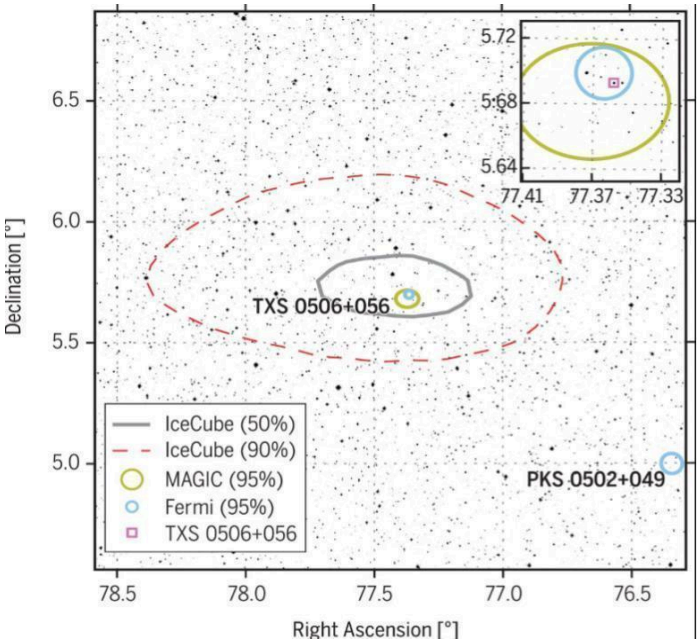


Figure 2: Circles represent positional uncertainty of previously detected gamma ray sources enabling multimessenger astrophysics to hone in on TXS 0506+056.[14]

The IceCube neutrino event aligns with the blazar TXS 0506+056, indicated by the pink square. The yellow circle represents the 95% positional uncertainty of very-high-energy γ-rays detected by the MAGIC telescopes during the subsequent observation campaign. Inset is a

zoomed-in view of the region around TXS 0506+056, superimposed on an R-band optical image of the sky.

Scientists Gao et al., 2019 employed redshift as a basis to calculate the muon-neutrino luminosity (rate at which muon neutrinos are emitted from a source, measured in units of muon neutrinos per unit of time) and found that it matched the luminosity of the observed gamma-rays from that source.[16] These findings attribute the high-energy neutrino to the blazar TXS 0506+056 with a statistical significance of 3 sigma, or 99.7% confidence level.

Motivated by this discovery, the IceCube collaboration examined lower-energy neutrinos detected over the previous several years, finding an excess emission at the location of the blazar. In order to understand this, we will next explore the two subclasses of blazars: BL Lac Objects and Flat-Spectrum Radio Quasars (FSRQs).

BL Lac Objects vs. Flat-Spectrum Radio Quasars:

FSRQs contain bright optical and UV emission lines, whereas BL Lac Objects lack these. FSRQs have a very high luminosity, but low source density (Figure 3).[17]

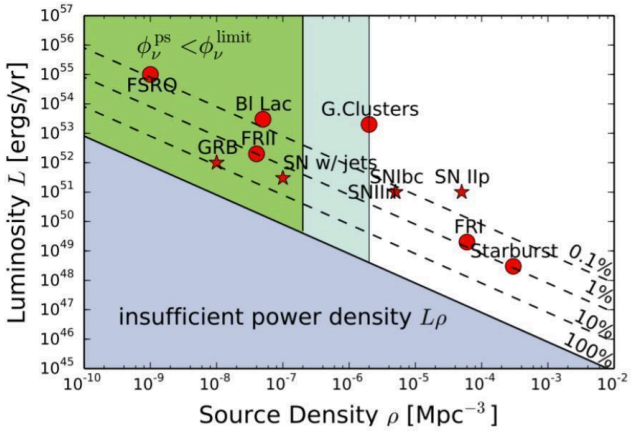


Figure 3: FSRQs are located in the upper left corner of this density-luminosity graph, illustrating that they are the highest in luminosity but lowest in source density of possible neutrino sources.[17]

Given the relatively small number of FSRQ sources in close proximity to each other, the detection of multiple neutrino samples from a single FSRQ source appears to be a reasonable expectation. However, this has not been detected, which indicates that FSRQs are likely not strong neutrino emitters.

This makes it unlikely for FSRQs to be strong neutrino emitters, because with such high power and low amount of FSRQs, one would expect to find multiple neutrino samples from a single FSRQ in the current data. However, since this is not the case, it seems unlikely that FSRQs would be strong neutrino emitters.

The FSRQ jet composition is also primarily made up of electrons and positrons (the antiparticles of electrons), whereas BL-Lacs are primarily electrons and protons, allowing for protons to be accelerated in BL Lacs. Photons are necessary for photohadronic interactions.

Furthermore, neutrinos from astrophysical sources are expected to fall between the 0.1 -10 PeV, based on known relationships between the target photons, protons, and neutrinos.

However, the proton frequency of FSRQs corresponds to very high energies of protons, and therefore also high energies of neutrinos above the PeV threshold. This provides another possible reason for a lack of neutrino emission from FSRQs.

Radiatively Inefficient Accretion (RIAF) flows and Blazars:

All super massive black holes have an accretion flow of particles around them. The quantity that determines the properties of this accretion flow is the accretion rate (the rate at which matter falls into the black hole

A radiatively efficient flow has an accretion rate greater than 10^{-2} Eddington units. This standard accretion disk is geometrically thin, optically thick (emits a wide range of electromagnetic radiation), and radiatively efficient. However, radiatively inefficient accretion flow is produced when the mass accretion rate is less than 10^{-2}. In a radiatively inefficient accretion flow (RIAF), proton temperatures remain much hotter than in standard accretion disks. This high temperature causes the electrons to be stripped from the atoms, which creates a plasma. Plasma is very good at scattering photons, so the photons can travel through the RIAF without interacting with the matter, thus making RIAF geometrically thin and optically thick.[18]

The Spectral Energy Distribution (SED), or the range of energies emitted by the object at different wavelengths, of RIAFs is much broader than that of standard accretion flows.

The SED of FSRQ and BL Lacs is measured as how much energy is being emitted at different wavelengths due to both the jet and the accretion process. RIAFs are thought to be target photon sources for accelerated protons in these jets, resulting in the production of neutrinos (proton collisions with photons result in neutrinos), thus making BL Lac Objects to be strong candidates for neutrino emissions. Moreover, BL Lac objects are subdivided into three classes:

First, Low-Synchrotron-Peak BL Lacs (LBLs), such as TXS 0506+056, have a high density of RIAF photons in the soft X-ray range. This allows neutrino luminosity of LBLs to be 4 orders of magnitude larger than HBLs. In this class, the external RIAF photons are completely dominant. Second, in Intermediate-Synchrotron-Peak BL Lacs (IBLs), external RIAF photons are still more important than internal photons, though internal photons do have a presence. Third, in High-Synchrotron-Peak BL Lacs (HBLs), internal photons are the most significant, while external RIAF photons have little contribution. This means HBLs have a very low neutrino production efficiency. Figure 4 illustrates the contribution of internal and external photons for each subclass.[18]

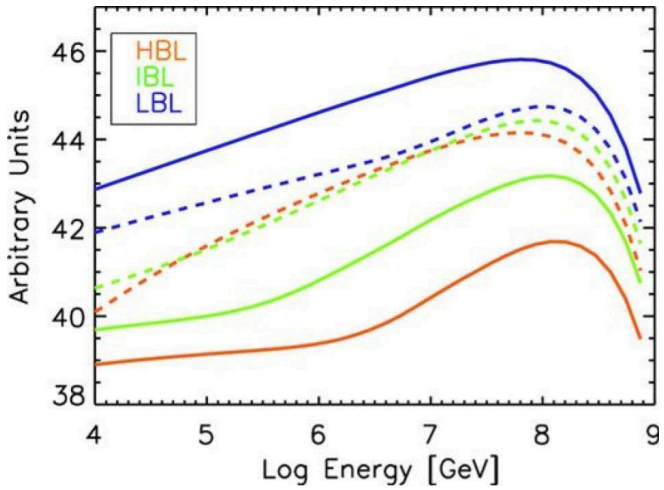


Figure 4: Internal photons (solid lines) and external photons (dashed lines) contributing differently to their photon target fields in neutrino creating photohadronic processes.[18]

BL Lac objects, especially LBLs, with weak emission lines and a lack of external radiation fields, were originally thought to be less likely as high-energy neutrino candidates. However, the high-energy neutrino from TXS 0506+056 came from a LBL. Despite HBLs emitting stronger X-rays, high-energy neutrinos have not been detected from them.

With evidence of RIAFs allowing for neutrino production and the previously mentioned characteristics that prevent FSRQs from being strong neutrino emitters, it can be concluded the BL Lacs are much more likely to be a major source of astrophysical neutrinos.

Spectral Energy Distribution (SED) of Blazars:

The Spectral Energy Distribution (SED) of all blazars come in two categories. The low-energy category, from radio to UV are likely due to synchrotron radiation by relativistic electrons (electrons that approach the speed of light). The high-energy category, from X-rays to gamma rays, is a result of the same relativistic electrons undergoing inverse Compton scattering off target photons or other hadronic processes. Dividing the broad band SED into two categories, the low-energy category and the high-energy category, is called the leptonic model for modeling electromagnetic radiation from blazars.[18]

Blazars are further subdivided into three classes depending on the highest point of synchrotron emission: low-synchrotron peaked, intermediate-synchrotron peaked, and high-synchrotron peaked. While FSRQs only fall under the low-synchrotron peaked class, BL Lac objects can fall under any of the three classes.

As we have previously seen in this paper, the production of neutrinos requires hadronic processes, thus causing the leptonic model to be modified. The hadronic model for electromagnetic radiation describes how cosmic-ray nucleons at energies ~ 10 PeV interact with UV photons to produce charged and neutral pions. Neutral pions decay into gamma-ray photons while charged pions decay into a muon and electron as well as neutrinos that travel to Earth.

However, this hadronic model does not entirely match scientific observation. X-ray emissions by the secondary electrons predicted in the model overshoot the actual observed X-ray flux. This means that the ideal model for electromagnetic radiation from blazars should not be entirely the hadronic model. A hybrid model was proposed to allow for neutrino emission but constrain the X-ray flux.[16] This hybrid model says that most photons are of leptonic origin, and any contribution by the hadronic processes is limited so that there are not so many X-rays produced that they overshoot the flux constraints. The hybrid model is shown in Figure 5.

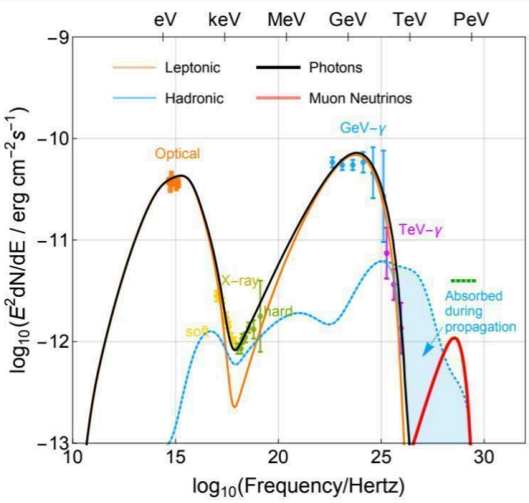


Figure 5: Hybrid model of neutrino production incorporating leptonic and hadronic parts, without overshooting the observed X-ray flux.[16]

Another constraint put on this model includes the Eddington limit, meaning that radiation from the blazar cannot be so powerful that it counteracts the force of gravity and blows away surrounding matter. The maximum contribution from photohadronic interactions is constrained by the fact that efficient neutrino production requires high energy photons, electrons, and positrons. This means that the electromagnetic cascade has to be visible as X-rays and TeV gamma rays.

As shown in Figure 6, Time-dependent modeling of emissions before, during, and after the injection boost of a blazar indicates a sharp increase in amplitude of hard X-rays and gamma-rays during the neutrino flux.

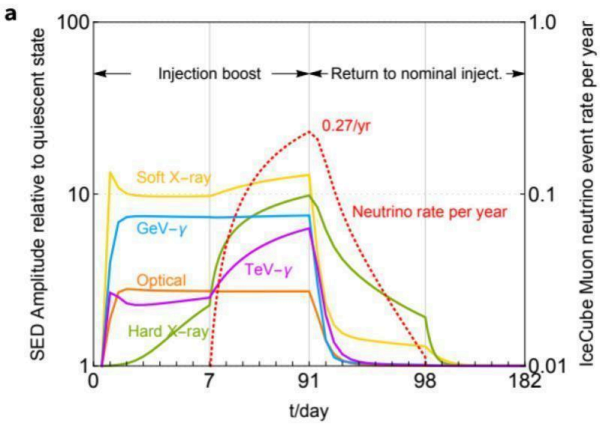


Figure 6: Relationship between hard X-rays, gamma-rays, and neutrinos underscoring the importance of multiwavelength astrophysics.[19]

Multiwavelength Astrophysics:

In multimessenger or multiwavelength astrophysics, studying all the processes that contribute to the overall observed electromagnetic spectrum is significant. Information from IceCube led to a spur in multi-messenger astrophysics as other detectors sought to correlate neutrino emission with other types of radiation. By studying the emissions across different wavelengths such as gamma rays, X-rays, radio waves, etc, scientists can piece together a more comprehensive understanding of the astrophysical phenomena and the underlying physical processes at play.

Radio Waves:

The Owens Valley Radio Observatory (OVRO) further analyzed radio data from blazars, detecting a long-term outburst of radio waves before reaching a peak during neutrino emission for both PKS 1502+106 and TXS 0506+056. Based on this and other studies, the correlation between IceCube neutrinos and radio-bright blazars has been quantified at a p-value of 0.002, indicating that the correlation between IceCube neutrinos and radio-bright blazars has a 0.2% probability of it being due to pure chance.[19]

Despite this statistical significance, observations from OVRO still did not indicate a strong correlation between radio emission and neutrinos since this was only two out of the five sources observed by OVRO. A third source was observed only after 70 days of the arrival of the neutrino. Though all five sources are monitored in radio, none demonstrated long term radio wave activity, indicating that more observation is needed to correlate them to the emission of high energy neutrinos.

On the other hand, a more recent study found that in recent years, an increasing number of neutrinos detected can be correlated to radio blazars.[20] It was found that radio blazars significantly correlated with the entire 7-year dataset from IceCube, including radio waves from

lower energies as low as a few TeV range. Combined with other analyses on independent data, the correlation of neutrinos with radio waves below and above 200 TeV was found to be significant at 4.3 standard deviations, which indicates that the differences between groups of data is large enough for there to be statistical significance. This means that there was enough variability in the evidence that the correlation was strong enough to overcome external factors.

With contrasting data from multiple analyses, more data needs to be collected to confirm a correlation between radio emission and neutrino emission. Recent data may be more accurate as it uses Very Long Baseline Interferometry (VLBI), a process that compares the distances traveled by light to each telescope in a system of telescopes placed far from each other. This allows for highly accurate astronomical data, especially when focusing on radio blazars to relate them to neutrino emission. The evidence indicates there is a high likelihood of neutrinos originating from radio blazars, but more monitoring by observatories such as OVRO needs to be done to identify the chance of a flux of radio waves during a single high-energy neutrino event.
Gamma rays:

Gamma rays were also correlated with neutrino emission.The first likely extragalactic neutrino counterpart is the gamma-ray blazar TXS 0506+056, identified on September 22, 2017. The gamma-ray blazar was found to be in a flaring state in spatial and temporal coincidence with the arrival of the 290 TeV neutrino event IC-190722A.[19]

Since TeV and PeV photons are quickly absorbed through photon-photon annihilation and cascade down to lower energies, GeV gamma-rays are the closest in energy to high-energy neutrinos. This makes them important to neutrino detection.

In the study of gamma-rays from astrophysical bodies, there were two neutrino observations from the same source.[21] The source emitted a 160-day-long neutrino flare in 2014 and again in 2015. It was not found to be accompanied by an increased activity in gamma-ray, optical, or radio wavelength. It was discovered that the gamma-ray spectrum hardened, but the discovery was not statistically significant. One study found that the hardening of the gamma-ray spectrum was statistically compatible at less than 2 standard deviations with the average spectrum, meaning there was likely no significant increase of the gamma-rays due to neutrino events.

Follow-up studies to discover other neutrino sources were initiated. However, while only measuring neutrino data and ignoring multiwavelength data, there was no detection of flares above the expected atmospheric background. This suggests that neutrino emission from these sources may be accompanied by emission at other wavelengths, such as radio waves, gamma rays, or X-rays. It is also possible that the neutrino emission from these sources is very weak and difficult to detect.

The Fermi-LAT telescope is sensitive to gamma rays, making it a crucial collaborator with Ice Cube in the detection of astrophysical neutrinos. The study of more blazars, this time focusing on multi-wavelength data, reveals more information about gamma-rays. Below is the analysis of data from two blazar neutrino sources.[21]

The study of the blazar 1H 0323+342 reveals that this source has a p-value of 0.08 for gamma-ray fluxes during neutrino flares, whereas other sources show p-values from 0.17 to 0.92. The neutrino from 1H 0323+342 came during a small increase in the gamma-ray flux, while an increase in UV, X-ray, and optical emission came one month earlier.

The blazar PKS 1502+106, a possible neutrino source for the neutrino event IC-190730A, is particularly interesting to scientists because it is extremely gamma-ray bright: it is the 15th brightest out of 2863 in terms of gamma-ray luminosity. The gamma-ray emission from this blazar has been explained to be from interactions between jet electrons and photons from the broad line region. This information indicates that the BLR photons could provide a target photon field for hadrons in the jet, allowing for neutrino production.

Over an 11 year period, the gamma-ray emission from PKS 1502+106 has been studied, identifying periods of both quiet and flaring states. Altogether, two hypotheses are consistent with the observed data.The first is that the gamma-ray brightness of blazars is linearly correlated with neutrino emission. This is supported by the neutrino event IC-170922A being correlated with a bright gamma-ray flare from TXS 0506+056.

However, blazar stacking analyses show that if the neutrino spectrum follows an $e^{-2.5}$ power law, the gamma-ray blazar contribution is limited to less than 27%. If the neutrino follows a steeper power law of e^{-2}, the stacking analysis shows that contribution from the gamma-ray blazars expands to become 40-80%.[19] Figure 7 illustrates the difference between these power laws.

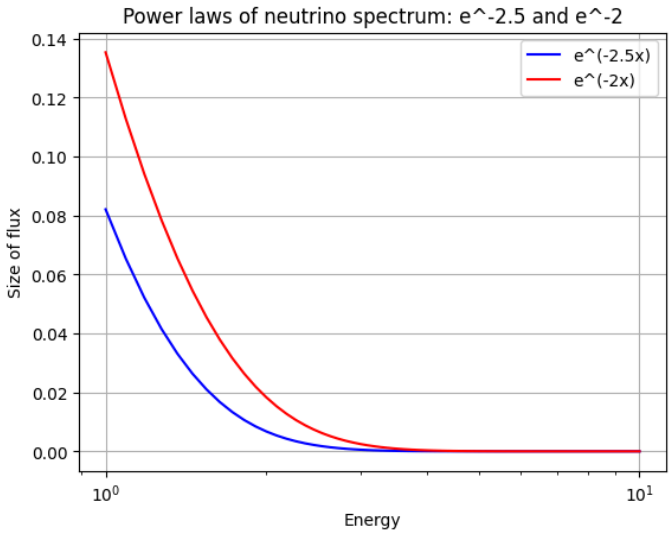


Figure 7: The graph showing the two possible power laws that the neutrino spectrum can follow: $e^{-2.5}$ and e^{2} . (Author).

The power law determines the relationship between the flux of neutrinos at different energies as the output of the energy of the neutrino. Stacking analyses show that if the neutrino flux follows a e^{2} power law, the contribution by gamma-ray blazars expands to 40-80%. Note

that this applies to neutrinos between the 10 TeV to 100 TeV range, while this graph is only used to depict the general pattern of these two power laws.

The second hypothesis, the background hypothesis, is that neutrino emission is not correlated to gamma-ray emission.There are a few possible reasons for this.The gamma-ray flux that has been identified a few times with neutrino emission could be coincidental. Another reason that scientists might conclude that neutrino emission does not have a correlation with gamma-rays is that gamma-rays from some neutrino sources are produced in optically thick regions, so gamma-rays could be absorbed and then cascade down to X-rays.

If the first hypothesis is true, gamma-ray flare coincidences can be used to study neutrinos and cosmic-ray acceleration. This also allows us to associate high-energy neutrino sources with more distinct properties. Since it would be impossible to detect the production of gamma rays beyond the optically thick regions, more observations would be needed to collect data points of various blazars with gamma-ray emission. IceCube-Gen2 will be especially useful for this as it will also be much more sensitive to weaker neutrino sources.[22]

X-rays:

The association of X-rays with neutrino producers is the most statistically significant compared to the other correlations discussed thus far. As explained in the previous section, broadband SED modeling suggests that X-ray photons from the corona (the outer edges of the blazar) could make up a target photon field for photohadronic interactions that produce high-energy neutrinos. Figure 8 shows a time-dependent model of the different parts of a Spectral Energy Distribution shows an increase in the flux of Hard X-rays and TeV gamma-rays at the same time there is a flux in muon neutrino events.[19]

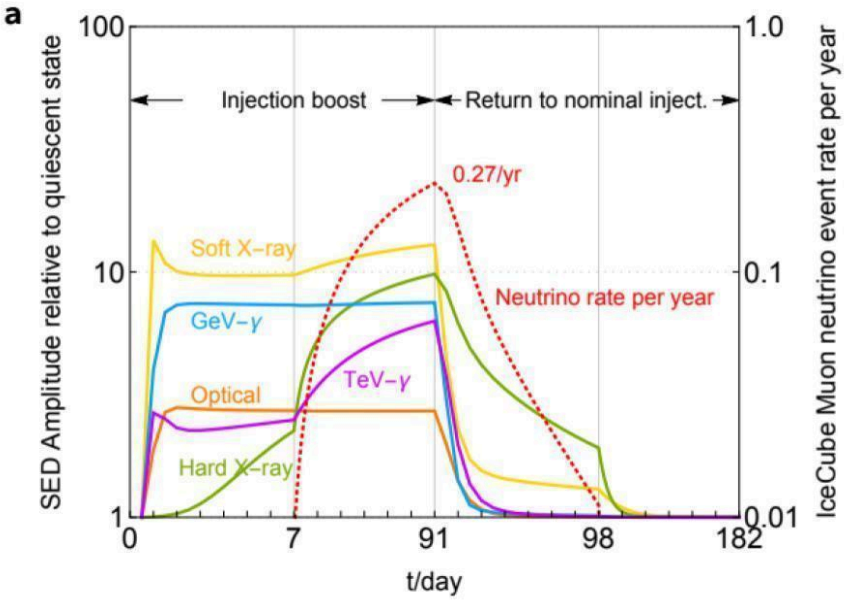


Figure 8: Time-dependent model of the Spectral Energy Distribution (SED) revealing concurrent increase in the flux of Hard X-rays and TeV gamma-rays coinciding with a flux in muon neutrino events.[19]

The steepening of the graph of the gamma ray spectrum is also explained by X-ray coronal photons because they absorb gamma-rays through pair production.

An analysis of X-ray neutrino sources was conducted by cross-matching X-ray sources with a sample set of Very-Long-Baseline-Interferometery (VLBI) bright sources, which are primarily blazars. If telescopes detected X-ray emission within a certain threshold of a VLBI source, it was named an X-ray source.[20] Then, an analysis was completed that counted the matches between neutrinos and X-ray VLBI blazars. This was compared to a count of the random expectations of the matches. For one sample, SRG/ART-XC catalog, the statistical significance of neutrinos correlated to X-ray VLBI blazars was 0.5%. In fact, all three of the hard X-ray catalogs studied, SRG/ART-XC, Swift/BAT, and INTEGRAL/IBIS reveal a correlation with IceCube neutrinos.

However, there was no correlation within the ROSAT catalog, a set of soft X-ray blazars. Thus, it was found that blazars that emit neutrinos likely have the characteristic of X-rays above 10 keV.

X-rays are found to make up the target-photon field for photohadronic interactions responsible for neutrino emission, given that they are produced in the jet. Thus, the emission of hard X-rays also explains the correlation of radio waves with neutrino emission because the number of synchrotron-self-Compton photons is proportional to the amount of radio-waves emitted by the photons. These synchrotron-self-Compton photons are located in the jetstream of a blazar.

Additionally, higher energies of GeV gamma ray photons are found to interact with low-energy photons and produce electron-positron pairs and cascading down to lower energies, which lose efficiency in the GeV range. So, although gamma-ray photons may accompany neutrinos in production, observing X-rays is a more reliable method to trace neutrino production.

X-ray flares are important for neutrino emission because they can produce pions, which then decay into neutrinos. Pions are produced when high-energy protons interact with photons, and X-ray photons are energetic enough to produce pions. Additionally, X-ray fluxes are often optically thick, which means that there is a high probability of protons interacting with photons. One model explains why focusing on X-ray flares is important. Since X-ray photons are energetic targets for photomeson interactions (interactions between high-energy protons and photons), they reduce the energy required of protons for pion production. Pions are unstable particles that decay into other particles, including neutrinos.[23] Thus, X-rays have the highest statistical significance in being correlated with neutrino emission not just based on observational analysis but also because they explain crucial production processes for neutrinos.

Therefore, as analyzed in this paper thus far, multiwavelength data is crucial to the understanding of neutrino production from blazars.

Neutrinos, Antineutrinos, and Glashow Resonance:

Much is still unknown about astrophysical neutrinos. Certain neutrino events have been traced back to their sources, allowing for there to be more data on blazars and neutrino production processes. However, other neutrino events have not been associated with a specific astrophysical source, but still provide crucial information. In 2016, IceCube measured a shower of particles with energies 6.05 ± 0.72 PeVas , determined by Cherenkov radiation. Antineutrinos Interacting with electrons in the ice results in the formation of a W boson, which decays into secondary muons. The detection of these secondary muons by IceCube indicated the occurrence of Glashow Resonance.[11]

The huge number of electrons located in Earth allows for an increased chance of Glashow resonance occurring. This is significant as it allows antineutrinos to be distinguished within the neutrino flux. Now, Glashow resonance can occur between either a neutrino and a positron (antielectron) or an antineutrino and electron, but because the Earth is made of matter and not antimatter, the neutrinos will almost never hit a positron.[23] However, as there is an abundance of electrons in everyday environments, some antineutrinos will hit electrons. So, if evidence of Glashow resonance is detected, scientists can be reasonably certain that this is evidence of an antineutrino.

Now, in a nucleon (the collective term for protons and neutrons), valence quarks are the primary quarks that contribute to its composition as well as being involved in the strong force interactions that hold nucleons together (akin to valence bonds in atoms). For example, a proton is made up of two up-quarks and one down-quark. A neutron is made of two down and one up-quark.[25]

Valence quarks are distinct because they are the only particles within a nucleon that are unpaired with an antiquark. Antiquarks are the antimatter counterparts of quarks. Also, valence quarks are left-handed (their spin is aligned to their momentum) the weak force acts on left-handed particles and right-handed anti-particles. In particle physics, quarks come in left- and right-handed versions. Only the left-handed ones can interact with W bosons because they have weak isospin, similar to electric charge for electromagnetic interactions. Due to this, valence quarks are more likely to engage with neutrinos and antineutrinos in comparison to other types of quarks within the nucleon. In other words, in astrophysical contexts, nucleons serve as interaction targets for neutrinos and antineutrinos.

However, at higher energies, the ratio of other quarks to valence quarks becomes high enough that valence quarks become lost in the noise. This is why in the realm of high-energy neutrino interactions, Glashow resonance, which is primarily driven by interactions with valence quarks, becomes increasingly important and thus proving high-energy electron antineutrino collisions.

Prior to the new analysis of neutrinos and antineutrinos, studies of the astrophysical neutrino flux assumed that there was an equal contribution of neutrinos and antineutrinos, and they focused only on a three-flavor composition. The three-flavor composition assumes that

there are three types of neutrinos: electron neutrinos, muon neutrinos, and tau neutrinos. The ratio of these three flavors is given by ($f_e : f_\mu : f_\tau$) = (1:2:0), meaning that there is one electron neutrino for every two muon neutrinos and no tau neutrinos.[24]

However, it was shown that this assumption is not correct. He showed that neutrino production by high-energy sources results in an asymmetry between the particles, necessitating a six-flavor composition. The six-flavor composition includes the three neutrino flavors and their corresponding antineutrino flavors.

This asymmetry is caused by the different ways that different hadronuclear and photo-hadronic interactions produce positively charged pions and negatively charged pions.[24] Positively charged pions decay to produce electron neutrinos and muon neutrinos, while negatively charged pions decay to produce electron antineutrinos and muon antineutrinos.

As a result of this asymmetry, the ratio of neutrinos to antineutrinos in the astrophysical neutrino flux is not equal. New ratios for the photo-hadronic scenario and the hadronuclear scenario were calculated. This ratio is given in the from of ($\{f_e, -v_e\} : \{f_\mu,-v_\mu\} : \{f_\tau, -v_T\}$), with $-v_e$ representing an electron antineutrino, $-v_\mu$ representing a muon antineutrino, and $-v_T$ representing a tau antineutrino . The photohadronic ratio is ({1, 0} : {1, 1} : {0, 0}), and the hadronuclear ratio is ({1, 1} : {2, 2} : {0, 0}).

As explained before, Glashow resonance is a unique interaction between a high-energy electron antineutrino and an electron. It results in the creation of a W- boson. This resonance process is significant because it enables the differentiation between neutrinos and antineutrinos in the astrophysical flux. Liu's work highlights the necessity of a six-flavor model to account for the intrinsic asymmetry between neutrinos and antineutrinos produced by high-energy sources interacting with earthly electrons. This six-flavor model encompasses both neutrino and antineutrino counterparts of the original three flavors (electron neutrinos, muon neutrinos, and tau neutrinos). This is significant as the processes by which neutrinos were produced, photoadronic or hadronuclear, can be distinguished based on the ratios of the neutrinos and antineutrinos detected in a flux.

In essence, this research unveils the underlying mechanisms that lead to an imbalance between neutrinos and antineutrinos, a possible evidence of CP violation. Glashow resonance complements this understanding by providing a means to identify electron antineutrinos, which are vital components of this newly recognized asymmetry. The resonance process, occurring due to the presence of electrons, allows for the discrimination between neutrinos and antineutrinos, thus enriching our insights into astrophysical neutrino production processes. This is the beginning of a deeper exploration of how neutrinos can provide evidence of CP violation.[26-27]

Conclusion

This review paper critically examined various hypotheses regarding neutrino physics and provides insights into the most promising ones. It also highlighted the limitations of existing experiments and underscores the inadequacy of the standard model in addressing fundamental questions about the universe, particularly concerning neutrinos.

IceCube has been the first neutrino detector to relate a neutrino to an astrophysical source, opening the realm of multi-messenger astrophysics.

IceCube has answered key questions about high energy neutrinos. It correlates neutrinos to blazars as sources with a statistical significance of 3.5 σ. The Radiatively Inefficient Accretion Flow (RIAF) that likely exists in the nucleus of a BL Lac Object provides a strong region for neutrino production, compared to a standard accretion flow of FSRQs.

Neutrinos provide crucial information about astrophysical bodies. Because neutrinos can be associated with blazars, we can provide specific characteristics of blazars. Photohadronic and hadronuclear interactions, crucial in neutrino production, require accelerated protons and a photon target field. As seen in the paper, blazars must provide these components in the form of jet streams, RIAFs, and possibly X-ray target photon fields from the jet stream.

To identify neutrino emission from astrophysical objects, IceCube data reveals that hard X-rays are key. The correlation between neutrinos and gamma-rays or radio-waves is yet to be statistically significant and more data needs to be collected. X-rays provide an ideal target photon field for neutrino production.

IceCube is beginning to answer questions about how CP violation can explain the matter-antimatter imbalance in the universe. Glashow resonance provides a way to distinguish between neutrinos and antineutrinos originating from astrophysical sources, but more data needs to be collected to see if this explains CP violation.

Improvements on IceCube are planned to be completed by 2032 to create IceCube-Gen2. With the installation of 750 advanced photodetectors and calibration devices, IceCube-Gen 2 will increase the volume of IceCube by tenfold, expanding it to 10 cubic kilometers. Its higher sensitivity and sharper focus will allow it to measure super PeV events and above 100 TeV astrophysical flux. It will be the first to measure neutrino cross sections at PeV and EeV energies, well beyond the capabilities of particle accelerators.

When it comes to multi-messenger astrophysics, data collected by IceCube-Gen2 will help provide answers to some of the uncertainties presented in this paper, such as the correlation of neutrino emission with radio and gamma-ray fluxes. IceCube-Gen2 will be able to cover a range of energies, with optical and radio detectors providing continuous coverage of emissions across the spectrum. This will provide more data that can then be used to correlate radio waves and gamma rays to neutrino events. IceCube-Gen2 will also be much more sensitive to weaker neutrino sources, up to five times fainter, than what could be detected with IceCube. As a result, it will be sensitive to hidden sources in optically thick environments where only neutrinos escape.

Being able to analyze this multimessenger information from high-energy astrophysical neutrinos is a vital tool that IceCube provides in understanding key processes in the universe.

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Biological Effects of Common Toxins: A Complete Review By Shreya Rangaswamy

Abstract

The prevalence of poisons today poses a significant threat to human health, as there have been more than 2 million poisoning cases in the US each year and the number increases every year. This paper will detail the different mechanisms of action and the associated health implications of different poisons such as anthrax, arsenic, mercury, and lead. Each poison exhibits a unique mode of action, influencing specific cellular proteins and pathways. Although there has been a lot of research conducted on these matters, there are not many details available on specific cellular molecules poisons interact with and how health symptoms occur. Understanding these interactions is crucial for developing treatment. This scientific review seeks to raise awareness about the pervasiveness of poisons and toxins in modern society and the potential for adverse health outcomes. Poisons are not only capable of causing death but also play a crucial role in the emergence of various diseases. It is also very important for implementing effective public health measures and minimizing their impact on human well-being. This research contributes to the broader scientific community as it answers the fundamental questions of how poisons work and what detrimental effects they inflict on the body.

Introduction to Common Toxins

Understanding the profound impact of poisons on human health is crucial for protecting people from potential harm and promoting public health and safety. A poison can be defined as any substance if taken in enough quantity causes physiological or anatomical harm (Amir 2019). Poisons have been a longstanding concern throughout history due to their capability of creating various distressing illnesses or death when absorbed by the body. Whether it be natural toxins from plants and animals, or synthetic chemicals developed for various reasons, the diverse characteristics of poisons require thorough research of their effects on the human body.

Historical events where poisons have been deployed have been instances of bioterrorism where poisons were intentionally used to inflict death or illness to humans, livestock, or crops (Rathjen, 2021). The research of the poisons and their effects includes analyzing the exposure pathways which are the routes through which the poisons enter the body and target specific organs. Certain toxins produce spores, which are cells that attack particular organ systems and spread the poison throughout the body (Vyas, 2023).

The poisonous spores disperse across the entire organism by interacting with various enzymes, which are proteins that facilitate chemical reactions with specific biological compounds within cells. In doing so, the poisons start to disrupt several cellular pathways, such as cellular respiration and DNA synthesis and repair processes. Such reactions can trigger diseases in the body and ultimately affect the health and well-being of the individual. Knowledge of the development of preventive measures and treatment procedures to reduce the harm and risks associated with poisons is extremely important for both healthcare professionals and the general

public. In this next section, common poisons such as anthrax, arsenic, mercury and lead will be evaluated for their specific mechanisms and effects on the human body.

Anthrax causative agent: *Bacillus anthracis*

Anthrax is spread by spores produced by a bacteria called *Bacillus anthracis*, which can enter the body through touch, consumption, or inhalation. The poison has commonly been used in several situations as a weapon of bioterrorism, such as in the 2001 anthrax attacks. *B. anthracis* is an aerobic, immobile bacterium enclosed in a thick cell wall (Lowe, 2012). The bacterium is also non-hemolytic, which means that it does not cause hemolysis or the destruction of blood cells in the body. Spores released by these bacteria are resistant, or unaffected by heat and several types of disinfectants and radiation. These spores develop and grow in animal tissues or blood, but they do not survive well outside of the host, where they cannot obtain necessary nutrients like amino acids, glucose, and nucleosides (Lowe, 2012).

When anthrax spores are introduced into the body, they are phagocytosed; indicating that they are engulfed by cells of the immune system called macrophages. In situations where surroundings support the growth and reproduction of bacteria, the dormant spores become active and start producing virulence factors, or molecules that are required for a bacterium to cause disease while infecting eukaryotic hosts such as humans (Abedon, 2009). At this point, the spores enter the bloodstream and are called vegetative bacteria, denoting the fact that they can grow and reproduce. For the bacteria to develop full virulence, it requires an antiphagocytic capsule to protect themselves from the macrophages (Lowe, 2012). *B. anthracis* produces three toxin components, and they bond together to form 2 toxins: edema toxin and lethal toxin (Lowe, 2012). These are the poisonous toxins that cause observable symptoms and possibly death to the individual. Edema toxin causes edema in the body tissues, which is swelling due to too much fluid trapped in the cells as water homeostasis is disrupted. It also weakens the neutrophil cells of the immune system, which makes the host more vulnerable to infections (Lowe, 2012). Lethal toxin causes the release of proinflammatory cytokines, which are small proteins that act to make diseases worse (Dinarello, 2000). This also results in a circulatory collapse, where almost all the blood circulation in the body is interrupted. Other results of the toxins are tissue edema and profuse hemorrhage, which is copious loss of blood from blood vessels (Johnson, 2023). There are different ways in which anthrax can be absorbed into the body, and these include inhalational, cutaneous, and gastrointestinal anthrax.

Inhalational Anthrax

One of the types of anthrax is inhalational anthrax, where the spores are deposited in the alveolar spaces in the lungs. The spores must be between one and five micrometers in size. If the particles are smaller than 1 micrometer, they get stuck to the mucus on the walls of the bronchi in the lungs, and if they are larger than 5 micrometers are trapped by mucus in the trachea and never reach the alveoli (Lowe, 2012). The spores do not cause infections in the lungs but are engulfed by macrophages in the alveoli and carried to lymph nodes. In the lymph node, the

spores germinate and produce the toxins mentioned above, which are released into the blood and cause edema, hemorrhage, and other conditions like necrosis (death of body tissue) and septic shock (a dangerous drop in blood pressure). Inhalational anthrax is usually a biphasic disease, having two phases of symptoms. The first stage of symptoms includes flu-like symptoms like fatigue, fever, chills, sweats, and others (Lowe, 2012). Pulmonary complaints, like wheezing or breathing issues, are not very common, but gastrointestinal symptoms such as nausea and vomiting are often experienced. The second stage of inhalational anthrax includes chest pains, dyspnea (difficulty in breathing), and stridor (abnormal respiratory sound because of irregular airflow in the airway) (Sicari, 2023). Eventually, the host would develop hemorrhage and multiorgan failure, which would lead to death. However, the infected individual can have a higher chance at survival if they are treated with antibiotics, glucose infusion, mechanical ventilation, and other methods (Lowe, 2012).

Cutaneous Anthrax

Cutaneous anthrax, or anthrax obtained by contact with the skin, is the most common type of anthrax infection. It is often acquired by people who have had exposed skin contact to animals or animal products, and the spores can also be obtained from cuts or injuries in the skin. Within a few weeks of exposure, lesions, or damaged regions in the skin start forming. The lesions then produce vesicles, which undergo necrosis to form a black eschar (a cluster of dry dead tissue) on the skin surrounded by purple vesicles and edema (Lowe, 2012). Another condition related to cutaneous anthrax is lymphangitis, which is the inflammation of lymphatic vessels. If left untreated with antibiotics, anthrax can cause conditions like hyponatremia (abnormally low sodium levels in the body), thrombocytopenia (lack in number of platelets, resulting in bleeding problems), septic shock, and eventually death (Lowe, 2012).

Gastrointestinal Anthrax

Gastrointestinal anthrax is often caused by the consumption of incompletely cooked or contaminated meat from diseased animals (Lowe, 2012). This type of anthrax can be further divided into two syndromes: abdominal and oropharyngeal anthrax. In abdominal anthrax, spores are deposited in the lower gastro-intestinal tract, causing lesions in the intestine, and the bacteria spreads from there (Lowe, 2012). Symptoms include abdominal pain, nausea, vomiting, bloody diarrhea, and others. A condition called ascites also develops, in which fluid collects in spaces in the abdomen. Also, massive blood loss, fluid imbalance, intestinal perforation (when a small hole in the intestine causes the contents to leak into the abdomen) and sepsis syndrome (in which the body doesn't respond properly to an infection) can cause mortality in the host. Oropharyngeal anthrax is less common and less severe than abdominal. In this case, lesions form in the middle part of the pharynx. Symptoms for this include fever, cervical edema, and respiratory difficulties.

The Impact of Mercury on Cellular Systems and Health

Mercury poisoning can affect several organ systems in the body, like the cardiological, pulmonary, neurological and several others. Mercury is recognized as an extremely toxic substance, and mercury poisoning has increased as the levels of mercury in the environment's soil, water and air have increased from processes like burning fossil fuels or volcanic eruptions (Ankrah). There have been over a thousand cases of mercury poisoning reported in 2022 in the US, and it is much more prevalent in other countries, especially among mining communities or seaside towns where food could become contaminated. Elemental mercury is used in various industries, such as thermometers, sphygmomanometers, electrical materials, and electrochemical operations (Rice, 2014). Occupational exposure, particularly in industries like mining and dentistry, can lead to mercury poisoning. Mercury can also be obtained by consuming fish from waters that have been methylated. Mercuric mercury compounds, resulting from mercury combining with chlorine, sulfur, or oxygen, include highly toxic substances like mercuric chloride and mercury fulminate (Azevedo, 2012). Some organomercury compounds were used as pesticides and antiseptics.

Different Forms of Mercury

Mercury exists in several forms of elemental, organic and inorganic compounds in the environment. Elemental mercury (HgO) in its liquid form poses low health risks as it is poorly absorbed in the body. However, in vapor form, it can be easily absorbed through the lungs and can pass through cell membranes, the blood-brain barrier, and placental barriers, reaching vital organs (Azevedo, 2012). In the bloodstream, mercury oxidizes and transforms into inorganic mercuric mercury (Hg++) and mercurous mercury (Hg+). Mercuric mercury in the bloodstream binds to various substances and accumulates in placenta and fetal tissues but does not efficiently cross the blood-brain barrier. Evidence suggests its transport via amino acid transporters and accumulation in the brain through binding to cysteine (Azevedo, 2012). Organic mercury compounds, also known as organometallic, form through a covalent bond between mercury and a carbon atom in an organic functional group like methyl, ethyl, or phenyl. Methylmercury (CH_3Hg^+) is the most common form absorbed by the body, primarily produced by microorganisms through the methylation of inorganic mercuric ions in soil and water (Azevedo, 2012).

The Systemic Effects of Mercury

At the cellular scale, mercury can cause changes in the permeability of the cellular membrane, changes in the molecular structures of macromolecules, and damage in the DNA. Mercury can also cause oxidative stress, where antioxidant levels in our body are low, and mitochondrial dysfunction, where the mitochondria malfunction and ATP synthesis decreases Additionally, the homeostasis of calcium in the cell is disrupted, and lipid peroxidation occurs, which in turn leads to membrane rupture and cell death (Cai, 2005). Therefore, understanding the consequences of mercury exposure remain crucial for protecting cellular cohesion and overall health.

Mercury can be inhaled and enter the circulatory system through the lungs. Elemental mercury vapor that is inhaled also deposits in large amounts in the brain. Methylmercury doesn't reach the brain as effectively, but significant amounts of it are still deposited in tissues throughout the body. Mercury salts mainly damage the lining of the intestinal tract and the kidneys. Many forms of mercury can slow down the production of enzymes that help in the digestive process like trypsin, chymotrypsin, and pepsin. Symptoms of mercury in the digestive system include abdominal pain, indigestion, and bloody diarrhea, among others. Mercury can also destroy microbes and bacteria that live in the intestines, which would cause undigested food particles to enter the bloodstream, which in turn would cause disruptions in immune reactions. Mercury poisoning causes a variety of kidney diseases, like renal cancer and chronic renal disease among several others. Mercury poisoning impairs immune system functioning by causing damage to polymorphonuclear white blood cells, hindering their ability to eliminate foreign substances. This makes the host more vulnerable to infections. People who are infected with mercury are also more likely to develop immune and autoimmune conditions like allergies, arthritis, eczema, epilepsy, and several others (Rice, 2014).

When mercury accumulates in the heart, it can lead to cardiomyopathy, angina (a type of chest pain because of less blood flow to the heart), and other types of heart disease. Mercury might also cause anemia as it can compete with iron molecules to bind with hemoglobin in the blood (Rice, 2014). According to some research, mercury might also be linked to forms of cancer such as leukemia and Hodgkin's disease. Mercury induces oxidative stress, generating free radicals and reducing antioxidant enzyme activity, increasing the risk of cardiovascular disease (Azevedo, 2012). Chronic inhalation of mercury can cause tremors, sleep disturbances etc. Several pulmonary conditions like bronchitis and pneumonia can also be caused by mercury poisoning.

The nervous system is the main target for mercury poisoning. One problem mercury causes in the nervous system is that it impairs the cellular detoxification process, which is vital in removing harmful chemicals from the body, so the cells either exist in chronic malnutrition or die off (Rice, 2014). Inorganic mercury can hinder the synthesis of some important components of a nerve cell structure, like tubulin and actin. Another significant impact of mercury is that it's known to increase reactive oxygen species in the body, which results in lipid peroxidation and apoptosis (Azevedo, 2014). Individuals who were exposed to mercury prenatally, the toxin can alter the cytoarchitecture, or the cellular composition of the central nervous system's tissues which was shown to damage motor and memory functioning following birth (Im, 2021) . Mercury can obstruct the organization of microtubules in the cytoskeleton and interfere with intracellular signaling (Azevedo, 2014). Studies have shown that the poison can cause many disturbances in intestinal peristalsis (the involuntary muscle movement in the digestive tract) by increasing activity of nitrergic nerves in the body (Bódi, 2019). Additionally, mercury can damage the barrier between blood and the brain and assist other toxic substances to enter and infect the brain. Some symptoms caused by mercury poisoning of the nervous system are depression, paranoia, hallucinations, memory loss and others. The toxin can also affect the

sensory nervous system, causing blindness, reduced sense of smell and motor and behavioral dysfunctions that are related to autism (Rice, 2014). In summary, mercury poisoning detrimentally affects several organ systems by impairing various processes, disrupting structural components of cells and inducing a wide array of symptoms.

Health Effects of Arsenic Exposure

Arsenic is a deadly toxin that can affect almost all organ systems in the body as a poison and as well as a carcinogen, or a compound that can cause cancer in organisms (Schrenk 2018). Arsenic is used in several industries, such as the manufacturing of paints, cosmetics, and agriculture pesticides. An estimated 140 million people in at least 70 countries have been drinking water containing arsenic at levels above the WHO provisional guideline value of 10 µg/L. Like anthrax, arsenic is also commonly used as a weapon for murder and bioterrorism, as several arsenic compounds look similar to white sugar. Since ancient Greek times, arsenic was also for healing purposes, and the long-term usage of it caused many diseases as people continued to poison themselves thinking of it as medicine. In recent times, arsenic is also used reduce the symptoms of leukemia in patients because of its ability to cause apoptosis, or the process of organized death of cancer cells in the patients. The toxin does this by releasing an apoptosis-inducing factor (AIF) from the mitochondrial intermembrane space to the nucleus of the cell. There, it executes apoptosis by breaking and separating the DNA and condensing the chromatins, which eventually leads to the cell dying off. Arsenic is also used in many Asian traditional medicines, but overall arsenic is more commonly used as a toxin rather than for helpful medicinal intentions.

Routes of Arsenic Exposure

Just like anthrax, people can get infected by arsenic through inhalation, ingestion, and absorption through skin. The most common cause of arsenic exposure is from ingesting contaminated water, but arsenic is also commonly ingested through solid foods like seafood and algae. Arsenic compounds can also enter the plant food chain from agricultural pesticides and other products. Most of the arsenic that enters the body is absorbed through the small intestine, because the pH in that area is optimal for arsenic absorption. The poison molecules then go through a process called hepatic biomethylation, after which they form acids called monomethylarsonic acid and dimethylarsinic acid. After arsenic enters the body, it can result in either acute or chronic poisoning depending on the degree of its effects on the body.
Arsenic is found mainly in two forms of compounds – arsenite (As III) and arsenate (As V). Arsenite is about 60 times more poisonous than arsenate. When arsenic infects the cell, it deactivates up to 200 enzymes that are involved in DNA replication and repair processes. It also disrupts cellular energy pathways by taking the place of Phosphorus in energy compounds like ATP. Additionally, arsenic also causes lipid peroxidation and DNA damage. These are only some instances of how it affects functioning of the body at the cellular level, and which will be presented in further higher detail in the upcoming sections.

Acute Arsenic poisoning

During acute arsenic poisoning, the arsenic is mostly concentrated in the liver and the kidneys. The poisonous acid can cause acidosis, or the buildup of excess acid in body fluids. When less than 5 mg of arsenic is ingested, it is usually excreted from the body within a day (Ratnaike, 2003). The patient would face symptoms like vomiting and diarrhea, but no treatment is necessary. In the deadliest cases of acute poisoning anywhere from 100-300 mg of arsenic is absorbed. In this case, depending on how much was consumed, the patient can die in one to four days, usually because of extreme dehydration, reduced blood volume and consequently circulatory collapse. More severe symptoms would be experienced such as nausea, abdominal pain, acute psychosis, cardiomyopathy, seizures, and others. Several conditions in the body like hepatic steatosis (fatty liver disease) and inflammation of the gastrointestinal tract have been reported (Ratnaike, 2003). Many abnormal blood conditions also occur from poisoning, like hemoglobinuria (blood in urine), intravascular coagulation (abnormal blood clotting in blood vessels) and bone marrow depression (when the bone marrow doesn't produce enough blood cells) among others. Respiratory failure and renal failures are also frequent symptoms. Relating to the nervous system, the most common symptom is peripheral neuropathy, where the nerves in the peripheral nervous system are damaged. Encephalopathy, or any form of brain damage and dysfunction, is also a frequent result of arsenic poisoning (Ratnaike, 2003).

Chronic arsenic poisoning

When a person is exposed to arsenic for long periods of time, it can cause disease and even cancerous tumors as the toxin accumulates in the heart, lungs, muscles, and several other organs. Some of the initial signs of arsenic poisoning are changes in the skin like hyperpigmentation (darkening of certain spots in the skin, characteristically in a raindrop shape for arsenic poisoning) and keratosis (rough patches on patches on skin). As mentioned, arsenic is associated with several types of cancer and malignancies in several organs. Though the mechanism of action that results in cancer is not complete, arsenic might be involved in disrupting DNA repair, DNA methylation, and/or cause abnormalities in the structure of chromosomes in the cell. Arsenic is known to disrupt various pathways in the cell like ones involved in cell migration, cell adhesion, cell survival and others (Singh, 2011). In serious conditions, chronic arsenic exposure can cause a form of cancer known as Bowen's disease, which is cancer in the squamous cells in the epidermis of the cell (Ratnaike, 2003). It also promotes other types of skin cancer by acting with sunlight, blocking DNA repair, and dysregulating cell cycle control and DNA methylation. Arsenic can act as a tumor-promoter and helps tumors grow larger by changing the expression of genes involved in cell growth and resulting in rapid reproduction of cells (Singh, 2011). Moreover, it acts as a teratogen, which means that it can cause fetal abnormalities when high levels are consumed in pregnancy.

Impacts of Arsenic on the Cell

Within the cell membrane of vascular endothelial cells and smooth muscle cells, arsenic triggers the enzyme NADPH (nicotinamide adenine dinucleotide phosphate) to increase the production of reactive oxygen species (known as ROS) like superoxides and hydrogen peroxide. These ROS can bind with nitric oxide to form peroxynitrite, which is known to cause several cellular symptoms like modulations of cell signaling and necrosis/apoptosis. Arsenic activates the expression of genes related to atherosclerosis (inflammatory diseases characterized by thickening or hardening of arteries), like HO-1, MCP-1 and IL-6. It also does this by increasing the synthesis of inflammatory mediators (molecules part of the immune response that induce inflammation), an example of which is leukotriene E4. Additionally, arsenic stimulates the protein kinase C alpha, which after many chemical reactions leads to increased permeability of the endothelium (Singh, 2011). Arsenic causes vascular endothelial dysfunction and many other cardiac issues by lessening the activity of endothelial nitric oxide (eNOS) which plays a critical role in regulating and maintaining a healthy cardiovascular system (Tran, 2022). Moreover, arsenic brings about vasoconstriction, or the narrowing of blood vessels, which results in elevated blood pressure and ventricular arrhythmias. Arsenic poisoning is also linked to cardiomyopathy and ischemic heart disease (weakened heart due to reduced blood flow). A peripheral vascular disease (where blood flow is reduced to peripheral system) called Blackfoot disease is a unique condition caused exclusively by arsenic poisoning (Singh, 2011).

High concentrations of arsenic can induce type II diabetes in the individual by reducing the expression of a protein called PPAR-γ, which reduces the responsiveness of insulin in the body (Singh, 2011). Arsenic interrupts the production of glucose and restricts the ATP-dependent insulin secretion by replacing a phosphate group from ATP and instead forms ADP-arsenate. Arsenic also binds with disulfide groups of insulin, insulin receptors and enzymes involved in glucose metabolism. Furthermore, high levels of arsenic can cause hypoglycemia, as it decreases the activity of the protein glucose-6-phosphatase in the liver and kidneys. Arsenic diminishes the expression of insulin mRNA, the gene that encodes insulin, and increases the expression of several stress mediators like NF-κB (Singh, 2011). Arsenic can cause hyperglycemia too, by slowing down insulin-dependent glucose uptake. The main targets of arsenic in the body are the liver and the kidneys. In chronic poisoning, the symptoms of diarrhea and vomiting are worsened, along with a condition called hepatomegaly, where the liver is enlarged beyond its normal size. Arsenic can cause acute tubular necrosis in the kidneys, where the tubule cells are damaged. As mentioned above, when arsenic increases the production of ROS, the toxin increases lipid peroxidation and cellular damage in renal and hepatic (liver) tissues, in addition to prompting apoptosis in them by increasing pro-apoptotic proteins in the organs. Furthermore, arsenic induces hepatotoxicity by upregulating various enzymes in the liver (Singh, 2011).

Neurotoxic effects

For many poisons, the nervous system is the main target, and arsenic causes several effects in it such as Parkinson's Disease, peripheral neuropathy, cognitive impairment, memory loss, and changes in behavior (Singh, 2011). Cerebrovascular disease, where blood flow to the

brain is reduced, and cerebral infarction, another name for a type of stroke, are also associated with arsenic toxicity (Ratnaike, 2003). The poison can also bring about apoptosis in the cerebral neuron cells and DNA damage in the brain. Arsenic can cross the blood-brain barrier freely, and it also affects the nervous system by increasing reactive oxygen species, decreasing superoxide dismutase (an enzyme that catalyzes many chemical reactions in the cell), and decreasing glutathione levels (a molecules that's involved in tissue repair, protein synthesis and other functions in the body). Arsenic also causes changes in the functioning of neurotransmitters like monoamines, acetylcholine, and glutamate. Arsenic can cause axonal degeneration, or the loss of communication between neurons, by destabilizing the framework of the cytoskeleton. (Wang, 2009). That causes thiamine deficiency in the body, which leads to encephalopathy and other neuronal problems. Arsenic inhibits the NMDA receptors in the hippocampus of the brain, which detect neurotransmitters and plays a crucial role in learning and memory (Singh, 2011). Ultimately, this results in cognitive dysfunction and neurobehavioral diseases.

Sources of Lead Exposure

Lead is an important and essential metal that has been used since ancient times for various purposes such as in food production, plumbing systems, battery manufacturing, fuel and in many more industries (de Souza, 2018). Despite a decline in its use, it remains a serious public health concern, particularly in developing countries. It is one of the most prevailing poisons in today's world, as an estimated one million people a year die from lead poisoning. Lead compounds primarily enter the body through the respiratory and gastrointestinal tracts, with respiratory absorption being more effective. Additionally, lead can also be absorbed through the skin, particularly in the form of hydrophobic organic compounds like tetraethyl lead, a compound consisting of four ethyl groups bound to a central lead atom. In the bloodstream, about 90% of the lead compounds bind with red blood cells and interact with plasma and many proteins containing thiol and sulfhydryl (de Souza, 2018). Notably, bones and teeth can store lead, and its release into the bloodstream can occur from processes like bone remodeling. Hormonal changes like lactation and pregnancy can stimulate lead mobilization in the body, which increases lead exposure to the fetus, which in turn can impair its growth and development. (de Souza, 2018) Lead also tends to accumulate in soft tissues, particularly the liver, kidneys, and the brain. Lead can cross the blood-brain barrier through protein channels that transport ions to brain tissues, though the endothelial cells of the choroid plexus of the brain fight the lead molecules to protect the brain from them. Lead poisoning has a wide array of symptoms, as it affects the nervous, cardiovascular, immune, skeletal, reproduction, renal and other systems by interacting with various chemicals and proteins and disrupting metabolic pathways in the cell.

Lead's Impact on Cellular Pathways

There are 23 proteins that bind to lead, and they are categorized into 3 types: stimulation (when lead increases protein activity), inhibition (when lead decreases the protein activity), and binding (where the lead's effect on the protein's function hasn't been observed yet). These

proteins are an integral part of several cellular pathways, and the interference of lead affects them in many ways, like it can cause anemia and disrupt cell homeostasis in blood cells. A protein called d-aminolevulinic acid dehydratase (ALAD) is one of the main targets of lead, and it helps in forming d-aminolevulinic acid (ALA), which is a crucial component in the heme synthesis pathway. ALAD also acts in the process of protein degradation and interacts with proteasome complexes, and the presence of lead strongly slows down all these major processes and increases the acid level in blood. Another protein that is inhibited by lead is Pyrimidine 50-nucleotidase, which results in the disruption of RNA catabolism and the accumulation of a large amount of RNA in red blood cells. Lead is also known to cause oxidative stress and lipid peroxidation in cells, which brings about serious mutations in the DNA, and eventually apoptosis (de Souza, 2018).

Lead often replaces metals like zinc or calcium in some cellular processes, and this can either hyperactivate or deactivate the function of proteins. Scientists have hypothesized that the way lead crosses the blood brain barrier is by pretending to be calcium. Additionally, lead replacing calcium can damage many pathways containing calmulodin, a calcium-binding protein that is an integral part of metabolic functions like intracellular movement, muscle contraction, nerve growth, immune response, and several others. Lead also impairs the function of another protein called cyclic adenosine monophosphate, or cAMP, which leads to neurotoxic effects as it impairs neurotransmitter release and axonal growth in nerves (de Souza, 2018). When lead ions in the cytosol of the cell reach the nucleus, they affect many nucleic proteins, like apyrimidinic endonuclease 1 (APE1), a major protein involved in DNA repair, and many others (de Souza, 2018). Overall, lead can diminish the transcription of genes involved in the immune system, neurodevelopment, and xenobiotic metabolism (the elimination of useless compounds from the body) .

Many proteins in the body act as chelators, which are compounds that form complexes with metal ions (Johnson 2010) and prevent the toxic effects of metals like lead. Metallothionein is an example of a chelator, as it binds lead ions in the cell and acts as a biomarker for lead poisoning, which means that it shows what is happening in the cell at a given moment. Additionally, when metallothionein is present in the placenta (the organ in which the fetus develops), it can prevent lead from entering it and affecting the fetus. Other chelator proteins include thymosin b4 and a2l-microglobulin. In the kidneys and glial cells of the body, lead often forms structures called inclusion bodies, which are large aggregates of lead molecules and cellular proteins (de Souza, 2018). These inclusion bodies are first formed in the cytoplasm and can then move to the nucleus of the cell. It is suggested that these inclusion bodies can protect the cellular structures from the poison, as they sequester or isolate the lead molecules in the cell. An example of this type of protein is GRP78 (78 kDa glucose-regulated protein). The protein is found in the endoplasmic reticulum, and along with being a binding site for lead, GRP78 performs other functions such as ensuring the correct folding of new proteins and maintaining calcium levels in the cell (de Souza, 2018). These types of interactions with lead and certain

proteins still need to be researched and understood better, because the studies as of now aren't completely conclusive.

Clinical manifestations of lead poisoning

The most studied effect of lead in the body is its chronic and acute damage on the nervous system. When the nervous system is infected with poisons like lead in its early developing stages, it is the most vulnerable to permanent damage for the rest of the individual's life. It can cause severe cognitive diseases and deficiencies in spatial and learning and memory pathways. When an individual is infected by lead in later years of life, it can cause neurodegenerative diseases like Parkinsons's and Alzheimer's (de Souza, 2018).
Predominantly, the symptoms of lead poisoning are associated with the central nervous system, causing dullness, irritation, and poor attention. The damage in the blood-brain barrier can result in conditions like cerebral edema and hemorrhages in the brain. (de Souza, 2018). When the individual is exposed to lead prenatally as a fetus, their brain-blood barrier is significantly more ineffective in protecting the nervous system during development. Some severe symptoms include seizures, paralysis, and coma. High levels of lead exposure can also cause kidney diseases like chronic nephritis and nephropathy, which is characterized by the failure of the functioning of the kidneys (de Souza, 2018). Another effect of prenatal lead exposure is the impairment of the axial skeleton. Also, when lead accumulates in the bone marrow it can hinder heme synthesis (heme is a compound that is a key part of hemoglobin).
There have been experiments conducted on how a compound of lead, lead (II) acetate, stimulates and increases the production signaling proteins like Interleukin 8, Macrophage Inflammatory Protein-1 Alpha, , Monocyte Chemoattractant Protein-1 and others from PMBC, (peripheral blood mononuclear cells, which are a major part of the immune system). This can considerably alter DNA transcription processes, which in turn can affect the expression of several cellular metabolic enzymes and chelator proteins. The changes in expression of genes can be used as biomarkers to assess lead exposure effects. Research shows that even blood lead levels lower than 10 μg/dL (the CDC recommended concern level) can cause cognitive dysfunction, neurobehavioral disorders and renal impairment (Gillis, 2012). Overall, high levels of lead concentration in the bloodstream can lead to several changes in gene expression and cellular responses.

Conclusion

In conclusion, this paper explores the complex details of the cellular effects and health implications of common toxins such as anthrax, mercury, arsenic, and lead to protect public health and advance the knowledge of problems of poison exposure. The research includes the various modes of entry of each of the toxin into the body, the specific organs they target, and the important cellular pathways that they disrupt. Each poison poses distinct challenges to the overall health and well-being of the human affected. While there was a lot of valuable information available for the cellular mechanisms of actions of some poisons, the research was still limited in

the way that there wasn't a large amount of information available for some other poisons. Additionally, many hypotheses are not completely concluded yet. Despite these limitations, the significance of this study is its contribution to the broader understanding of poisons' impact on human health. The detailed analysis of anthrax, mercury, arsenic, and lead enhance awareness among the public. This knowledge can serve as a foundation for development for preventive measures, treatment strategies and environmental regulations to reduce the risks associated with these poisons.

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The Technological Beacon: Illuminating the Path to Social Anxiety's Respite Fanxiu By Sophie Qiu

Background

Social anxiety disorder (SAD) is a fear of social situations with potential embarrassment, often disproportionate to the actual threat (Segal). Research based on large-scale surveys has shown that as much as 33.7% of individuals experience anxiety disorders at some point in their lives (Bandelow and Michaelis). In the US, 15 million adults are affected by SAD (Facts & Statistics: Anxiety and Depression Association of America, ADAA), the most common psychiatric disorder with a lifetime prevalence rate of up to 16% in the general public (Hidalgo et al.). Unfortunately, general practitioners often struggle to recognize SAD (Ehlers et al.), making it challenging for individuals to get the help they need (Pilling et al.). While there are treatment options, many people face significant obstacles when seeking help, such as a shortage of available providers and resources, long wait times, and financial constraints (O'Brien et al.). However, technological advancements have led to more accessible and convenient tools to support individuals dealing with SAD.

SAD causes intense anxiety in social situations due to the fear of rejection or humiliation, and symptoms include sweating, confusion, dizziness, heart palpitations, and potentially panic attacks in social situations (White Swan Foundation). This condition can lead to avoidance of social encounters and disruption in daily life, with fewer friends and difficulty maintaining relationships (Whisman et al.). It may also lead to dropping out of school and lower academic performance (Van Ameringen et al.). Individuals who suffer from SAD tend to have reduced marriage rates, elevated divorce rates, and fewer offspring (Wittchen et al.). Moreover, despite being employed, they may take more sick days and experience decreased productivity due to their symptoms (Stein et al.).

Currently available treatment

Two types of psychological treatments are available for individuals with SAD: in vivo exposure and social skills training (National Collaborating Centre for Mental Health (UK)). Both approaches aim to build confidence in navigating social situations. In vivo exposure involves gradually confronting feared situations, while social skills training involves non-verbal and verbal communication strategies. Another type of treatment involves pharmacological interventions, and the medications fall into four classes: Selective serotonin reuptake inhibitors, Serotonin and norepinephrine reuptake inhibitors, noradrenaline and selective serotonin antagonists, and Monoamine oxidase inhibitors (National Collaborating Centre for Mental Health (UK)).

Advanced technology is now available to help treat SAD, providing more accessible, feasible, and convenient approaches for patients. The Challenger app and virtual reality exposure (VRE) therapy are examples of such advancements.

Virtual Reality Exposure Therapy

An evidence-based, technologically advanced virtual reality exposure (VRE) therapy (ScienceDirect) has been developed for treating SAD (Sherrill et al.). Virtual reality allows for a fully immersive encounter that engages multiple senses, such as sight, sound, touch and smell. VRE therapy involves an experienced therapist guiding the individual through a simulation, gradually reducing their anxiety or fear until they can tolerate it without avoidance. Specifically, the therapist monitors patient-simulation interactions to ensure therapeutic exposure. The therapist begins by creating a plan that is derived based on the patient's past experiences with particular stimuli and how they typically react when faced with anxiety-inducing situations. The virtual environments then allow patients to confront specific stimuli in a controlled environment without avoiding them. The therapist achieves this by utilizing realistic responses from the virtual audience, such as laughter that follows an impromptu joke from the patient.

VRE has the potential to become more feasible and precise than traditional exposure therapy (ScienceDirect). First, increasing feasibility is apparent throughout VRE therapy. For example, instead of hosting a large event to expose one patient to counter his or her fear of crowds, VRE allows multiple patients to be treated with the same settings in the therapist's office. VRE systems also offer various contexts that enhance the transferability of what is learned during therapy sessions. Unfortunately, there has been evidence that even after receiving adequate treatment, patients could still encounter fear responses (Horigome et al.). VRE systems offer various scenarios for therapy with minimal effort. For fear of public speaking, scenarios can include speaking at a party, on stage, in a classroom, or in a company's meeting room. In addition, precision is the goal of VRE systems when targeting exposure stimuli. The VRE therapist is entirely responsible for when, what, and how incentives are presented, creating a unique experience that suits the patient's learning needs. For instance, when treating anxiety associated with interaction with the audience during a speech, the therapist can control the time interval in which a question is raised.

Challenger App

Even though SAD is a common psychiatric disorder, only 50% of those affected seek medical help even after struggling for 16 years (Wang et al.). Additionally, only 3.4% reach out for assistance during the first year of onset (Blackburn and Goetter). Online interventions can improve access to evidence-based mental health care and reduce prevalence of SAD.

Mental health apps for smartphones makes treatment more accessible to patients (Bhatty et al.). Specifically, online cognitive behavioral therapy for anxiety is just as effective as face-to-face treatment in reducing symptoms and improving anxiety (Olthuis et al.). The smartphones are consistently connected to the internet, and their built-in sensors enable them to collect location and other data (Chen et al.). The use of text-based bibliotherapy has the potential to be easily adapted into other languages, offering a means of introducing mental health services to new populations (Andersson et al.).

The following outlines a novel mobile app called the "Challenger," which was developed by the Department of Psychology at Stockholm University (Miloff et al.). Setting up a Challenger App on an iPhone is simple and free. The app's purpose is to assist users in overcoming social anxiety by providing them with progressively more challenging interactions with their social situations. The app has advanced features, including real-time location tracking and anonymous socializing. Challenger App's game board has an implicit objective of moving from one end to the other. Users select an avatar, and each step indicates a personal achievement, like giving a speech at school. The "Add a Reward" box at the end of the game board lets users choose personalized rewards, like buying a box of chocolate. Games are effective for learning purposes, according to Prensky (Prensky). He stated that games provide enjoyment, intense involvement, structure, motivation, interactivity, outcomes and feedback, ego gratification, adrenaline, creativity, social interaction, and emotion. In the field of psychotherapy, it is believed that patients who pursue goals for their own personal enjoyment and fulfillment rather than because of external pressure from others tend to have more successful therapy sessions (Michalak et al.). The Challenger App offers the development of 27 skills, including personal, social and physical. Setting goals with awareness can facilitate the achievement of these skills (Kolb and Boyatzis). Specifically, goal-oriented self-directed behavior change exercises increase success rates by 17% (Kolb et al.).

Conclusion

At last, SAD is a prevalent mental health issue that severely impacts people's lives. Fortunately, advanced technologies are available to assist these individuals in managing their symptoms and lead satisfying lives because new treatment options are more accessible, feasible, and have similar effects to face-to-face therapies.

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False Hope: The 1969 Canadian White Paper and Canada's Statement on Indigenous Policy By Emily Fan

Abstract

The publication of the 1969 White Paper in Canada was one of the most crucial moments in the global Indigenous rights movements in the 1960s, marked by the poignant conflicts between indigenous communities and the federal government. This essay traces the history of the 1969 White Paper since its release, showing the social, historical and economic plight of the Canadian Indigenous communities as well as the mechanism behind the policy-making process of the Pierre Trudeau government, which aimed to "solve" the indigenous issue by erasing both the "Indian status" and in turn the colonial legacy through the paper. Through detailed analysis of the publications and statements, such as *The Unjust Society* and *Citizens Plus*, written by Indigenous members in response to the controversial 1969 White Paper, this essay inquires how the federal government should have dealt with both the treatment of the Indigenous and the ongoing colonial legacy. The end of the essay shows those previously forgotten voices in the history of Indigenous rights movements, such as the efforts of local governments and indigenous leaders as well as concludes with the effects felt today.

Introduction

From the 1960s to the 1970s, Canadian Indigenous experienced massive cultural evolution. In a decade of mass revolt and demonstration, the decade would serve as a crux for future indigenous policy. The publication of the 1969 White Paper and the essays written in response would lead to the zenith of unrest. In 1969, Prime Minister Pierre Elliot Trudeau published the "Statement of the Government of Canada on Indian Policy," more famously known as the White Paper, officially abolishing "Indian status" for all of Canada, creating a highly controversial and arguably assimilationist policy.[35] Looking at evidence from the Hawthorne Report, the Red Paper, and *The Unjust Society*, it is clear that the policy presented in the White Paper was not purely the product of a singular person, but a mistake resulting from the ideal ingrained in the Trudeau administration, a product of decades of apathy.

Background

The indigenous of Canada were the first people of the land. Living in small communities with centralized powers, multiple sovereign nations made up Canada. This included the Athapaskan-speaking peoples, Slavey, Tłįchǫ, Tutchone-speaking peoples, and Tlingit in the northwest, the Haida, Tsimshian, Salish, Kwakiutl, Nuu-chah-nulth, Nisga'a and Gitxsan in the pacific, the Blackfoot, Kainai, Sarcee and Northern Peigan in the plains, Cree and Chipewyan in the northern woodlands, the Anishinaabe, Algonquin, Iroquois and Wyandot around the Great

[35] James Rodger Miller, *Skyscrapers Hide the Heavens : A History of Indian-White Relations in Canada* (Toronto: University of Toronto Press, 2000), 270-275.

Lakes, and the Beothuk, Maliseet, Innu, Abenaki and Mi'kmaq lining the Atlantic.[36] When the settlers came to Canada, their relationship started peacefully, before eventually souring.

Although in the beginning the indigenous outnumbered the Europeans, eventually due to diseases like tuberculosis and smallpox[37], the balance of power shifted as many were wiped out.[38] This shifting of population led to a change in how treaties were approached. In the beginning, treaties were used to establish friendship, famously the negotiation of Peace and Friendship Treaties with the Mi'kmaq, Maliseet (current Wolastoqiyik) and Passamaquoddy recognizing their sovereignty and right to the land.[39] This was because the economy at the time was reliant on the fur trade, something that groups such as the Huron-Wendat, Algonquin and Innu specialized in.[40] In 1763, fearing conflict due to settlers encroaching on native land, the British Crown released the Royal Proclamation, a foundational document that recognized the sovereignty, land rights, and culture of the various indigenous nations.[41] According to Haida Leader Miles Richardson, the Royal Proclamation guaranteed that "without a nation-to-nation treaty, the Indigenous Peoples would not be disturbed in their authorities and [in] the places that they called home for thousands of years, for hundreds of generations", guaranteeing their way of life.[42]

As the economy shifted from fur to agriculture, the Crown's reliance on the indigenous nations dwindled. Knowing this, they began to expand westward. The Europeans viewed the land through the idea of "*terra nullius*," that nobody had discovered it yet. Although the land already had inhabitants, the British and the French believed that the land was "discovered" and could therefore be individually owned.[43] The fundamental belief was that the indigenous were not "civilized" because they did not adhere to the ideals of Europe, therefore invalidating their ownership of the land.[44] This expansion would begin the era of the numbered treaties, eleven documents signed between 1871 and 1921 that would include land in Northern Ontario, Manitoba, Saskatchewan, Alberta, and parts of Yukon, the Northwest Territories and British Columbia.[45] Using the Royal Proclamation as a basis, these treaties were used to gain land rather than friendship.[46] The treaties were signed with an opportunistic mindset, only being discussed when the federal government either needed something or would benefit. These agreements transferred the land to the British Crown in exchange for guaranteeing the indigenous their way of life.[47] In some regions, this also meant the promise of specific rights such as the coverage of

[36] Crown-Indigenous Relations and Northern Affairs Canada, "First Nations in Canada," *Government of Canada*, published May 2, 2017, https://www.rcaanc-cirnac.gc.ca/eng/1307460755710/1536862806124 (accessed January 28, 2024).
[37] Cole Harris, *A Bounded Land : Reflections on Settler Colonialism in Canada* (Vancouver : UBC Press 2020), 35-36.
[38] Lillian Eva Dyck and Scott Tannas, *How Did We Get Here? : A Concise, Unvarnished Account of the History of the Relationship between Indigenous Peoples and Canada* (Ottawa: Standing Senate Committee on Aboriginal Peoples, 2019), 14.
[39] Dyck and Tannas, *How Did We Get Here?* ,13.
[40] John E. Foster and William John Eccles, "Fur Trade in Canada," *The Canadian Encyclopedia*, published July 23, 2013, https://www.thecanadianencyclopedia.ca/en/article/fur-trade#:~:text=The%20fur%20trade%20was%20a%20vast%20commercial%20enterprise,to%20satisfy%20the%20European%20demand%20for%20felt%20hats (accessed January 24, 2024).
[41] Dyck and Tannas, *How Did We Get Here?* ,13.
[42] Ibid., 13.
[43] Ibid.,10.
[44] Ibid.,10.
[45] Michelle Filice, "Numbered Treaties," *The Canadian Encyclopedia*, published August 02, 2016, https://www.thecanadianencyclopedia.ca/en/article/numbered-treaties (accessed January 24, 2024).
[46] Dyck and Tannas, *How Did We Get Here?* ,13.
[47] Ibid., 15.

healthcare, found in Treaty 6.[48] As the land and situation were changing, many indigenous tribes, especially those in the prairies, had to adapt as their traditional ways of life were dying out. Food sources and money became scarce, with some First Nations such as Moosomin, Thunderchild and Little Pine negotiating treaties for their people's survival.[49]

Many would end up viewing treaties as a betrayal by the British government to the indigenous people. In his book *The Unjust Society* (1969), Cree leader and activist Harold Cardinal deems it as the 'Great Swindle,' stating that "their [the ones who signed] gravest mistake was to give the white man the benefit of the doubt and attribute to him the same high principles. He didn't have them. He, the white man, talked one way, and wrote another," showing the bitterness held from the situation. [50] Although values like "peace, friendship and understanding" were expected from the treaties, it was not upheld on both sides.[51] Since the indigenous people of Canada relied on oral traditions, many used interpreters to write their promises, leading to the treaties omitting many verbal commitments.[52] The treaties acted as a symbol of a lie, acting as an easy vehicle to strip indigenous people of their rights and lands. Traditionally, the idea of ceding or surrendering did not exist in many indigenous cultures, with nations like the Cree instead writing their laws to share the land.[53] Without the precedent of extinguishment, the indigenous leaders signed the treaties under the assumption that the land would be shared.[54] The dissonance between how Western powers and the indigenous peoples of Canada viewed treaties became a main point of conflict, as promises made were not kept. This distrust would create the foundation for the modern relationship between the government and the indigenous, tainted by broken agreements.

Indian Act

The *Indian Act* was what defined the Indigenous peoples of the 1960s, trading freedoms such as culture and governance for the guarantee of their treaty rights. Established in 1876, the Indian Act was used to determine Indian status among First Nations people.[55] Starting with the *Gradual Civilization Act* of 1756,[56] a series of acts were created to encourage enfranchisement among the First Nations population, an act that voluntarily terminated Indian status to gain full Canadian Citizenship.[57] The goal of Indian Status was eventual enfranchisement, as although it guaranteed the rights of the treaties to those that fell under the *Indian Act,* it also prevented someone with the status from exercising the full rights of a Canadian citizen.[58] As an extension

[48] Harold Cardinal, *The Unjust Society:The Tragedy of Canada's Indians* (Vancouver: Douglas & McIntyre,1999), 29.
[49] Dyck and Tannas, *How Did We Get Here?* ,15.
[50] Cardinal, *The Unjust Society*, 33.
[51] Ibid., 16.
[52] Ibid., 16.
[53] Ibid., 16.
[54] Ibid., 16.
[55] Ibid.,16.
[56] Erin Hanson, "The Indian Act," *Indigenous Foundations*, https://indigenousfoundations.arts.ubc.ca/the_indian_act/#potlatch (accessed January 24,2024).
[57] Karrmen Crey, "Enfranchisement," *Indigenous Foundations*, https://indigenousfoundations.arts.ubc.ca/enfranchisement/#:~:text=Enfranchisement%20is%20a%20legal%20process,assimilation%20policies%20regarding%20Aboriginal%20peoples (accessed January 24,2024).
[58] Hanson,"The Indian Act."

of the assimilationist agenda of the Canadian government, the *Indian Act* sought to remove indigenous people as a whole, banning them from practicing their traditions and customs.[59]

In the 1960s, the *Indian Act* restricted the ability of Indigenous people to make decisions in their daily lives, instead giving power to the Superintendent General of Indian Affairs .[60] This meant that the superintendent would be able to control crucial aspects of First Nations peoples' livelihoods, from loans and benefits to band council (local government) leadership.[61] This is seen most evidently in the Potlach Law, in which jail time would be given to those who practice traditional ceremonies like potlatches, sun dances, and more.[62] This law became extremely damaging, especially to communities located in the West, as they acted as both a ceremonial and economic role in the community, redistributing wealth amongst the population.[63]

Besides dictating who would be given Indian status, the *Indian Act* also determined the rights given, including the transfer of Indian Status through generations.[64] Although currently, the three groups recognized are the First Nations, the Inuit, and the Métis, the *Indian Act* only extended Indian status to the first. While the Inuit were not included in the *Indian Act* because their homeland in the North joined Canada after the *Indian Act* was written, the Métis were excluded because of their status as "half-breeds", part First Nations and part European.[65] While not all children born of First Nations and European parents were considered Métis, the policy was used to stop the transmission of their unique culture across generations. This was also reflected in the policy applying to First Nation women, who would be stripped of their Indian status if they were to marry someone non-indigenous, depriving their children of it as well.[66] This meant that indigenous women who married non-indigenous men would end up giving up their lives and culture, never to return to the reserve again.

Although the *Indian Act* was a problematic piece of legislation, its importance could not be understated. The *Indian Act* legally recognized the relationship between the government and the First Nations.[67] Cree Activist and lawyer Harold Cardinal described the situation by stating "No just society and no society with even pretensions to being just can long tolerate such a piece of legislation, but we would rather continue to live in bondage under the inequitable *Indian Act* than surrender our sacred rights", explaining that even if the *Indian Act* was discriminatory, it still provided an important purpose.[68] The *Indian Act* and Indian status are crucial as they recognize the treaty promises and the history behind the relationship between the First Nations and the Crown.

THE TRUDEAU-CHRÉTIEN ADMINISTRATION

[59] Ibid.
[60] Ibid.
[61] Ibid.
[62] Ibid.
[63] Ibid.
[64] Mary-Ellen Kelmand and Keith Douglas Smith, *Talking Back to the Indian Act : Critical Reading in Settler Colonial Histories* (Toronto : University of Toronto Press,2018), 2.
[65] Alan Cairns, *Citizens Plus: Aboriginal Peoples and the Canadian State* (Vancouver: UBC Press,2000), 21.
[66] Kelmand and Smith, *Talking Back to the Indian Act*, 2.
[67]Hanson,"The Indian Act."
[68] Ibid.

The 1960s and 1970s acted as a crucial turning point for Canadian politics, especially regarding policy surrounding minorities. Set in the backdrop of the Quebec Quiet Revolution, the Trudeau government took a more active role in Indigenous issues. Born in the province of Quebec, the Francophone lawyer and Prime Minister Pierre Elliot Trudeau rose to prominence as a vocal leader in the Quiet Revolution, a period in which the province rapidly developed both economically and culturally, marked by increasing nationalism among the Francophone Quebecois.[69] Recruited by Prime Minister Lester B. Pearson to encourage Francophone participation, Trudeau worked under the Liberal Party of Canada as a minister and later rose to lead the nation.[70] Appointing the young Quebecois politicians Jean Chrétien and Robert Andras into his cabinet, together they worked on indigenous policy.[71] As the head of Indian Affairs and Northern Development, the department that historically dealt with the Indian Act, future Prime Minister and lawyer Jean Chrétien became the spokesperson for Trudeau's indigenous policy.[72] Being a part of the Quiet Revolution helped to influence their policies, especially regarding the cultural minorities of the country, as Trudeau had a distaste for the "special status" given to both. Trudeau believed that excessive nationalism would lead to ethnocentrism, destabilizing the nation.[73] Instead of giving special privileges to the indigenous, Trudeau believed that like the economy, cultures could only survive and remain by being in competition with each other, fostering a need to maintain practices in order to come out on top.[74] As a result, the Trudeau-Chrétien administration became more involved in indigenous issues compared to the cabinets beforehand.

The Hawthorn Report

In 1963[75], Minister Richard Bell, pressured by both indigenous activists and the Imperial Order of the Daughters of the Empire (IODE), launched a three-year inquiry into the investigate the status of the First Nations and gather feedback from communities.[76] Written by Harry B. Hawthorn, the Hawthorn Report was commissioned as a way to get feedback from communities and appease First Nations leaders.[77] Harry Hawthorn was a New Zealand-born anthropologist and leader in University of British Columbia's anthropology department, hired because of his

[69]Gilles Labrie, "Quebec's Quiet Revolution in Jacques Poulin's Les Grandes Marées," *The French Review* 79, no. 5 (2006): 1037–1038.
[70] Durocher, René. "Quiet Revolution." *The Canadian Encyclopedia*, Article published July 30, 2013. https://www.thecanadianencyclopedia.ca/en/article/quiet-revolution (accessed January 24,2024).
[71] Cardinal, *The Unjust Society*, 101.
[72]Terence McKenna, Michelle Gagnon, Andre Thiel and Lance Neveu, *Life and Times Jean Chretien* (Toronto: CBC Documentary Unit, 2003).
[73]Sally M. Weaver, "Summer: The Season for Strategy," in *Making Canadian Indian Policy* (Toronto: University of Toronto Press, 2019), 53–56. https://doi.org/10.3138/9781487584849-004.
[74] Ibid., 53–56.
[75] Rose Charlie, "The White Paper 1969," *Indigenous Foundations*, https://indigenousfoundations.arts.ubc.ca/the_white_paper_1969/ (accessed January 29, 2024)
[76] Dennis Madill, *Study of the Hawthorn Report* (Ottawa: Treaties and Historical Research Centre,1976), 77.
[77] Sally M. Weaver, "The Hawthorn Report: Its Use in the Making of Canadian Indian Policy," in *Anthropology, Public Policy, and Native Peoples in Canada*, ed. Noel Dyck and James B. Waldram (Montreal: McGill-Queen's University Press, 1993), 77. https://doi.org/10.1515/9780773563711-004.

experience with the First Nations in the British Columbia [78] and his work with racial minorities in Canada.[79]

Split into two volumes, the Hawthorn Report found that the indigenous people of Canada were the most marginalized and disadvantaged group in Canada.[80] Addressing the issue of their health, dignity, and equality in Canadian society, the report states that "the Indians do not now have what they need in some of these matters arid they cannot at present get what they want in others".[81] The report goes on the explain how the lack of support and resources for the Indian Affairs Branch exacerbates the issues, with the needs of the Indigenous such as healthcare and education not being met.[82] The Hawthorn Report argued that the status of the indigenous was due to the government's lack of engagement with the communities, and not providing proper resources in order to be able to succeed. Treated as second-class citizens, the Hawthorn Report exposed the inequities faced at the time, stating that "by every calculation, they [the indigenous] have been disprivileged and low-cost citizens up to the present time and many services will need to be increased for them before they catch up".[83]

The Acting Deputy Minister of Indian Affairs, H.M. Jones, wrote Harry Hawthorn with the express intention of integrating the indigenous population into Canadian Society.[84] The goal that the ministers had in mind for the Hawthorn Report was a research project that would help the government more effectively assimilate and enfranchise communities. The Hawthorn Report however instead argued against assimilation, recommending that "integration or assimilation are not objectives which anyone else can properly hold for the Indian."[85] It argued for the end of all assimilationist programs, including the residential schools and easing the off-reserve movement.[86] The Hawthorn Report introduces the idea of citizens plus and minus, the statuses that the indigenous people have held since colonization.[87] In Canadian Society, the indigenous peoples have been branded with the status of citizens minus, a state in which they were disadvantaged and marginalized.[88] The crux of the Hawthorn Report is the idea of moving the indigenous to citizens plus status, a state in which the government gives extra support to improve their conditions, retaining the full rights of Canadian citizens while also possessing certain rights as charter members of Canada.[89]

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[78] Ibid.,77.
[79] Katie Ferrante, "Harry Bertram Hawthorn," Museum of Anthropology Archives, November 20, 2015, https://atom.moa.ubc.ca/index.php/harry-bertram-hawthorn (accessed January 24, 2024).
[80] UBC white paper Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy" (Ottawa: Indian and Northern Affairs Canada, 1969) https://publications.gc.ca/site/eng/9.700112/publication.html (accessed Jan 28, 2024).
[81] Harry Bertram Hawthorn, *A Survey of the Contemporary Indians of Canada : A Report on Economic, Political, Educational Needs and Policies* (Ottawa: Indian Affairs Branch, 1966),5.
[82] Ibid., 5.
[83] Ibid., 7.
[84] Madill, *Study of the Hawthorn Report*, 2.
[85] Hawthorn, *A Survey of the Contemporary Indians of Canada*, 13.
[86] Ibid., 13.
[87] Ibid., 6.
[88] Ibid., 13.
[89] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."

When presented to the provincial government, the reception of the Hawthorn Report was relatively positive, with branches agreeing to one hundred and ten of the recommendations, partly agreeing with nine, disagreeing with ten, and being undecided on eight. [90] The general Canadian public too had a positive reaction to the report, with the Toronto Globe and Mail writing a positive review.[91] Although the reactions of the government were positive, however, many social scientists deemed the report too paternalistic, not challenging the structure of the government and handing off too much power to the Bureau of Indian Affairs. William Dunning, an anthropologist at the University of Toronto, was quoted in his review stating that the report was "worthy of 1867," criticizing the report's oversight.[92] Many anthropologists held the view that instead of questioning the system that created the issues that the indigenous people faced, the Hawthorn Report only addressed the symptoms.

Factors Towards Change

Besides the Hawthorn Report, other investigations were being held in the decade. In 1967, Frank Calder and other Nisga'a elders sued the government of British Columbia, claiming that their land had never legally been ceded through a treaty.[93] This case would eventually go up to the Supreme Court, becoming the first modern land claim in Canada.[94] Although it would be eventually lost, this landmark case would shake up the Canadian political landscape and become known as the Calder Case.[95] The case was important in building upon the *Indian Act*, being the first acknowledgement by the legal system that the Indigenous had a claim to the land before colonization.[96] The Calder Case's legacy on the political landscape of Canada was profound, as although at the time it had not reached its conclusion, the message was clear to the Trudeau government: the indigenous people would continue to push further.

Besides the changes in legal action, another major event in the 1960s shook Canadian politics: the death of Chanie Wenjack. Due to the poor treatment found in residential schools, twelve-year-old Chanie Wenjack died in his Kenora school due to starvation.[97] His case sparked an international outcry, with his story ending up in newspapers all over the world, putting pressure on the Canadian government.[98] The horrific nature and the backlash at his death led to a federal investigation and the treatment of the First Nations. Running away from the physical and sexual abuse that he faced in the residential school, he ended up starving to death after walking twelve miles in the snow.[99] In the 1960s and 1970s, Chanie became a symbol of the treatment of

[90] Weaver, "The Hawthorn Report," 80.
[91] Ibid., 81.
[92] Ibid., 80
[93] Tanisha Salomons, "Calder Case," *Indigenous Foundations*,https://indigenousfoundations.arts.ubc.ca/calder_case/ (accessed January 24,2024).
[94] Ibid.
[95] Hamar Foster, Jeremy Webber and Heather Raven, *Let Right Be Done : Aboriginal Title, the Calder Case, and the Future of Indigenous Rights* (Vancouver: University of British Columbia Press, 2007), 3-6.
[96] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[97] Georgia Carley, "Chanie Wenjack," *The Canadian Encylopedia,* published March 21, 2016, https://www.thecanadianencyclopedia.ca/fr/article/chanie-charlie-wenjack (accessed January 24,2024).
[98] Ibid.
[99] Ibid.

the indigenous people and the injustice that they faced due to policies enforced by the government.[100] His death became an awakening for Canadians about the treatment the indigenous faced and the consequences of the policies that were implemented.

Choosing A Path

As a consequence of the increased interest in indigenous policy, the Trudeau administration opened discussions and consultation toward possible amendments to the policy.[101] Thus the *Choosing a Path* pamphlets were sent out to every household with people of Indian Status. Worded as simple yes or no questions, they covered everything from band council leadership, education, economic prospects and more.[102] Written by the previous Head of Indian Affairs Arthur Laing, the pamphlet's main idea was assimilation, writing that "those who want the benefits of modern life, as many have shown they do, will have to accept some of the attitudes which make those benefits possible," showing that although it framed itself as a pamphlet meant to aid in choosing whether to enfranchise, it still carried many of the beliefs held at the time.[103]

The *Choosing a Path* pamphlets exposed the major issue that many government documents and policies had at the time, being overly paternalistic of the indigenous people. Explaining even the basics of indigenous policy, something that people with Indian status would be extremely familiar with, treats the First Nations population as naive and mindless. Harold Cardinal would write of its author, Arthur Laing, that "his ignorance of the Indians in Canada in the mid-sixties was exceed only in his arrogance," showing his distaste for the minister.[104] The pamphlets although try to frame themselves as supporting more independence for the First Nations, instead remain more stifling, as both its simplicity and wording leave little for discussion. Stating that "while the old days are gone and new attitudes prevail, the new ways have not yet helped all the Indians to do things for themselves," it treats the indigenous with pity, unable to function without the aid of the government, an idea that would be resented by many.[105]

Changes In Discussion

Spurred on by the *Choosing a Path* pamphlets, on April 28, the government convened First Nations leaders to discuss the future of indigenous policy.[106] Facilitating the discussions was Minister Jean Chrétien, opening with his remarks that "with this meeting, the first round of discussions will be completed. Then we of the Government must make our choices."[107] Representing the National Indian Brotherhood, Elder Dr. Dave Courchene proposed during the

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[100] Ibid.
[101] Cardinal, *The Unjust Society* , 101.
[102] Ibid., 101.
[103] Department of Indian Affairs and Northern Development, *Choosing a Path: A Discussion Handbook for the Indian People* (Ottawa: Indian Affairs Branch, Department of Indian Affairs and Northern Development,1968), 6.
[104] Cardinal, *The Unjust Society* , 100.
[105] Department of Indian Affairs and Northern Development, *Choosing a Path*, 7.
[106] Cardinal, *The Unjust Society*, 101.
[107] Department of Indian Affairs and Northern Development, *Verbatim Report of National Conference on Indian Act: April 28-May 2, 1969, Holiday Inn, Ottawa.* (Ottawa: Department of Indian and Northern Affairs, 1969), 2.

discussions that the treaties would be recognized, that all aboriginal rights would be recognized, that reconciliation of injustices would occur, and finally that a claims commission would be established.[108] The National Indian Brotherhood emphasized the rights of the land, with Dave Courchene stating that "there were two signatures on the Treaties yours and ours. We further state that in the eyes of the Indian, the Treaties constitute solemn promises and in fact contractual obligations," making the goal evident in the discussions.[109] Furthermore, the demands made by the National Indian Brotherhood and Dave Courchene were the honouring of two signatories on the treaties, meaning that arbitrary change without consultation would mean further breaking promises.[110] Although they discussed land rights and the status of the First Nations people, the discussion on April 28 made it clear that the *Indian Act* would remain, with the delegation for the National Indian Brotherhood stating that they are not prepared to discuss "the amendments to the Indian Act."[111]

The White Paper

In 1969, the "Statement of the Government of Canada on Indian Policy" or the "White Paper" was presented to the House of Parliament by Minister of Indian Affairs and Northern Development Jean Chrétien and Prime Minister Pierre Elliott Trudeau.[112] In the White Paper, both the *Indian Act* and by extension, Indian status would be abolished entirely, with land becoming privatized to band governments – indigenous governments within the community.[113] With the privatization of the land, Trudeau and Chrétien also proposed the dissolution of all treaties in Canada, meaning that all documents signed would be null and void.[114] Furthermore, instead of the Federal Office for Indian Affairs, provinces would be in charge of financing and monitoring their own indigenous populations.[115] Finally, the Federal government would appoint a commissioner in order to follow up on indigenous land claims and provide economic compensation.[116]

The White Paper was written under the assumption by Trudeau and Chrétien that the policies that applied to the First Nations under the *Indian Act* were discriminatory and exclusionary to their communities.[117] Under this assumption, they published the White Paper as an equalizer, getting rid of Indian status as a legal term in order to mitigate the effects of previous policies. By making them the same as other Canadians, Trudeau and Chrétien believed that it would give them a chance to experience more equality and better treatment in society,

[108] Ibid., 43-44.
[109] Ibid., 44.
[110] Ibid., 44.
[111] Ibid., 44.
[112] Lagace and Sinclair, "The White Paper, 1969."
[113] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy," 11-12.
[114] Ibid., 11-12.
[115] Ibid.,11-12.
[116] Ibid., 13.
[117]Lagace and Sinclair, "The White Paper, 1969."

stating that "we [the government] cannot continue to perpetuate the separation of Canadians."[118] Presenting the White Paper as a definitive solution for the First Nations, Trudeau and Chrétien used it as an economic solution to the rising costs of dealing with tribes.[119]

Positive Reaction To White Paper

Many academics and government officials had a positive reception to the White Paper.[120] Assimilation was the leading solution that many non-indigenous scholars believed in at the time, with leading professors at schools like the University of Toronto and Yale echoing sentiments such as "in the end, of course, the civilization of the whiteman must prevail," showing that indigenous culture and identity was not valued.[121] The idea that the First Nations were inferior and less civilized meant that from the perspective of many leading non-indigenous peoples, the White Paper had done them a favour by removing the Indian status.[122] Fuelled by a Darwinian idea of cultural superiority, many deemed that in order for the First Nations to succeed, their culture had to be completely erased and enfranchised.[123] Even leading anthropologists voiced their views on assimilation, with leading scholar Diamond Jenness proposing the elimination of Indian status as early as 1947.[124]

What remains more interesting however is the reactions from indigenous populations, with some also being supportive of assimilation. Although it was a small number, some indigenous people did think that assimilation was the best solution and that it would be better to become one with general Canadian society.[125] In his 1939 conference with the University of Toronto, Yale Professor of Race Relations Charles Loram stated that "including paradoxically a large number of Indians," believed in enfranchisement.[126] Even as the White Paper was published, a study by Menno Boldt showed that fifth of then "native Indian leaders had expressed favourability in getting rid of Indian status."[127] Although many white contemporaries at the time supported the White Paper, it would be amiss to say that no indigenous people, especially those living on reserve, did not also have a positive reception to the policy.

Negative Reactions To White Paper

The overwhelming response to the White Paper was shocked and anger. First Nations people felt betrayed on many levels because of the injustice.[128] Not only had the government repeatedly failed to listen to their wishes, but also claimed that the White Paper had "drawn on

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[118] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy," 5.
[119] Lagace and Sinclair, "The White Paper, 1969."
[120] Cairns, *Citizens Plus*, 53.
[121] Ibid., 53.
[122] Ibid., 54.
[123] Ibid., 61.
[124] Ibid., 55.
[125] Ibid., 58.
[126] Ibid., 58.
[127] Ibid., 59.
[128] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."

extensive consultations with Indian people."[129] During the April 28th discussions, groups had actively expressed disinterest in amending the *Indian Act*, rejecting the possibility of changing it. At no point from the beginning of the Hawthorne Report to the publication of White Paper had the topic become one of large significance. Although the *Choosing a Path* Pamphlets had covered some of the content, all of the questions brought up were about policy rather than the act's dissolution.[130] The White Paper was not only drafted and released without the consultation of any indigenous organization but also actively ignored the responses from the discussion on April 28 as well as the opinions expressed by many before. The dissolution of the *Indian Act* and previous treaties would mean the removal of recognition for the First Nations and their ownership of the land. Not only would it mean that previous land claims would be dissolved due to lack of legal backing with the treaties, but it also would result in the loss of rights given due to Indian status.

Besides the loss of land rights, the passing of responsibility onto the provincial government was also heavily criticized. Instead of taking responsibility for the inequities that the First Nations were experiencing, the Federal Government instead chose to, as Harold Cardinal put it, "pass the buck" to provincial offices to deal with.[131] Although the White Paper framed it as a solution, many First Nations people criticized the policy for its lack of real change. Instead of addressing or innovating to create solutions to the growing issue of poverty within the reserves and the lack of resources given to the communities, the White Paper chose to attack a problem that the First Nations did not bring up. By doing this, it misses the point of both the Hawthorne Report and the discussion on April 28, instead prioritizing an economically positive solution over a fair solution. Many First Nations, including those of the National Indian Brotherhood, felt as if the government was choosing to absolve itself of its historic responsibilities, choosing once again to prioritize assimilation over engaging in policies recommended by indigenous leaders.[132]

Citizens Plus

Citizens Plus or the Red Paper was the Nation Indian Brotherhood's and the Indian Association of Alberta's response to the White Paper. Presented to the Liberal Cabinet in parliament, *Citizens Plus* heavily advocated for treaty rights and self-determination of the indigenous people.[133] Led by Harold Cardinal, John Snow, and Adam Soloway, it critiqued the way the federal government approached the First Nations, stating that "no Treaty Indians asked for any of these things and yet through his concept of "consultation," the Minister said that his White Paper was in response to things said by Indians.", showing the transgression that had taken place.[134] Instead of arguing for the *Indian Act* to be repealed, *Citizens Plus* requested both a full-time Minister for Indian Affairs (Jean Chrétien was technically under the Ministry of

[129] Ibid.
[130] Cardinal, *The Unjust Society*, 103.
[131] Ibid.
[132] Ibid.
[133] Indian Chiefs of Alberta, *Citizens Plus* (Edmonton, Alberta: Indian Association of Alberta,1970), 2.
[134] Ibid., 4-5.

Immigration jurisdiction) and the full recognition of the treaties.[135] Going point by point in a counter-proposal, *Citizens Plus* affirmed that "the recognition of Indian status is essential for justice" as the assumption that the White Paper is based on "indicates a complete lack of understanding of the significance of the concept of equality".[136] Instead of forcing all the First Nations to lose Indian status, the Red Paper instead argues that "to be a good useful Canadian we [the First Nations people] must first be a good, happy and productive Indian."[137] Instead of the loss of Indian Status, *Citizens Plus* argued that it was crucial, as it provided First Nations people more autonomy to self-govern.

An important concept that *Citizens Plus* touches upon is the idea of self-autonomy from the First Nations tribes. The idea of self-government has been popular since the beginning of colonization, as the First Nations had done for centuries. *Citizens Plus* argues that in order for First Nations people to succeed, a level of self-determination and self-governance is needed within communities.[138] Rather than getting rid of Indian status or appointing a commissioner, *Citizens Plus* points out that "it will be necessary to assist bands with the complete development of self-government through which they can express their wishes" in order to "build communities of security and achievement and dignity." [139] Instead of asking for the Federal government to step in, *Citizens Plus* instead asks for the support needed for band leaders to determine the First Nations people's future without interference. Although it emphasizes the importance of the Indian Act, it rejects the paternalism that confines "the Indian and the tribe as if they were incompetent, not able to conduct their personal business affairs, or be responsible for local self-government."[140] Indigenous nationalism is crucial to understanding *Citizens Plus* and the backlash to the White Paper, as the cultural identity of each nation is the backbone of the discussion.

The Unjust Societies

The Unjust Society is a critique of the treatment of the First Nations from colonization to the release of the White Paper. Written by Harold Cardinal in 1969, it expands on the ideas of Citizens Plus, being a more personal and emotional perspective to the discourse. Cardinal expresses his opinion on the Trudeau and Chrétien administrations, positioning the White Paper as the final straw in a series of disappointments felt by the federal government.[141] Touching upon self-determination specifically, he expressed that the First Nations people needed to be able to self-govern, as the federal government would not advocate for or support them.[142] Branching from his writings in the Red Paper, he states that "one of the most painful lessons that the Indian people are learning is the need for an organization through which they can articulate their needs

[135] Ibid.,10.
[136] Ibid., 5.
[137] Ibid., 5.
[138] Ibid., 35.
[139] Ibid., 37.
[140] Ibid., 13.
[141] Cardinal, *The Unjust Society*, 107.
[142] Ibid., 76.

an alternatives to the Canadian society and its government," expressing the disillusionment that many First Nations leaders felt about the federal government.[143]

The Unjust Society called out the hypocrisy of the Trudeau-Chrétien administration, likening the policy of the White Paper to cultural genocide.[144] In response to their lack of consultation, Cardinal wrote "in spite of all government attempts to convince Indians to accept the white paper, their efforts will fail, because Indians understand that the path outlined by the Department of Indian Affairs through its mouthpiece, the Honorable Mr. Chrétien, leads directly to cultural genocide. We will not walk this path."[145] These phrases showed his view of the actions taken by the Department of Indian Affairs and the federal government. *The Unjust Society* compares Trudeau and Chrétien's actions to their predecessors, showing how the trend of ignoring the testimony of the First Nations was something ingrained into the system.[146] It is clear from the perspective of Cardinal that there is little faith left in the federal government's policies regarding the First Nations characterizing officials in Ottawa as liars.[147] In the final chapter of his page, like in the White Paper, he calls for self-determination and independence, emphasizing the need to push rather than break down indigenous identity.[148] Stating that "controlling our choice of a path—the realization of the full potential of the Indian people, or despair, hostility and destruction—is our belief that the Indian must be an Indian… Only by being an Indian, by being simply what he is, can he ever be at peace with himself or open to others," Cardinal leaves the choice for the First Nations people to decide, championing a new era.[149]

A DECLARATION OF INDIAN RIGHTS: THE BC INDIAN POSITION PAPER

Besides the response written by the delegates of the National Indian Brotherhood, the White Paper also faced opposition from leaders in British Columbia. Led by Rose Charlie of the Indian Homemakers' Association, Don Moses of the National Indian Brotherhood, and Phillip Paul of the Southern Vancouver Island Tribal Federation, the Brown Paper or "A Declaration of Indian Rights: The BC Indian Position Paper" was a clear rejection of the White Paper, echoing the sentiments of *Citizens Plus*.[150] Submitted by the Union of British Columbia Indian Chiefs, it sought the retention of indigenous lands, self-determination for the First Nations, and also highlighted the legal responsibility the government held to them.[151] Although it touched upon similar ideas as *Citizens Plus,* it also emphasized the feeling of betrayal that was felt with the dissolving of all the historic treaties. Writing that "to terminate this relationship would be no more appropriate than to terminate the citizenship rights of any other Canadian," the Brown

[143] Ibid., 76.
[144] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[145] Ibid.
[146] Cardinal, *The Unjust Society*,100-101.
[147] Ibid., 101.
[148] Ibid., 145.
[149] Ibid., 145.
[150] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[151] Union of BC Indian Chiefs, "A Declaration of Indian Rights: The BC Indian Position Paper (1970)," *BC Studies*, no. 200 (2018/2019 Winter): 13-18.

Paper directly linked the identity of the First Nations to the existence of the historic relationship.[152] This relationship plays an important role in the counter-proposal made in the Brown proposal, as many of the solutions include "continued Federal government commitment to our people" or "complete and continued consultation with us during the revision of pertinent legislation".[153] The Brown Paper and the many other responses from Manitoba, Saskatchewan, and other provinces were a representation of the growing movement of Red Power, rejecting the policies placed onto by the government through demonstrations and marches, demanding equal and fair treatment.[154]

AFTERMATH

In the summer of 1970, after mass demonstrations against it, Trudeau had the White Paper withdrawn from the House of Parliament. Embittered by the backlash his policy faced, Trudeau expressed massive discontent towards the indigenous people.[155] The immediate effect of the withdrawal of the White Paper was huge, as it meant that the First Nations would still be able to maintain their land and territory. The defeat of the White Paper would signify a turning point within indigenous history, as activists continued to gain more victories.[156] This would include the 1973 ruling by the Supreme Court the indigenous people had land claims from before colonization,[157] the continued resilience of indigenous organizations, and the 1982 Constitution Act amendment that officially recognized indigenous rights to their life and lands.[158]

Although the victory was huge, it also came with drastic consequences. As Mi'kmaq hereditary chief and scholar Stephen Joseph Augustine put it, many programs such as education were transferred to local tribes after the defeat of the White Paper.[159] Unable to support these programs due to the lack of development or governmental funding, many tribes struggled to maintain them.[160] The defeat of the White Paper helped to usher in many successes for indigenous groups but at the cost of bearing the heavy burden of development by themselves.[161] As Stephen Augustine described, many places would just have a limited budget and were unable to create more culturally relevant curricula, leading to the old Anglophone materials being taught.[162] The unintended immediate consequence of the defeat of the White Paper was the immense pressure that was added onto communities, as the federal government lost interest in First Nation's policy.[163]

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[152] Ibid., 1.
[153] Ibid., 5.
[154] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[155] Lagace and Sinclair, "The White Paper, 1969."
[156] Ibid.
[157] Cruickshank, "Calder Case."
[158] Andrew McIntosh and Stephen Azzi, "Constitution Act, 1982," *The Canadian Encyclopedia*, published February 06, 2012, https://www.thecanadianencyclopedia.ca/en/article/constitution-act-1982 (accessed January 24,2024).
[159] Unama'ki College. "Indian Affairs Reaction to the White Paper," May 25, 2017, https://youtu.be/vSEhtZjY0BI?si=e6coqcP2p0wGOcEd (accessed January 29,2024)
[160] Ibid.
[161] Ibid.
[162] Ibid.
[163] Ibid.

LEGACY

The defeat of the White Paper was a victory that could not be understated, as for the first time, a major policy of assimilation was prevented.[164] The White Paper was the first real test for many indigenous organizations, including the National Indian Brotherhood and the Union of British Columbia Indian Chiefs.[165] Both were recently established by the time the White Paper was published, the massive effort against the policy proving that large organizations like them would be able to exist and effectively represent First Nation's interests.[166] After decades of failed coalitions due to external influences, the White Paper was able to bring together disparate groups, united under the younger generation of the time.[167] The 1960s and 1970s were a critical time for indigenous youth, as they gained education and political might. Leaders such as Harold Cardinal, Rose Charlie, Philip Paul, and Don Moses shaped conversations within their respective circles, voicing concerns for the future of the indigenous nations.[168] The White Paper helped to set the precedent for the younger generation to speak out, a legacy that remains to this day.

The defeat of the White Paper was influenced mainly by the historical discrimination that indigenous communities would face. Made to suffer through humiliation after humiliation, the federal government's treatment of the First Nations always was a contradiction between promises and actions.[169] The assimilation policy that was pushed by the White Paper was never made in the interest of the First Nations, but instead to appease what non-indigenous policymakers wanted to see.[170] Although the White Paper was defeated, the underlying discrimination that the Indigenous faced was not changed by the withdrawal. To put it adequately, the assimilation failed but the gap remained.[171] This was seen through the loss of the Nisga'a elders in the Calder Case,[172] the forgotten legacy of Chanie Wenjack, and the erasure of women's voices in this movement. The legacy that the defeat of the White Paper is one of both victory and failure, defiance against a systemic issue still presents even 50 years after.

NEVER MEANT TO CHANGE

Even from the beginning, the Trudeau-Chretien administration never truly viewed the First Nations of Canada as Canadian, choosing to assimilate through the White Paper rather than creating the infrastructure needed for the indigenous to succeed. Although the *Indian Act* remains a largely controversial piece it still guaranteed crucial rights to hunting, land, and more. The policy proposed by the White Paper highlighted the difference between nationhood and citizenship within Canada, as although they were a part and subject to the Canadian government, the First Nations were never considered true citizens.

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[164] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[165] Ibid.
[166] Cardinal, *The Unjust Society*, 81-90.
[167] Department of Indian Affairs and Northern Development, Canada, "Statement of the Government of Canada on Indian Policy."
[168] Ibid.
[169] Cardinal,*The Unjust Society*,107.
[170] Cairns, *Citizens Plus*,67.
[171] Ibid., 6.
[172] Cruickshank, "Calder Case."

Although Trudeau claimed to listen to the First Nations, he instead fell into the assimilationist policy of his predecessors. It is important to acknowledge that in *The Unjust Society*, Cardinal first comments that "Indian leaders, briefly, hope that Mr. Trudeau's just society might include native peoples,"[173] showing that there was a possibility of mending relationships at the beginning of his administration. The Trudeau-Chrétien office through the White Paper showed they never viewed the indigenous of Canada as Canadian, instead seeing being First Nations as a problem, choosing to destroy their identity as a whole. In the minds of the federal government, being indigenous and being Canadian were mutually exclusive, and therefore never accept indigenous voices without enfranchisement. Showing their intentions by ignoring the Hawthorn Report, the *Choosing a Path* Pamphlets, and all the nationwide discussions they claimed to have, the White Paper became a representation of their thoughts, not an ignorant mistake. As the political researcher for the Hawthorne Report put it, "the assimilation policy, therefore, was never the policy of the Indian people, although it had some support. It was white, majority, government policy."[174]

The policy of previous prime ministers still rings true to this day. Since the publication of the White Paper in 1969, many things have changed, from the repatriation of the Canadian Charter of Rights and Freedoms[175] to affirming the land rights of the Indigenous to the establishment of the National Day of Truth and Reconciliation[176], as well as the passing of leadership to Pierre Trudeau's son, Justin Trudeau.[177] Although time has passed since the policy was created, critics of Indigenous policy by the government maintain that harmful legislation is still being upheld. With the Federal Government being liable for almost $76B in land reparations and lawsuits towards First Nations communities, Nunavut MP Lori Idlout commented that "it means that Canada is still implementing its genocidal policies," stating that "indigenous Peoples are not putting up with it anymore."[178] Although ongoing efforts towards reconciliation are being made, many of the issues pointed out in Cardinal's Unjust Society remain, with the poverty rate being 11.8% for First Nations living on reserves in 2020, and 14.1% for First Nations people living off reserve, 9.2% for the Métis and 10.2% for the Inuit.[179] As time passes, it can only be hoped that one day Cardinal's Vision of a just society can come to fruition.

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[173] Cardinal, *The Unjust Society*, 101.
[174] Cairns, *Citizens Plus*, 67.

[175] Sheppard, Robert. "Patriation of the Constitution." *The Canadian Encyclopedia*. Historica Canada. Article published September 03, 2012. www.thecanadianencyclopedia.ca/en/article/patriation-of-the-constitution (accessed February 20, 2024).
[176] Canadian Heritage, "National Day for Truth and Reconciliation," *Government of Canada*, published September 21, 2023. https://www.canada.ca/en/canadian-heritage/campaigns/national-day-truth-reconciliation.html (accessed February 20, 2024).
[177] Azzi, Stephen. "Justin Trudeau." *The Canadian Encyclopedia*. Historica Canada. Article published April 23, 2013. www.thecanadianencyclopedia.ca/en/article/justin-trudeau (accessed February 20, 2024).
[178] Forester, Brett. "Federal liabilities 'likely' owed to indigenous people grow to $76B under Trudeau." CBC News. Article published December 14, 2023. https://www.cbc.ca/news/indigenous/canada-liabilities-indigenous-legal-claims-1.7058139 (accessed February 20, 2024).
[179] Statistics Canada, "Disaggregated trends in poverty from the 2021 Census of Population," *Government of Canada*, published November 9, 2022. https://www12.statcan.gc.ca/census-recensement/2021/as-sa/98-200-X/2021009/98-200-X2021009-eng.cfm (accessed February 20, 2024).

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Do Elections Express the Will of the People Anymore? By Ziqing Jack Wang

Introduction

From the first democratic elections in ancient Athens 2,500 years ago, votes to determine leaders is a system that has been fraught with complications. Since then, the world has grown only more complex. Interest groups, acrimonious bipartisanship, foreign interference, and electronic tampering are only a few examples of how elections are being affected. An election can only be said to deliver the will of the people when it properly reflects the views of the various social groups of the electorate. By completing case studies of the structural flaws within both a winner-takes-all and proportional representation system, as well as an investigation into the possibility of external manipulation of such elections, this essay will argue that elections do not express the will of the people effectively.

The Structural Flaws of Elections in a Winner-Takes-All System

One can start with a case study of the U.S., the most notable example of the winner-takes-all election system. An important aspect is the Electoral College, the body responsible for electing the President. Unfortunately, this body encourages politicians to campaign more in swing states and markedly less in other states. A swing state is near enough to the 50/50 mark regarding which party is leading in the polls that targeted campaigning can have a material effect on elections. These states are more determinative of the outcome of elections than the "safe states" of either party, meaning that politicians are unlikely to campaign significantly in them. For instance, it does not make sense for a Republican candidate to campaign in solidly Democratic states, like New York, or for a Democrat to campaign in Alabama. Consequently, some citizens receive fewer opportunities to obtain a genuine impression of the candidate, especially compared to those who live in swing states. Additionally, voters can feel discouraged to vote in pre-determined outcomes states or districts, thus further distorting the popular vote.

A greater issue with the Electoral College only becomes truly apparent when the entire nation is considered. An appropriate way to illustrate this issue would be to look at the 2020 General Election. While Mr. Biden won by around seven million votes in the popular vote, one need only move around 150,000 votes in key swing states, namely Georgia, Arizona, Nevada, Pennsylvania, and Wisconsin, to give the electoral college victory to Mr. Trump. In this example, Mr. Trump would have won the election while trailing Mr. Biden by nearly seven million votes. Therefore, he would lack a democratic mandate by a large margin, and once again, it would be tough to argue that his reassumption of the highest office in the land reflected the will of the voters.

Aside from the Electoral College, most states have a "winner-takes-all" system that gives the congressional seat to the candidate who wins the majority in a particular district. But consider this hypothetical case: Florida has 30 electors. If the Republican candidates there won every district by a small margin of the total vote, then although Florida is almost 45 percent Democrat,

not a single seat would be awarded to a Democrat. Therefore, the 55 percent of Republican voters would enjoy 100% of the representation. Could this be said to reflect Florida's makeup accurately?

Due to the winner-takes-all system, minor parties also face an unfair disadvantage. In the past several elections, the Libertarian Party did not win a single House seat despite having millions of votes. Other parties, such as the Working Families Party, suffered similar fates. This implies that it would be extremely difficult for the will of the supporters of these parties ever to be heard in the government, as there would be no representative to speak for them. In the winner-takes-all system, the Democrats and Republicans have absolute power to dictate legislation and can maintain an iron grip on government. These two parties have no desire to level the playing field either, since power is never willingly shared.

Finally, one essential element for protecting the integrity of elections is the Fourth Estate, or the free press, which should provide facts and balanced perspectives on candidates to allow citizens to cast an informed vote. However, the major news networks in America are increasingly polarized and have become "mouthpieces" for the parties. Fox News, for example, has been blamed for being a mouthpiece for the Republicans, persuading around four out of ten Americans to distrust it entirely. In a recent lawsuit brought against Fox by Dominion Voting Systems, it has been shown that "some network hosts and executives endorsed lies about Trump's election loss, hosted conspiracy theorists who they thought were unhinged, and overtly prioritized the company's profit over truth." Without a free and objective press, the public can easily be swayed or disinformed about candidates and elections, inhibiting informed elections.

The Structural Flaws of Elections in a Proportional Representation System

Contrary to the U.S., a prime example of a proportional representation election system is Germany. The central political body in the German system is the national parliament, known as the "Bundestag." Germans elect the members of the Bundestag with two votes. The first is for a "direct candidate" in an electoral district, while the second is for a favorable party. The Bundestag's seats are comprised of the representatives voted in from the first vote and a party proportional representation based on the second vote. Germany has five main parties: The Social Democratic Party ("SPD"), the Christian Democratic Union of Germany ("CDU"), the Christian Social Union in Bavaria ("CSU"), the Greens, and the Free Democratic Party ("FDP"). A recent alarming newcomer is the Alternative for Germany Party ("AfD"), which represents concerning nationalist and anti-immigrant views. It gained 11% representation in the most recent election.

In this representative structure, it is common to see coalition governments form, such as the current "traffic light coalition" (SPD, FDP, and Greens) under the head of Olaf Scholz. However, coalitions have their share of problems as well. One way coalitions render elections less effective is that smaller parties can be sidelined or stifled by existing coalitions. For example, the Left Party has consistently been targeted by coalitions due to its more radical left-wing policies. As a result, its supporters go almost unheard in the government. Elections within a representation system, while having some advantages over the winner-takes-all system,

often end up with the same pitfall: only those parties viewed as cooperative or capable of compromise by the largest parties can form coalitions. If you, as the voter, prefer one of these historically marginalized political parties, your voice will remain unheard.

Furthermore, the German system often causes confusion by rallying different political parties. The average German voter would be hard-pressed to inform themselves on the agendas of every major candidate. As *The Economist* commented on Germany's 2021 election, "The campaign has been dispiritingly superficial, avoiding serious policy debate and focusing instead on the peccadillos and gaffes of party leaders...German citizens are not being given a clear choice of direction." Uninformed or bamboozled voters voting, in effect, goes against the true purpose of having elections, which is to reflect the well-considered vote of the election base.

The Possibility of External Manipulation in General

Aside from structural flaws, elections can be negatively affected by external manipulations, distorting an accurate representation of the people's will. These external manipulations may include a foreign or domestic power or group affecting the election results.

The risks relating to election legitimacy are especially highlighted in developing countries. In Nigeria, Bola Tinubu "w[on] a flawed election", according to numerous reliable sources. Mr. Tinubu won 37 percent of the vote, placing him well ahead of his opponents Atiku Abubakar (29 percent) and Peter Obi (25 percent). However, these numbers raised immediate doubt in Nigerians and commentators abroad, as most predictions had suggested that Mr. Obi would win the popular vote. Later investigations confirmed the manipulation of the process and results. Some polling stations were attacked by armed men who intimidated voters to vote for Mr. Tinubu. Several seizures of ballot boxes and the burning of ballot papers occurred. The eventual counting was haphazard, as many results were uploaded illegitimately and incorrectly, invalidating large portions of the vote. Nigeria showcases the danger of external manipulation, as the people's will might be twisted or ignored completely.

Even a more robust election system like the US has not been immune to external manipulation. In the 2016 elections, the heads of the FBI and the NSA voiced significant concern about the possibility of external attempts to hack the elections, such as Russian interference. Reports published in September 2016 corroborated that hacking attempts did happen, including one incident that tried to steal roughly 200,000 voting records in Illinois. These data hacks were seriously hazardous to electoral integrity, as many attempts directly aimed to influence political debates or "tweak" results. If successful, such attacks would render elections ineffective in expressing the genuine decisions of citizens.

The Convincingness of Recent Positive Trends

In the U.S., the latest 2020 presidential election witnessed the highest voter turnout rate in its history, signifying that more Americans sought to cast their ballot than ever before. However, as the Electoral Knowledge Network, an authoritative organization that examines the quality of elections, notes, "measuring electoral quality is like chasing moving target...The tools

and methodologies used for measuring...are many and diverse." Other factors besides turnout rate, such as the representation of different social groups or the possibility of external manipulation, must be considered when analyzing the effectiveness of elections. By these crucial metrics, democracies, especially in the developing world, suffer from many significant issues.

Even if one only examines the voter turnout rate, the trend is worrying on a global scale. In Africa, in particular, the voter turnout rate has been decreasing for many recently established democracies, which can be partially attributed to their poor economic and unstable political statuses. Aside from Nigeria, one database of the Electoral Institute for Sustainable Democracy in Africa shows that the turnout rates in Angola, Botswana, and the Democratic Republic of the Congo are declining. These worrying trends illustrate that election systems are becoming more incapable of capturing the will of the people globally.

Conclusion

Overall, the structural flaws in a winner-takes-all and proportional representation system and the growing possibility of external manipulation point to the notion that elections increasingly do not express the people's will. Not only do these two points have more merit, but the popular argument for the ability of elections to express the people's will (i.e., that voter turnout rate is still high) is lacking merit.

While elections are becoming more ineffective, this essayist would not argue for abolishment. After all, elections are the keystones of any democratic system. At its core, the idea of an election allows the freedom of expression and association to blossom. However, elections must adapt and evolve to serve their purpose effectively in a more complex and volatile modern context. Regulations must keep up with the rapid spread of social media, providing new options for politicians to manipulate and solicit votes illicitly. Improved education must continue to edify the citizenry, equipping them with the ability to make well-considered decisions. An election can only be effective when the larger democracy it belongs to is efficient and robust.

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Prochlorococcus-Mediated Restoration of Hypoxic Ecosystems Across Varying Levels of Turbidity in Aquatic Environments By Elliott Lee

Abstract

The current approaches to manage hypoxia caused by high turbidity levels only prevent or lessen the quantity of sediment discharge; little research is done on the areas that are already hypoxic, which causes these areas to become low-nutrient because aquatic plants' opportunity to photosynthesis is reduced. The goal of this study is to utilize the Cyanobacteria Prochlorococcus marinus to provide a bioremediation solution to locations where sediment flow has caused hypoxia. When exposed to high turbidity conditions, Prochlorococcus marinus will create an equivalent or comparable amount of oxygen to when it is not present in low turbidity conditions. In order to simulate aquatic habitats, fifteen tanks were set up with varied turbidity levels and the common aquatic plant Phaeophyceae (brown algae). Turbidity levels were shown using the inhibition of different amounts of UV light (25%, 50%, 75%). Analysis through a When and ANOVA statistical test was performed, the results indicated that there was a significant effect of time (p-value day < 0.0001) and the presence of Prochlorococcus marinus (p-value treatment < 0.0001) on oxygen production levels. Ultimately supporting the hypothesis that when Prochlorococcus marinus is exposed to high levels of turbidity-mimicked conditions via UV light inhibition, it does affect ecosystems by producing equal or similar levels of oxygen. With this in mind, future research should focus on applying Prochlorococcus marinus to actual marine ecosystems that currently face hypoxia to replicate the results of the current study.

Introduction

Sediment runoff has been part of Earth's processes for millennia. The geological activity goes as follows: as rainwater enters the ocean, its speed slows and the sediment particles eventually spread out onto seabeds and coral reefs (Carilli, 2014). This natural process, indeed harmful, takes thousands of years for there to be enough accumulation that harms the environment (Snelgrove, 2013). More recently, however, anthropogenic sources have hindered this delicate balance. The Natural Oceanic and Atmospheric Administration reports that 80% of ocean pollution comes from land (NOAA, 2023). The biggest contributor is what is called a nonpoint source resulting from runoff, which encompasses a variety of anthropogenic sources such as septic tanks, vehicles, farms, and ranches. The Environmental Protection Agency reports that 40% of all impaired ocean waters or turbidity stems solely from nonpoint sources of pollution generally resulting from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification (EPA, n.d). Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources (EPA, n.d). The heightened levels of pollution on land eventually lead to higher levels of sediment runoff which enters the ocean through water sources. The biggest detrimental effect is a higher level of turbidity or the measure of water clarity (USGS, 2018). An increase in turbidity levels has been shown to have harmful effects on water ecosystems as lesser intensities of sunlight UV penetrate the water surface reaching the aquatic plants or Submerged Aquatic Vegetation (SAV;

ICPRB, 2017). Less sunlight results in less plant growth due to less photosynthesis, and because plants produce less oxygen, there is less oxygen available for aquatic organisms (ICPRB, 2017). These hypoxic regions, where there is low or depleted oxygen in a water body, create "dead zones" that are unable to sustain life in an ocean environment. (NOAA, 2022). The frequency of “dead zones” has only been further exacerbated in recent years, in 1950 only 10 documented cases were identified to at least 169 in 2007 only over 50 years (NGS, n.d).

In recent years many solutions have been proposed in response to turbidity levels, a relevant case being the Great Barrier Reef (GBR) in Australia. An estimated 17 million tonnes of waste pollutants each year go into rivers which are eventually deposited into the Great Barrier Reef (GBR) which is five to nine times greater than 200 years ago (TNCA, 2019). As a result, turbidity levels near these sites were found to be 0.3 - 0.4 times higher than the average which was around five NTU (Nephelometric Turbidity Units) (Macdonald, 2015). To combat this, the Australian Government has pledged to spend nearly 8.2 billion dollars by 2025 on cleaning up the Great Barrier; nearly eight times the amount set up the year prior where one billion dollars was set aside for nine years from 2022-2023 to 2029-2030 (APH, 2022).

Traditional methods of cleaning and lowering turbidity levels include vegetative buffer strips (using natural vegetation to create buffers that trap the sedimentation), sedimentation basins (a basin that allows suspended particles to settle out before reaching the ocean), erosion control measurements (carefully managing the amount of erosion that occurs before reaching the ocean), and regulatory measures (regulating the amount of anthropogenic activity that causes). Although all traditional solutions mitigate or prevent sedimentation runoff from reaching the ocean or other water sources to avoid hypoxia, however, most fail in several aspects. Initially, these methods can only prevent or mitigate the turbidity levels in an area and fail to address environments that are already affected by high levels of turbidity which currently or will experience hypoxia. The other aspect is cost efficiency, just like in the aforementioned case study, large amounts of funds are required to continually maintain these conditions. For example, every year the Australian government spends about 20-21 million dollars on maintenance alone (APH, 2023). Current methods have tried to use organisms to improve water quality such as filtration and removal of pollutants through the use of aquatic plants, however, they lack any fundamental value in environments that have high levels of turbidity. However, a new approach using certain cyanobacteria may provide new insight into finding cost-effectiveness, and unlike traditional methods that struggle with high turbidity hypoxia regions, certain cyanobacteria with unique characteristics may be the key to addressing these challenges.

Prochlorococcus marinus, or Prochlrococcus as it is commonly known, is a type of cyanobacteria defined as marine unicellular cyanobacterium and is the most abundant photosynthetic organism on Earth (SD, 2020). Members of this genus are classically thought to be adapted to high-oxygen and nutrient-poor ocean conditions, with a principle divergence between high-light and low-light ecotypes (NIH, 2021). This organism was first discovered and isolated by scientists in 1989 from the bottom of the euphotic zone in the Sargasso Sea (NIH, 1999). Prochlorococcus is characterized by a genus of very small (0.6 μm) marine cyanobacteria

with unusual pigments (chlorophylls a2 and b2) (NIH, 1999). These bacteria are responsible for causing 5% of global photosynthesis (Pennisi, 2017). Due to its high number of gene strains (80,000; Pennisi, 2017), there are several ecotypes (i.e., different environmental conditions that organisms are fit for) these bacteria can survive in - ranging from sunlit water surfaces to 200 meters depth (Pennisi, 2017). As such using its unusual pigmentation (chlorophylls a2 and b2), the photosynthetic bacteria enacts photosynthesis to produce nearly 20% of all oxygen produced in the biosphere, a higher percentage than all of the tropical rainforest combined (NOAA, n.d). The utilization of this resilient cyanobacteria may prove to be invaluable in areas experiencing hypoxia due to high levels of turbidity, which are not only limited to aquatic plants but also common algae that exist in marine environments for example: Phaeophyceae (brown algae).

Phaeophyceae or brown algae class of about 1,500 species of algae in the division Chromophyta, common in cold waters along continental coasts (Britannica, n.d.). There are 16 species of Phaeophyceae (brown algae), comprising about 285 genera and about 1800 species (Yoon, 2009). Species range from simple microhairs to giant kelps that can reach 60 meters in length. Large multicellular phaeophyceae or giant kelps play an important role in coastal marine ecosystems. These multicellular organisms, with distinct multicellular structures including holdfasts, stipes, and blade(s) later carry specialized transport cells (referred to as trumpet hyphae depending on their size) to transport metabolites (Yoon, 2009). Large kelps are large biomass that grow extensively and form marine forests that are home to a variety of species.

This experiment aimed to determine whether the use of Prochlorococcus under different dust concentration conditions (25%, 50%, 75%) simulated with different solar irradiance suppression could produce the same amount or amount of oxygen with similar results when compared to conditions without hypoxia and low turbidity. Confirmation of these findings may provide insights for environmentalists to find solutions to protect marine ecosystems currently facing high levels of hypoxia and turbidity because these factors provide plants with low solar radiation penetrating water reducing photosynthetic rates (ICPRB, 2017). Prochlorococcus is the most abundant photosynthetic bacterium on Earth and can replace plants that lose their energy levels in low-growth areas primarily by reversing hypoxia in the water or preventing increased turbidity (NIH, 2017). From the perspective of a government agency, the use of Prochlorococcus may be an alternative to biological management. Current methods revolve around preventing and reducing erosion to keep sediments dry. These have been highly successful for their goals: of mitigation and prevention, but essentially fail to address areas already experiencing high levels of disturbance and subsequent hypoxia.

The Alternative hypothesis (H1) states that when Prochlorococcus marinus is exposed to high levels of turbidity-mimicked conditions via UV light blockage, it will positively affect ecosystems by producing equal or similar levels of oxygen (ml/g) to low turbidity level treatments that are not exposed to Prochlorococcus, thus serving as a viable alternative for restoring low-light/growth aquatic ecosystems impacted by sediment runoff. According to the Null hypothesis (H0), the oxygen levels (ml/g) produced by experimental groups introducing Prochlorococcus marinus will be equal or comparable to each other. There would be no

significant differences in oxygen concentration between low and high turbidity level environments.

Methods

Fifteen individual tanks were set up for this experiment, with each one having a volume of 1,200 ml and measuring 226 ml meters high by 82 ml meters wide. Each tank was bedded with a substrate layer consisting of 0.5 cm of artificial ocean sand at the bottom, followed by 1 cm of aquatic sand soil. After which, the tanks were populated with 3 grams of Phaeophyceae (brown algae) per tank, and 1,000 ml seawater sourced from the South Korean East Sea coast was gently poured into each tank. The initial temperature of the seawater was between five to seven degrees Celsius as such the tanks were left to acclimate for a total of three days before the experiment began.

Bacteria introduction of the Prochlorococcus consisted of an initial inoculation period in 1L of Pro99 Growth Medium and 100 ml of Prochlorococcus starter culture for three days. The treatment phase consisted of adding the Prochlorococcus culture into tanks six through fifteen for a total of 122 ml per tank after which each tank was gently mixed to assimilate the Prochlorococcus with the new environment.

All tanks were kept under UV LED shelves to mimic sunlight which they would have typically received in their normal environments. Before beginning day one of the experiment to simulate low light conditions the initial lumens were calculated (6,000 lux) after which medical clothes were employed to cover the tanks at varying percentages (25%, 50%, 75%) to emulate the varying degrees of turbidity in an ocean environment. Tanks seven through nine were covered at 25% (4,500 lux), tanks ten through twelve were covered at 50% (3,000 lux), and tanks thirteen through fifteen were covered at 75% (1,500 lux). Tanks four through six were also covered by 50%, however, the aforementioned did not include the bacterial treatment as such acting as the control while tanks one through three were not covered to simulate a normal healthy ocean environment.

Seawater chemistry measurements included oxygen levels (measured twice daily using a dissolved oxygen probe - morning and night, in ml/g). Tank measurements consisted of measurements being taken every morning and every night and included observation of LED lights on the two shelves where the tanks were placed (set for 12-hour day/night periods), temperature (room temperature was set between 20.5-22.5 degrees Celsius while water temperature was kept between 19-20 degrees celsius), pH (kept between 7-7.5 using pH strips), and salinity (maintained between 25-28 ppt using a salinity probe). All aforementioned measurements were taken daily (day and night) during the experimental period lasting 21 days (Day 1- Day 21) during which all conditions were carefully observed and controlled adjusting if needed.

All data collected (day/night) was inputted into RStudio where code was created to compare all the data. To test the effect of time and treatment on each response variable, a linear regression model (y=mx+b; lm = response ~ Day*Treatment) was used, and an ANOVA

statistical test was enacted on the linear model. These results correlated with each line plot. To test the overall effect of treatment on each response variable, an ANOVA statistical test was used with Treatment as a fixed factor and each environmental measurement as the response variable (aov(response~ Treatment)). These correlate with each boxplot with treatment on the x-axis. To test the overall effect of tank and treatment on each response variable, an ANOVA statistical test was used with Treatment and Tank as fixed factors and each environmental measurement as the response variable (aov(response ~ Treatment*Tank)). These correlated with each boxplot with a tank on the x-axis.

The independent variable during this study was the level of sunlight exposure (UV LED) which was manipulated through the different percentages of coverage (25%, 50%, 75%). The dependent variables were the response variables (day/night) which included: Oxygen level (ml/g), Temperature (celsius degrees), Salinity (ppt), pH, and Light intensity (lux).

Results

The results of the two-way ANOVA testing the effect of treatment and tank content on important response variables (oxygen, temperature, salinity, and pH) revealed robust statistical patterns. The treatment factor revealed a highly significant effect on oxygen concentration (F value = 174.261, $P < 0.0001$; Table 1). In contrast, the tank factor had no significant effect on all response variables, with a P-value of 0.829 for oxygen. The residues exhibited a range of variations, ranging from large variations for oxygen to moderate variations in temperature, salinity, and pH.

Table 1. Tank vs. All four response variables (Oxygen, Temperature, Salinity, pH).

Response	Factor	Df	Sum Sq	Mean Sq	F value	P-value
Oxygen	Day	20	382.760	19.138	2279.640	< 0.0001
	Treatment	4	748.200	187.050	22280.500	< 0.0001
	Day	80	278.480	3.481	414.650	< 0.0001
	Residuals	525	4.410	0.008		
Temperature	Day	20	128.736	6.437	107.667	< 0.0001
	Treatment	4	0.107	0.027	0.448	0.774
	Day	80	7.470	0.093	1.562	0.0025
	Residuals	525	31.387	0.060		
Salinity	Day	20	1.450	0.072	2.315	0.0011
	Treatment	4	0.178	0.044	1.419	0.226
	Day	80	1.948	0.024	0.778	0.918

	Residuals	525	16.437	0.031		
pH	Day	20	2.000	0.100	3.536	< 0.0001
	Treatment	4	0.079	0.020	0.701	0.592
	Day	80	2.875	0.036	1.271	0.068
	Residuals	525	14.848	0.028		

Considering the analysis of tank and response variables, it was clear that the "day" factor had a significant effect on all response variables, which were found to be highly significant, especially for oxygen (F value = 2279.640, P < 0.0001; Table 2). The treatment factor, although significantly effective on oxygen concentration (F value = 22280.500, P < 0.0001; Table 2), showed significant effects on temperature, salinity, and pH.

Table 2. Day vs. All four response variables (Oxygen, Temperature, Salinity, pH).

Response	**Factor**	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**P-value**
Oxygen	Treatment	4	748.200	187.050	174.261	< 0.0001
	Tank	1	0.100	0.050	0.047	0.829
	Treatment	4	0.100	0.030	0.024	0.999
	Residuals	620	665.500	1.070		
Temperature	Treatment	4	0.110	0.027	0.099	0.983
	Tank	1	0.010	0.009	0.032	0.858
	Treatment	4	0.130	0.032	0.117	0.977
	Residuals	620	167.460	0.270		
Salinity	Treatment	4	0.178	0.044	1.391	0.236
	Tank	1	0.009	0.009	0.269	0.604
	Treatment	4	0.018	0.004	0.139	0.968
	Residuals	620	19.808	0.032		
pH	Treatment	4	0.079	0.020	0.630	0.641
	Tank	1	0.180	0.180	5.731	0.017
	Treatment	4	0.049	0.012	0.389	0.816
	Residuals	620	19.495	0.031		

When an ANOVA statistical test was performed, the results indicated that there was a significant effect of time (p-value day < 0.0001) and the presence of Prochlorococcus marinus (p-value treatment < 0.0001) on oxygen production levels. Ultimately supporting the hypothesis that when Prochlorococcus marinus is exposed to high levels of turbidity-mimicked conditions via UV light blockage, it does affect ecosystems by producing equal or similar levels of oxygen (Fig. 8).

Through the careful design of the experimental design, factors were controlled which in turn allowed the experiment to solely focus on the fact that it was the Prochlorococcus that influenced the results. The boxplots comparing the Tank vs. the three response variables (Temperature, pH, and Salinity; Fig. 1-3) further emulate this as it demonstrates that there was no overall effect of the tank on any of the four response variables. Indicating that the experimental conditions remained consistent across all tanks and providing confidence that an average of the values could be taken among the three tanks for each treatment type so that it is representative of the entire treatment (Fig. 1-3).

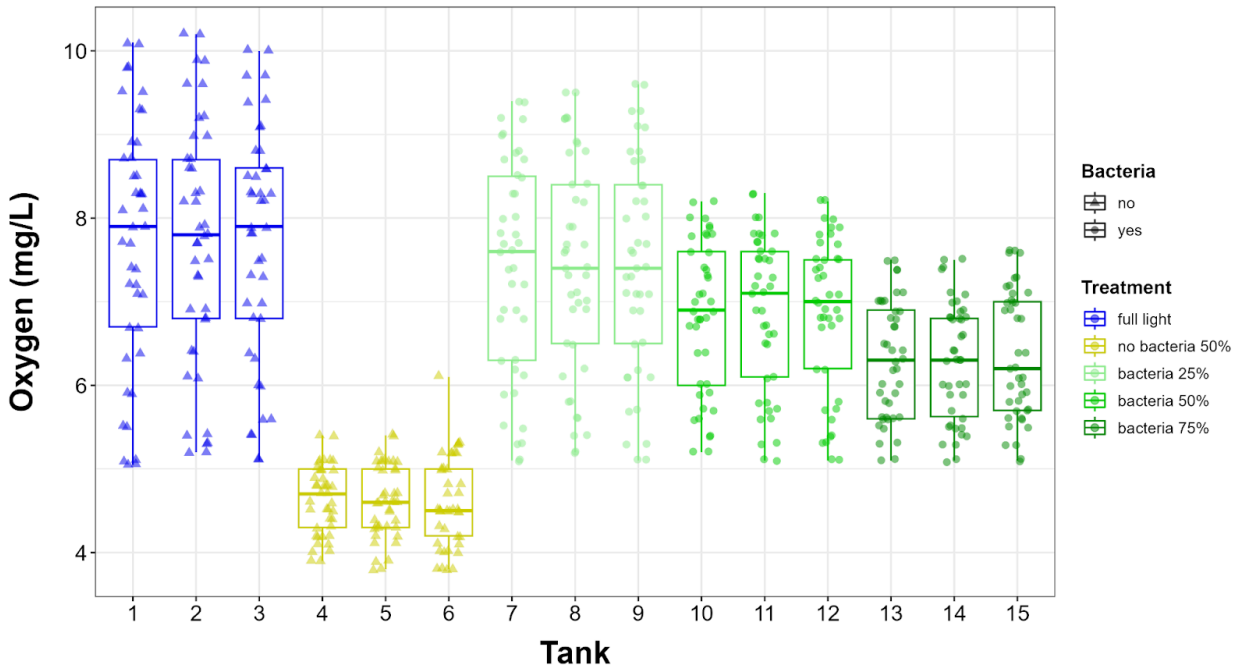


Figure 1. Boxplot of oxygen (ml/g) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

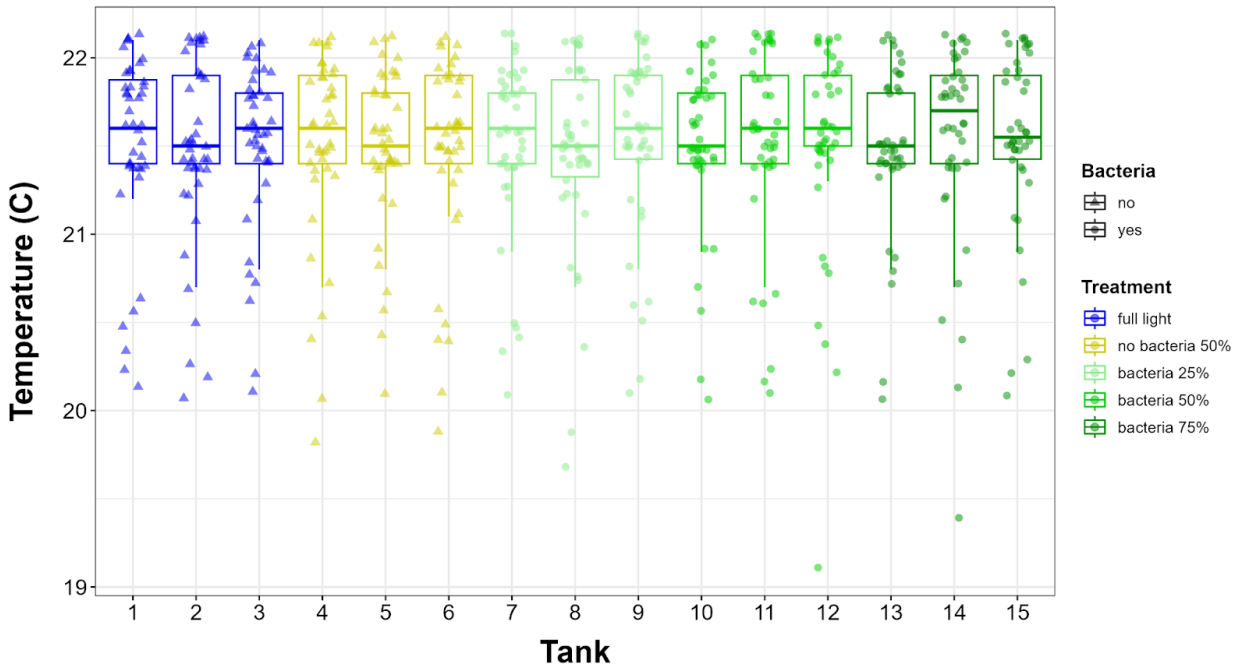


Figure 2. Boxplot of temperature (celsius degrees) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

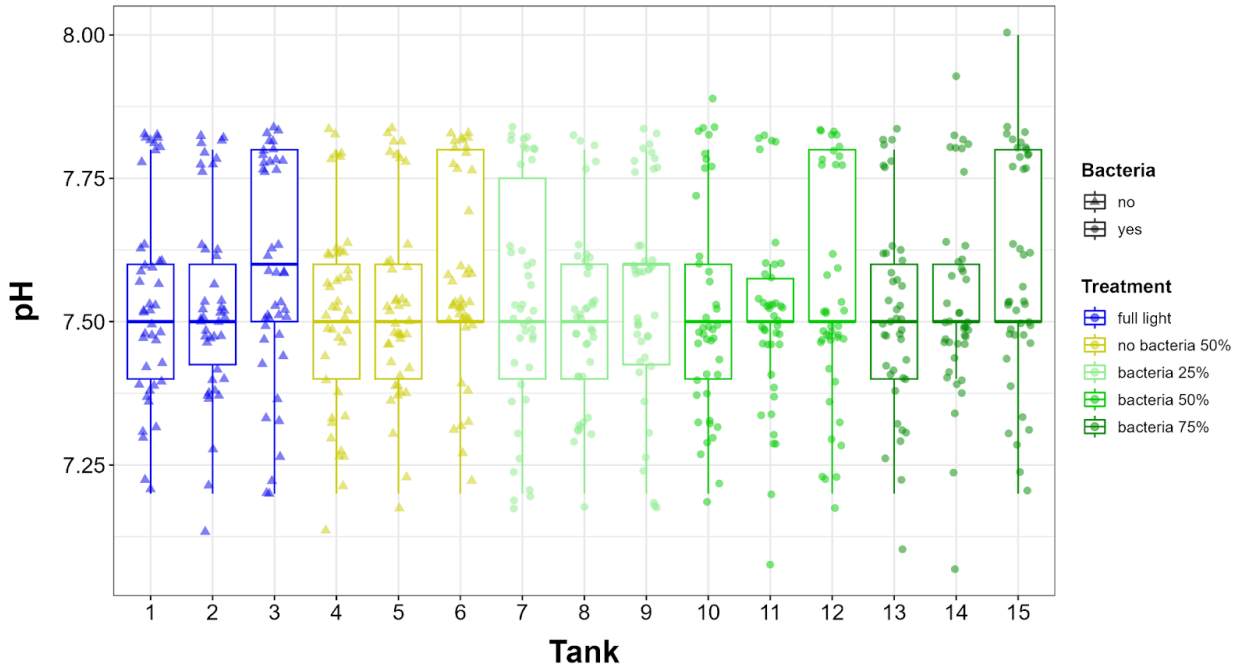


Figure 3. Boxplot of pH (pH) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

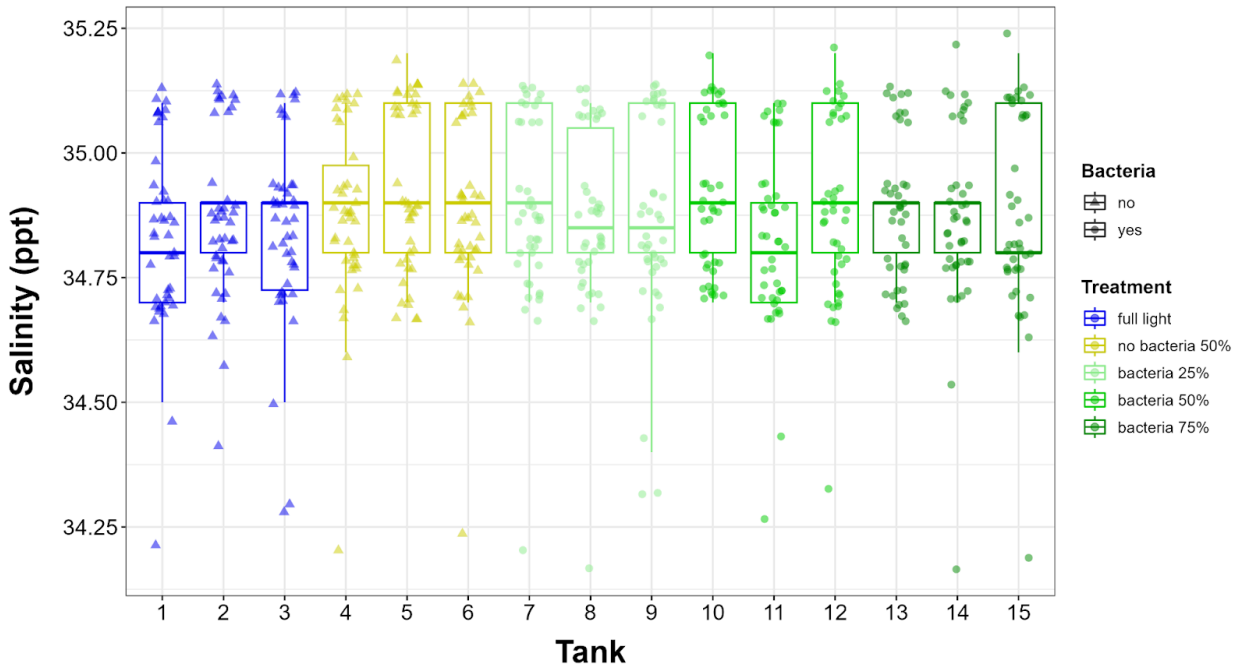


Figure 4. Boxplot of salinity (ppt) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

The line graphs comparing Day vs. Temperature, pH, and Salinity (Fig. 4-6) further provided similar reasoning to the boxplots comparing the Tank vs. the four response variables (Temperature, pH, Salinity);(Fig. 1-3). Figures five through seven demonstrated that the experimental conditions did not change over time. This implies that the experiment was constant and consistent throughout the 21-day experiment. Further strengthening the claim that the Prochlorococcus increased the oxygen (ml/g) within the (green) treatment tanks (tanks one through three and seven through fifteen; Fig. 4-6).

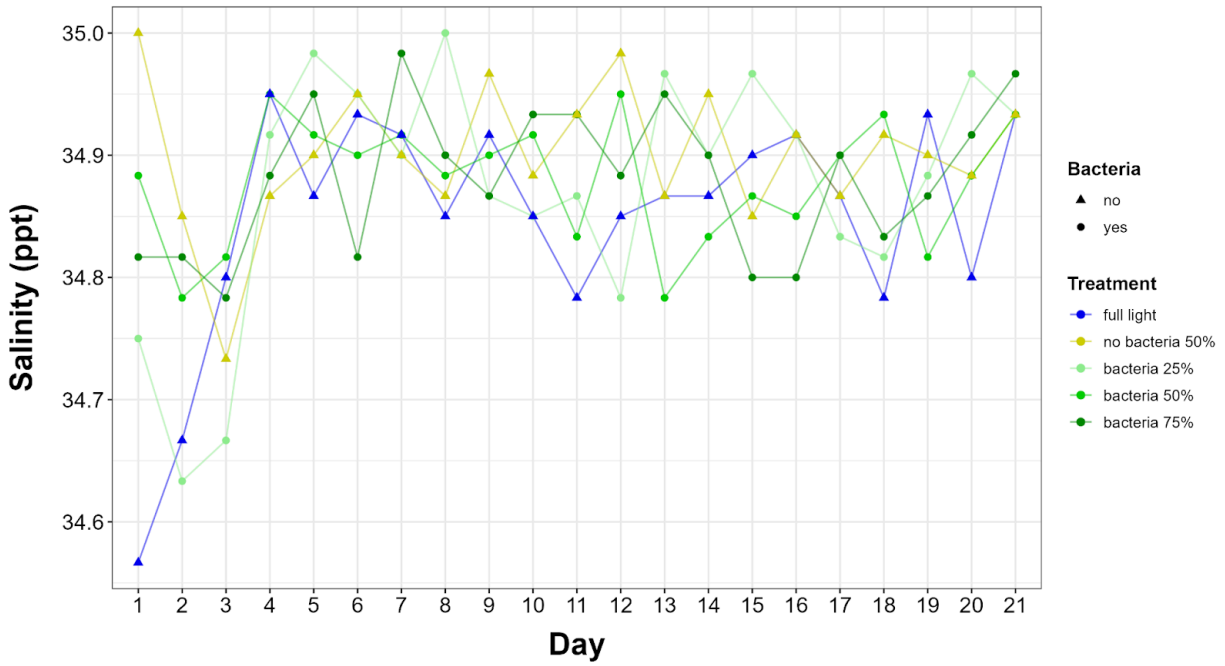


Figure 5. Linegraph of salinity (ppt) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

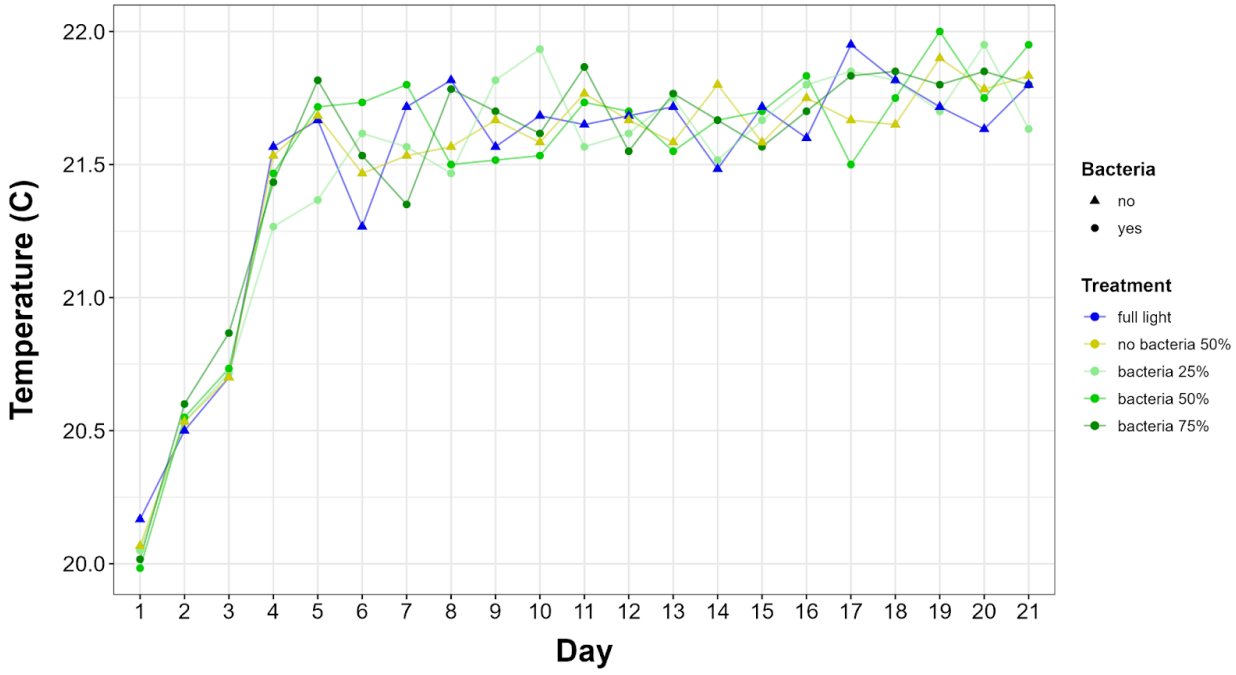


Figure 6. Linegraph of temperature (celsius degrees) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

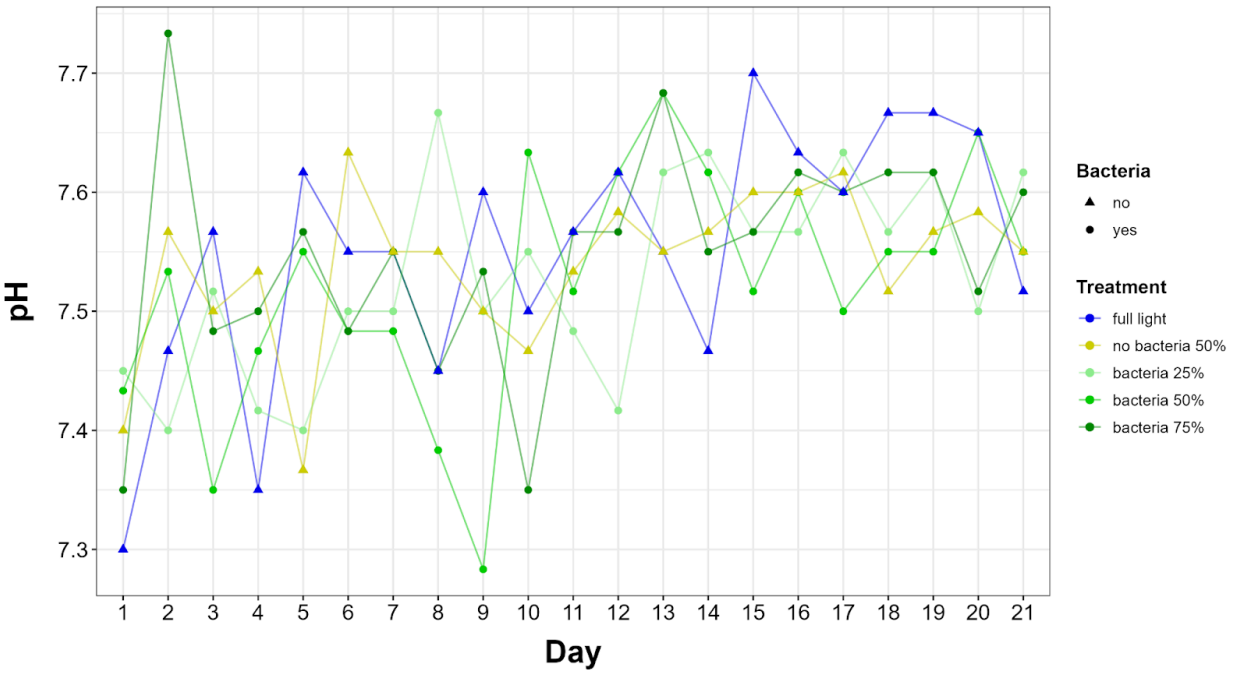


Figure 7. Linegraph of pH (pH) levels over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

Like the above interpretations, the line graph comparing day and oxygen (Fig. 7) supported the conclusion that the addition of Prochlorococcus affected oxygen production in all three treatments in addition to the absence of bacteria and 50% light showed a significant decrease in oxygen production. f showed a steady increase independent of time, supporting the conclusion that bacteria contribute to oxygen production that nearly satisfies full light conditions (25% in full light treatment vs. bacteria); again (Fig. 7). This is evident as early as day 6, and only increases with time (Fig. 7). The treatment box with oxygen (Fig. 6) is similar to the above interpretation, and supports the claim that bacteria included in this treatment are beneficial for oxygen production as it also indicates that affect bacterial treatment is evident regardless of time (Fig. 6).

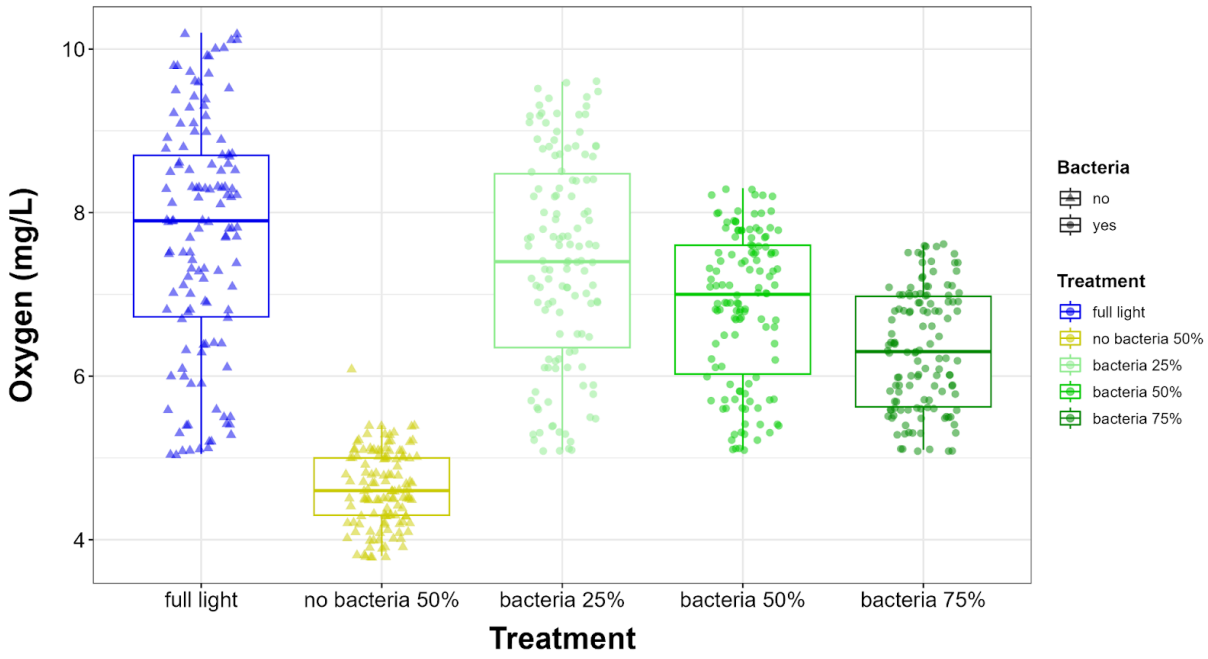


Figure 8. Boxplot of oxygen (mg/L) production over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

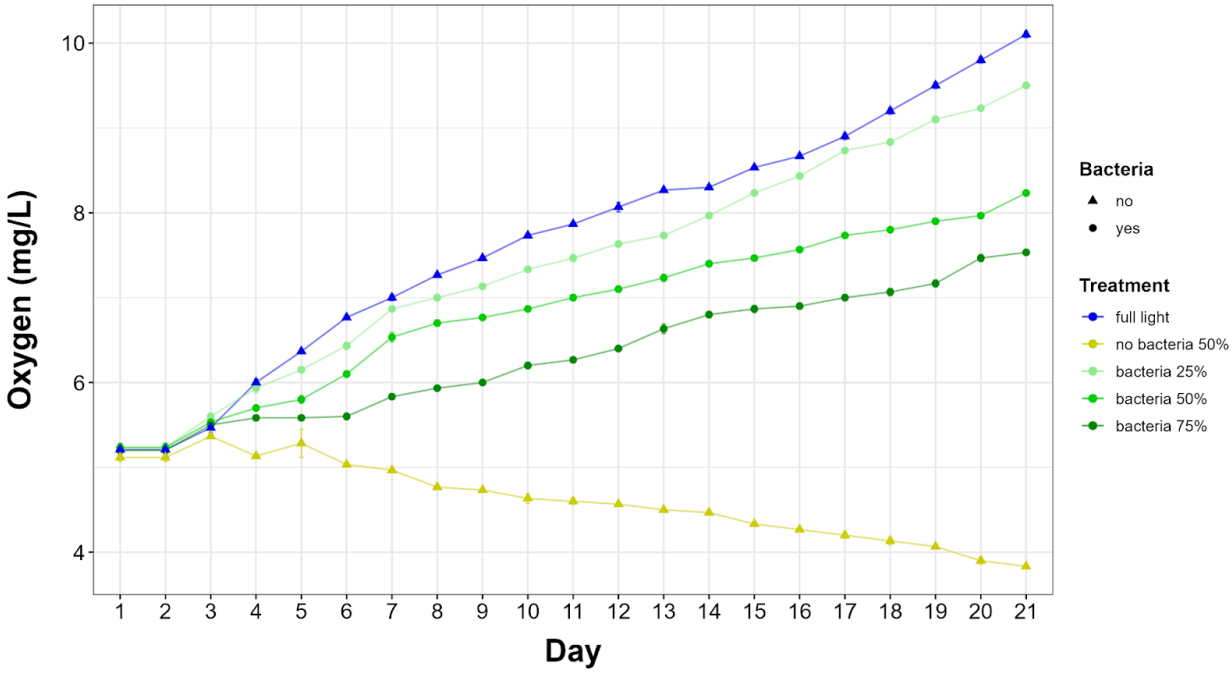


Figure 9. Linegraph of oxygen (mg/L) production over time (days). Bacteria presence in each treatment is indicated by shape and treatment is indicated by color.

Discussion

The purpose of this experiment was to determine if the Cyanobacteria Prochlorococcus marinus could be a viable solution to resuscitating aquatic ecosystems that face hypoxia due to high levels of turbidity. If found true the method of using photosynthetic organisms, particularly Prochlrococcus marinus may prove to be a viable solution for environmentalist and governmental agencies who spend large amounts of money each year on prevention and mitigation such is the case with the Australian Government which used 8.2 billion dollars by 2025 on cleaning up the Great Barrier nearly eight times the amount set up the year prior where one billion dollars was set aside for nine years from 2022-2023 to 2029-2030 (APH, 2022). Current methods against hypoxia and high levels of turbidity merely stop at the prevention and mitigation of sediment runoff from reaching these aquatic ecosystems neglecting areas that already are experiencing these detrimental conditions. However, with this study, there may be an innovation and possible solution to tackling these low-light/oxygen areas for the Great Barrier Reef. The original hypothesis stated that when Prochlorococcus marinus is exposed to high levels of turbidity-mimicked conditions via UV light blockage, it will positively affect ecosystems by producing equal or similar levels of oxygen (ml/g) to low turbidity level treatments that are not exposed to Prochlorococcus.

However, the results of the study cannot be immediately implemented as a permanent fix solution. The current experiment done was in a closed ecological system the approximation to material closure which requires methods for regenerating air, and water and producing food (SD, 2015). As such the experiment has its limitations in only simulating an aquatic environment; it does not account for natural factors (i.e. waves and the frequent water circulation) found in a normal marine ecosystem. These limited environmental factors pose the question of the scale of application that this study may apply to a larger scale (river, lake, or ocean) whether the same results can be achieved based on scalability, and if the effectiveness of Prochlorococcus can stay the same.

Future work should focus on applying Prochlorococcus marinus to actual marine ecosystems that currently face hypoxia to see whether the same results can be achieved in comparison to this study. Regardless, a strong correlation is observed between oxygen production (mg/L) at low turbidity sites (tanks one to three) and the presence of Prochlorococcus marinus (tanks seven to fifteen) indicating that when exposing Prochlorococcus marinus to high levels of turbidity-simulated conditions. This study has begun to discuss Prochlorococcus and its potential use as an alternative for restoration against hypoxia due to high turbidity.

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Optimizing Pharmaceutical Wastewater Treatment: A Comprehensive Review and Unique Experimental Insight By Arnav Muthali

Abstract

The increased production and consumption of pharmaceuticals to combat evolving diseases, bacterial infection, and generally as a treatment for elusive ailments (i.e. psychiatric treatments for Alzheimer's), results in higher concentrations of pharmaceuticals in the natural environment both from production processes and human waste. This issue, while seen at a greater effect on a local level (concerning the production facility), can potentially become a global issue through the alteration of ecosystems. Here, we analyze conventional treatments for pharmaceutical wastewater treatment, which are classed under Advanced Oxidation Processes, Bio-activated methods, and treatments that involve separation methods. These treatments are then evaluated for their pros and cons when dealing with pharmaceutical wastewater. We conclude by creating an experimental treatment solution after we evaluate the standard wastewater treatment solutions that are considered staples and proven to work in breaking down organic compounds.

Introduction

Medicine as we know it has evolved to not only better human ailments but also advance human health, leading to transformations in the medical field. However, the impact medicines and pharmaceuticals can have on the environment is often overlooked. Pharmaceuticals, such as antibiotics and steroid hormones, are chemical compounds that are produced to be used as medicinal drugs, and their environmental effects are becoming rapidly well-known [1,2]. It has been revealed that 3000 different (i.e. not natural) chemical substances are used in medicines. When those are exposed to the environment they can have toxic effects, such as behavioral changes or immune system compromisation, on most organisms, from humans to fish. They cannot be removed by traditional wastewater treatment methods [3].

Figure 1 below shows how pharmaceuticals enter the environment [4]. Regardless of the route of pharmaceuticals into the environment, the presence of pharmaceutical waste in the environment has detrimental effects on environmental and human health, in the forms of antibiotic resistance and behavioral changes for aquatic organisms.

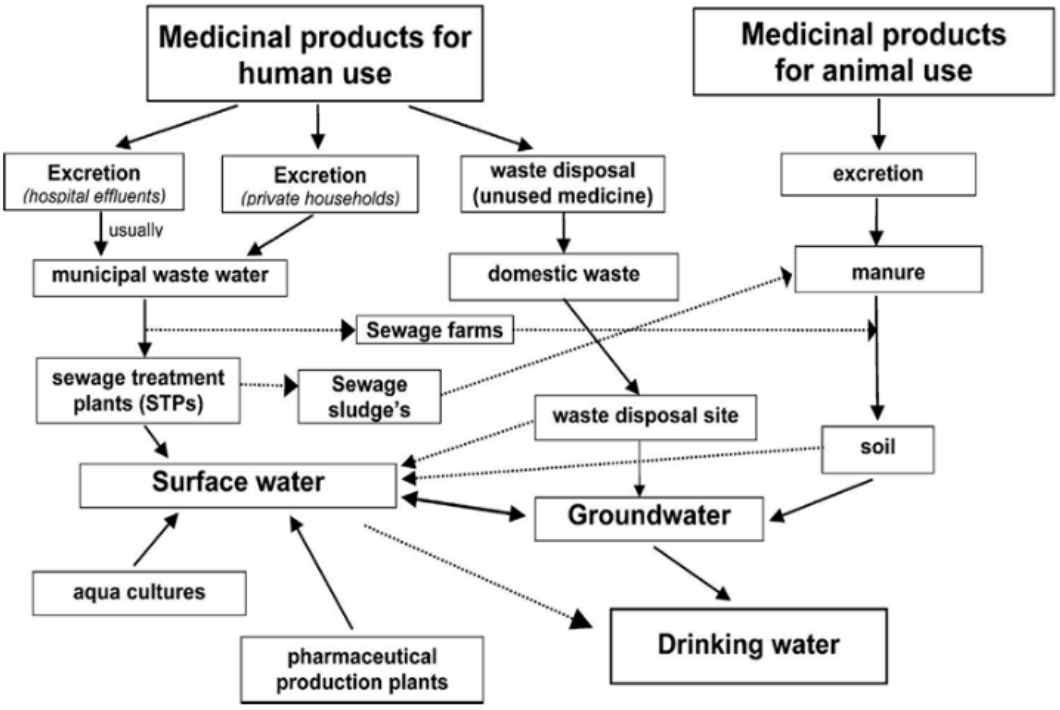


Fig 1. Routes of Pharmaceutical Waste into the Environment, taken from Ganiyu et al. (2015)

Pharmaceutical waste arises largely from pharmaceutical production plants, wastewater treatment plants (WWTPs), and landfills [5]. Due to the avenues of exposure, Active Pharmaceutical Ingredients (APIs) have become widespread in waterways, and are present in 80% of 47 groundwater sites and 139 surface water sites, found and researched across the United States [6]. Contrary to earlier research findings on the environmental impact of pharmaceuticals [7,8], recent studies have delved deeper into their effects, especially in aquatic environments. This newer literature emphasizes the tangible effects in these settings, highlighting the influence of pharmaceutical waste. The connection lies in molecular pathways shared between the environment and humans, revealing how pharmaceuticals affect both [9].

Pharmaceutical contamination has been shown to damage aquatic ecosystems [10]. Aquatic life, primarily fish, that has been exposed to pharmaceutical waste show changes in behavior, such as inhibitions of reproductive activity and reduction in activity necessary for survival, subsequently leading to a decrease in feeding [11,12]. In a different study, various fish species have exhibited inhibitions of cardiovascular systems (at greater than 10 μg/L) and reproductive functions (between 1–100 μg/L) due to ibuprofen throughout their habitat, with sub-lethal effects occurring within measured concentrations at 0.37–0.85 μg/L [11,13]. Prozac, an antidepressant, was found to have behavior changes in freshwater fish, such as territorial aggression, decreases in growth, feeding rate inhibition, and inhibition of predatorial activities at low concentrations [13]. These studies show that, even though the effects are not lethal, even at low concentrations (environmental concentrations of "acceptable" pharmaceutical waste typically being at 0.1 –185

μg/L [11]) of pharmaceutical entry (through hospitals, production plants, households, all viable sources) into aquatic life behavioral changes like these are prevalent, which can lead to a disruption of ecosystems and long-term potential of environmental devastation.

It's been discovered that aquatic life and ecosystems are affected by pharmaceutical deposits, but that water is also fed on by other organisms, which are affected as well. Organisms reliant on open water sources (e.g. lakes, rivers) affected by pharmaceutical waste, experience antibiotic resistance to viruses [14]. Antibiotic-resistant genes (ARG) will proliferate in humans in the event of exposure to high non-lethal concentrations of pharmaceutical wastewater and pharmaceutical compounds [15,16]. Antibiotic resistance will affect the immune systems of organisms at a local level, preventing them from fully fighting common diseases, as those diseases will be able to resist the medicine that is meant to eradicate them.

Given the negative impacts of pharmaceutical contamination of waterways, treatment methods to break down or remove pharmaceuticals are required. Advanced Oxidation Processes (AOPs) and Bio-activated methods are commonly used to break down pharmaceutical compounds. AOPs generate radicals that break down APIs while Bio-activated methods use bacteria and other microorganisms to facilitate oxidative breakdown.

A possible solution to pharmaceutical wastewater treatment would be combining various types of established treatments, possibly including their complementary treatments (should they be necessary for requirements), and establishing them together so that these combined treatments complement each other well. Simultaneously, I will be theorizing how best to alter these already-established treatments so that their drawbacks are mitigated or completely eliminated.

Section 2- Types of Waste Treatment Solutions

For wastewater treatments to be successful in removing APIs, the treatment must be economical, non-toxic, and have versatile scalability. Current methods, while effective across a wide range of pharmaceutical compounds, fail in their applicability on target sources, either due to issues with versatility, purification effectiveness, or the production of toxic byproducts. In the following subsections, I will explain the working principles and highlight the effectiveness and limitations of radical-based, bio-, and separation-based treatments.

Radical-Involved Treatments

AOPs are oxidation reactions that make use of radicals, specifically the hydroxyl radical, to oxidize and aid in the breakdown process of biochemical molecules [17]. Hydroxyl radicals (·OH), differ from hydroxide ions (OH^-) primarily in their electron configuration. Hydroxide ions possess an overall charge of -1, whereas an unpaired electron on the oxygen atom characterizes ·OH. This characteristic makes radicals extremely reactive, which makes them an excellent species for pharmaceutical wastewater treatments due to their effectiveness in dealing with wastewater. Figure 2 below, which is adapted from[18] gives a general overview of radicals' effects on Pharmaceutical and Personal Care products (PPCPs) and pharmaceutical compounds. The diagram shows the different types of AOPs and how they are applied to the breaking down

of pharmaceuticals. These different treatments are applied to wastewater samples to make pharmaceutical degradation more efficient.

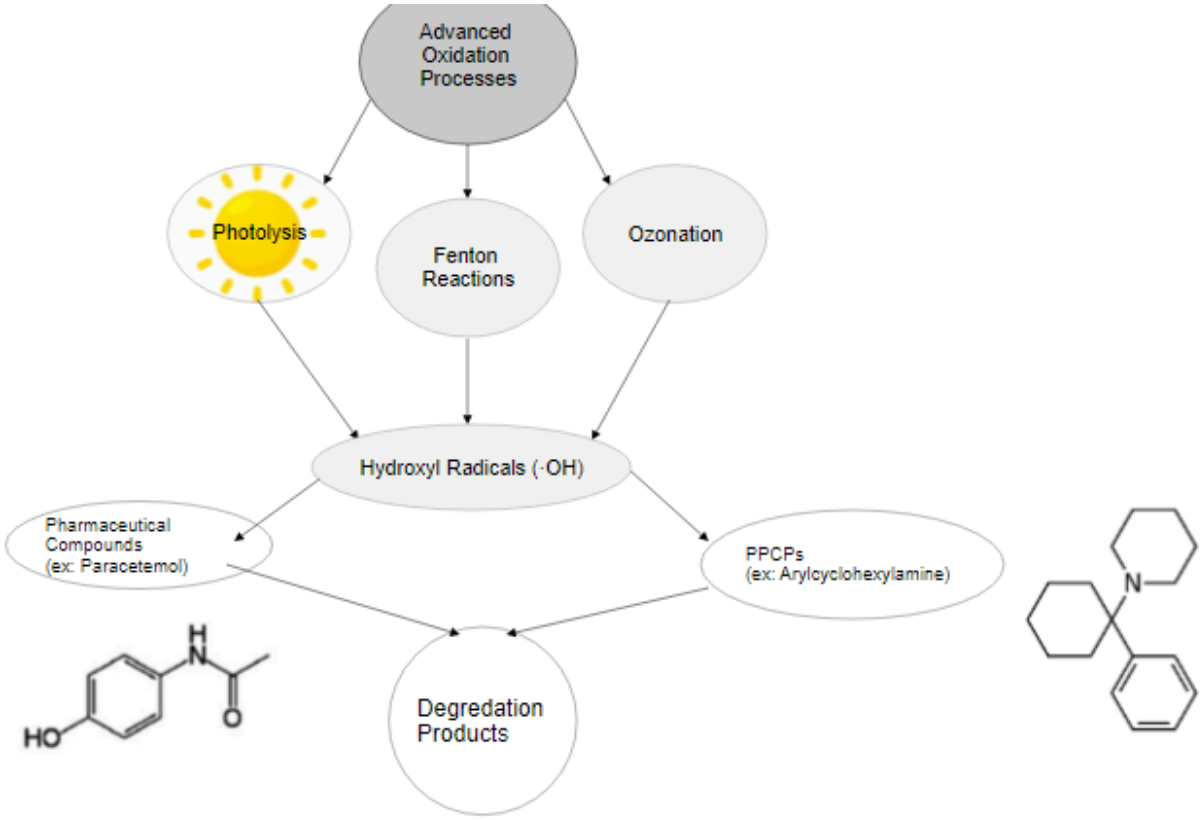


Figure 2: Process flow of pharmaceuticals and PPCPs through AOPs, adapted from Krishnan et al

Photolysis is a stable staple in wastewater treatment of organic and/or pharmaceutical compounds. There are two types of photolysis, direct and indirect. Direct photolysis involves the degradation of a compound through direct absorption of UV light (either direct sunlight or a UV lamp), while indirect photolysis occurs when the compound reacts with another substance that has absorbed light, leading to degradation. Direct photolysis, which is particularly effective for APIs, is the preferred approach [19]. It's demonstrated by a successful experiment using an ultraviolet lamp to break down 2-chloropyridine, a pharmaceutical effluent component, in just 20 minutes [20]. A general direct photolysis treatment starts with an entrance of influent through a reactor with a UV lamp and is pumped into a biological aerating filter (BAF), then through a filter and into a water tank [21].

Photolysis has a low efficiency in breaking down APIs. For example, indirect photolysis accounted for 38% of the degradation of sulfamethoxazole, while direct accounted for 48% [22]. Given the higher degradation efficiency of direct photolysis, this is more useful for the proposed

solution than indirect photolysis. To combat the low efficiency of direct photolysis, photolysis needs to be catalyzed/paired with a complementary reaction such as the Fenton reaction.

Fenton reactions are the involvement of an iron catalyst in a solution of hydrogen peroxide (H_2O_2) to create radicals. Photolysis when coupled with Fe (III) and H_2O_2 or TiO_2 can be more efficient than the treatment on its own, as it's shown to remove over 98% of pharmaceuticals including estrogens [23,24]. Fenton reaction mechanisms involve, in the presence of excess iron, the following reactions:

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + HO\bullet$

$Fe^{3+} + H_2O_2 \rightarrow HOO\bullet + Fe^{2+} + H^+$

$2H_2O_2 \rightarrow HOO\bullet + HO\bullet + H_2O$

Here, excess H_2O_2 following the reaction is decomposed into diatomic oxygen and water, which is later converted into hydroxyl radicals to break down APIs. Superoxide molecules (O_2^-), which are formed via partial reduction of molecular oxygen (O_2), can recycle Fe^{3+} back to Fe^{2+} at the reaction's end by donating its electron to Fe^{3+} in the following reaction:

$Fe^{3+} + O_2^- \rightarrow Fe^{2+} + O_2$

This makes Fenton reactions reusable. Fenton involves the preparation of $Fe(ClO_4)_2$ under molecular nitrogen (N_2) [25].

The photoreduction of Fe (III) to Fe (II) is aided by UV, which is helpful for water treatment due to the non-toxic nature of iron. Complete oxidation does not require UV, enabling the procedure to work without sunlight as well, but it does help enhance Fenton reactions [26]. This works on a larger scale since the conditions can be met without a complicated setup that simulates specific pressure and temperature conditions, implying that this can work at normal pressure and room temperature [27]. The downside is that there is a need for an aqueous solution system with a pH requirement between 2-4 to make hydroxide radicals, as well as a need to regulate and control the concentrations of hydrogen peroxide & ferrous ions, as well as facilitate the disposal of the iron sludge [28]. Fenton reactions can be used partially to make a non-toxic biodegradable intermediate and then treated with another biological step for complete oxidation [29].

An example of the efficiency of Photo-Fenton (PFP) reactions is in an experiment to break down the analgesic drug Dipyrone (DIPY), which quickly hydrolyzes to 4-methylaminoantipyrine (4-MAA), where Photo-Fenton reactions on 4-MAA had a 96.4% removal, which lasted around 45 minutes after an 83.2% removal rate after 2.5 minutes [30]. The setup involved a large 1.0 L reaction vessel in which 400. mL of DIPY (later hydrolyzed to 4-MAA) was added, afterward Fe^{2+} ions were added & following 5 minutes of magnetic stirring, the H_2O_2 was added. For the PFP experiment, the reaction vessel was put under a UV lamp to activate the peroxide and enhance the formation of radicals [30]. This experiment concluded that the technology and processes used for pharmaceutical wastewater treatment and mineralization are promising [30]. The versatility in these experiments can, as well, be applied to different targets of organic waste in water.

Ozonation works as a treatment due to its strong disinfection and sterilization properties [31]. The hydroxide radicals and the ozone (O_3) molecules that help in a chemical attack increase the oxidation capacity of the wastewater [32]; thus making ozonation a staple for wastewater treatment. A general ozone wastewater treatment starts with the entrance of wastewater to an ozone contact column where it is met with ozone. Following the reaction the water is transported to a tank, and then the effluent is filtered out following a biofilter, while the ozone is released into the atmosphere [33]. Fig. 3 below shows the system, with a granular activated carbon (GAC) filter that helps to eliminate compounds contributing to the further mutagenicity of the water [34].

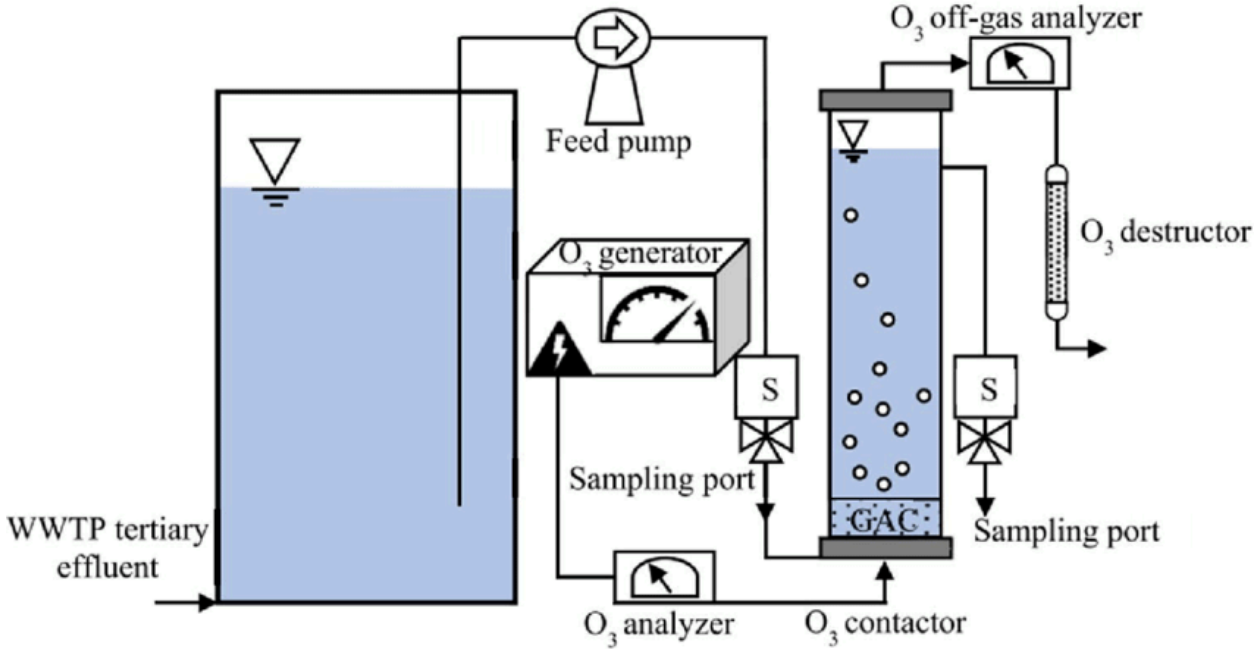


Fig. 3- Wastewater treatment via ozonation mechanism, taken from Uddin et al. 2021

Complementary reactions can be added onto the main treatment to either make the process more efficient or counteract any toxic byproducts as a result of the treatment [35]. Even with the addition of complementary reactions that will provide depth and safety to the treatment, organic compounds containing amides remain resistant to the treatment(s), as only aromatic compounds, amino groups, and other compounds containing a double carbon bond (C=C) are susceptible [36]. A study of ozonation attacks on amoxicillin showed that the phenolic ring was broken down, causing the formation of hydroxyl derivative intermediates. Sulfur, an element present in amoxicillin, was not oxidized in the treatment of amoxicillin [37]. Ozonation's limitation is that the compounds being treated are not fully oxidized, which provides a route for harmful byproducts to be created, such as bromate. By-product bromate is formed when the water source contains a source of bromine, which is a possible carcinogen [38]. Other harmful byproducts, such as *N*-nitrosodimethylamine, and *N*-nitrosodimethylamine (NDMA), was also reported in drinking water ozonation [39]. This results in the need for an additional treatment, such as sand filtration, to deal with the harmful products. Due to ozone causing the reduction of the microbial count, odor,

color, and foam, this causes multiple reactive oxidation products to be generated, meaning ozonation as a whole is expensive, as the detoxifying treatments following are additional costs [40]. Overall, while ozonation is effective as a treatment, it is not what we want for an experimental solution to wastewater treatment, due to the need to be paired with other treatments to be effective (which means higher costs), the incapability to attack amides, and the toxic byproducts that are a result of the treatment.

Bio-Activated Treatments

Activated sludge is a form of treatment where excretion and waste products are related to the target effluent. The downside to this treatment is the inability for the treatment to be done on-site, leading to multitudes of wastewater effluent being shipped to activated sludge plants, causing operational issues such as color, foaming, and bulking in secondary clarifiers, which separate the suspended solids from the wastewater [41]. This also requires high energy consumption and the tons of sludge produced for this purpose [42]. Efficiency is also inhibited by temperature or pH changes, dissolved oxygen, organic load, microbial community, and toxic or recalcitrant substances [43,44]. Figure 4 provides an overview of how activated sludge treatment works. Wastewater is fed through a grid, as solids are removed and the sludge is added to the water to rid it of organic compounds, and following filtration and disinfection, the effluent is released [45].

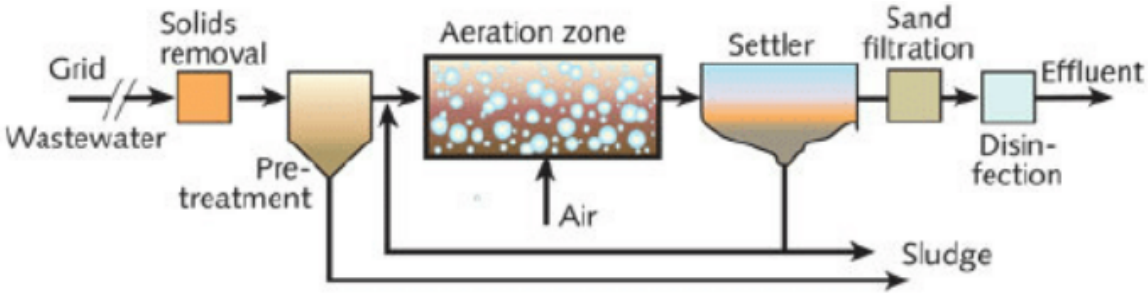


Fig. 4 A simplification of Activated Sludge Procedures taken from Pandey and Singh

This was seen in a wastewater treatment plant in India, called Patancheru Enviro Tech Ltd (PETL), where activated sludge was used on pharmaceutical water samples [14]. Overall, activated sludge is neither sanitary when the water source is for sustenance, nor is it good enough to remove APIs and other pharmaceutical constituents in water [1]. Activated sludge works by utilizing the bacteria in the biomass (feces, scat, etc.) to break down organic molecules in a biologically friendly way. Moreover, the treatment cannot work on-site, as large amounts of activated sludge will need to be transported or transportation of sludge to the target water source to WWTPs would be required [41]. Moreover, the pharmaceutical compounds (in general) that are not broken down in the WWTPs are released back into the environment via the plants, as seen with PETL which shows that the facility is not the only environmental source for poorly treated effluents containing high levels of APIs [14]. All this makes activated sludge and other

bio-activated methods a poor option for the experimental solution to pharmaceutical wastewater treatment.

Separation-Based Treatments

Separation-based treatments involve the use of highly packed filters to separate organic molecules and compounds from water. Adsorption is a separation-based treatment where organic pollutants (even at the trace level) bind to the adsorbent surface. This is becoming a widely used method for sterilizing [3]. Meanwhile, membrane treatments act as filters. Figure 5 below shows a general process flow of separation treatments being used, where separation is being used to treat wastewater [46].

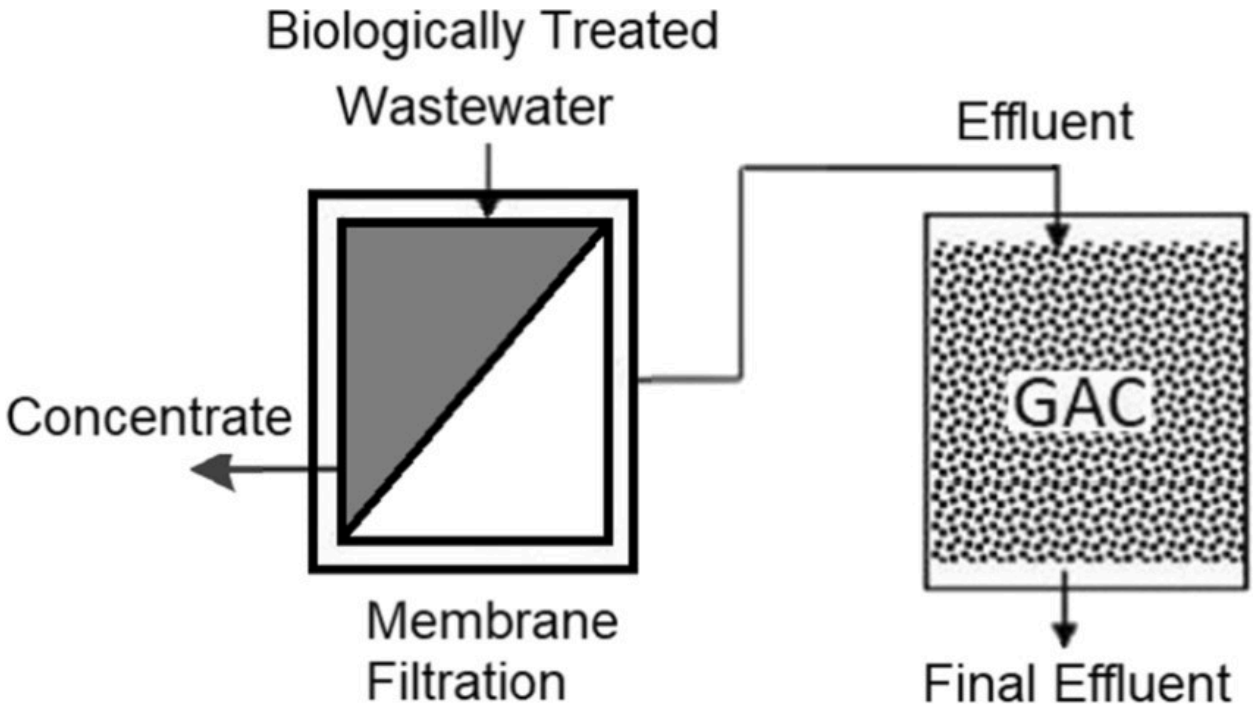


Fig. 5: Membrane Filtration generalized to treat wastewater, taken from [46]

A general schematic of adsorption treatment involves waste being fed into the column, where waste is treated. Following that, the water exits the process [47]. A form of adsorption treatment is called activated carbon, which involves a carbon that has been processed to have low-volume pores for greater adsorption of pharmaceuticals [3]. There are two main types of activated carbon classifications, granular activated carbon (GAC), which excels at continual contact and pollution treater, whereas powdered activated carbon (PAC) while having less contact time, is cheaper and still effective [3]. GACs and PACs target different pharmaceutical compounds, for example, GACs excel at filtering pharmaceutical compounds and

endocrine-disrupting substances (EDS) [48]. Overall, adsorption is an effective removal agent and can be reusable, but the cons of this process are the high costs and oftentimes the need for specialized adsorptive materials, which can be as expensive as $200/mol of substance (and perhaps more expensive), with cheaper and perhaps ineffective ones being as cheap as $1/mol of substance [49].

Membrane treatments are done under the driving force of water, components within the water are driven through a membrane filter and, as a result, the permselective membrane leaves behind the components while the water goes through [50]. A general membrane treatment solution has the wastewater being pumped through a filter, and the purified water exits the process while another round of wastewater is cycled back again through the process [51].

There are four broad types of membrane filtration: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO); these different kinds of membranes differ in filter-pore size (as seen in Fig. 5 below) [52]. NF/RO membranes are efficient in rejecting pharmaceutical particles and substances in the micro size due to the smaller pore structure [52 53]. MF and UF methods are ineffective for smaller particles but are comparable with a larger concentration of pharmaceuticals in the target area [54 53].

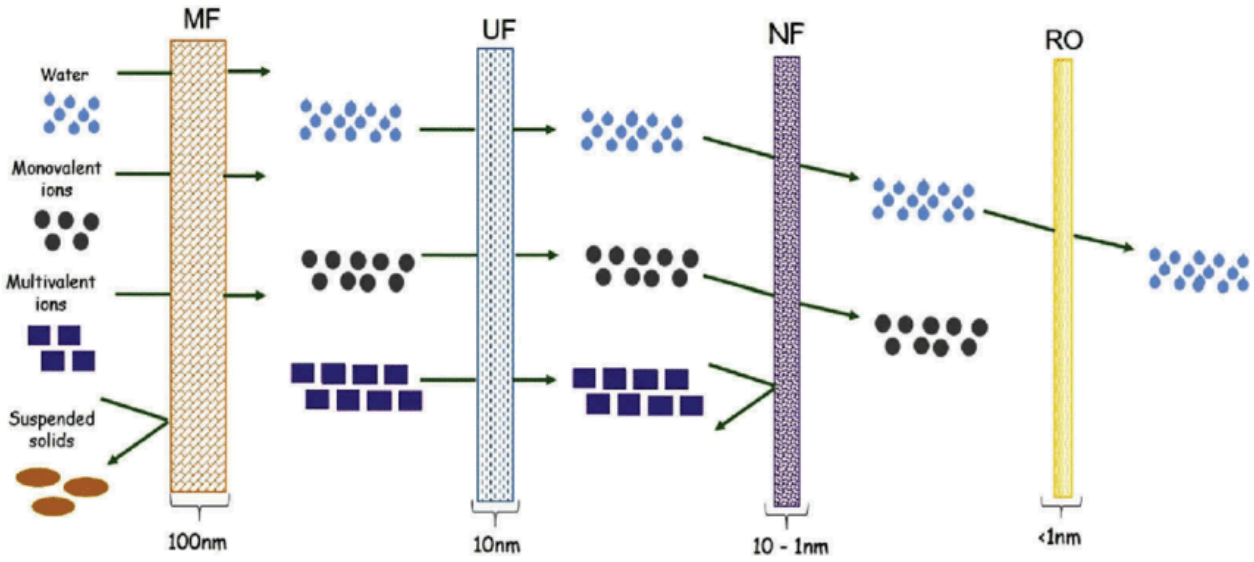


Fig. 5 taken from Syafiqah et al. 2019 depicts the filtration differences between various membranes.

<u>Section 3-</u> Next Steps in R&D

I am seeking an efficient and cost-effective solution that can offer a more generalized approach to API treatment, to reduce resource utilization and mitigate the expense associated with the prolonged practice of transporting wastewater via trucks between the site and WWTPs. Past research done on measuring the effectiveness of pharmaceutical wastewater treatments, as covered above, has been done in isolation, instead of coupling these treatment technologies together. Moreover, this solution must minimize the generation of hazardous sludge. In the

following subsections, I will describe the more common wastewater treatment solutions and their implementation for pharmaceutical wastewater. Here, I will propose further research to test coupling these processes to develop a more effective pharmaceutical wastewater treatment procedure.

An example of this is combined photolysis and Fenton reactions. Direct photolysis plus Fenton reactions involve the use of either sunlight or UV lamp-light. How this experiment works is that, either in the open or in a large reaction vessel, the target water source can have hydrogen peroxide (H_2O_2) plus ferrous salt added, and later can be exposed to sunlight. This can also involve the addition of a UV lamp-light, in case the sunlight procedure either takes too long or is too weak on its own. The process works through the activation of the peroxide by UV light and coupled with the breakdown of the ferrous salt, both reactions begin to form radicals, which aid in the breakdown process.

Utilizing radicals from other AOP treatments to combine with photolysis, which unfortunately does not break down all the organic compounds in the target water source [22]. Prior research has shown that AOPs are non-selective, and are versatile at treating a variety of wastewater (pharmaceutical, activated sludge, etc.). However, a limitation of AOPs is that they perform only at low pH, and when isolated from each other, they are not efficient Including a separation process following AOP treatment could address this limitation. Given that the main goal of this experimental solution is for it to be implemented on-site instead of resources being diverted to factories, adding more strain to an already complicated process. A downside to photo-Fenton procedures is that they perform only at low pH, but this can be combated by using chelating agents to raise the reaction pH of the photo-Fenton radicals to be produced at neutral [55]. Beforehand, the use of photo-fenton would have been ineffective for pharmaceutical wastewater treatment, but with chelating agents such as ethylenediaminetetraacetic acid (EDTA), the reaction can proceed at a neutral pH.

Membrane technology already has made an impact in filtering pharmaceutical waste products out, converting it into reusable water [56]. Moreover, membrane separation can make use of effluent feeding repeatedly through the membranes. However, the problem is with fouling and subsequent cleaning and maintenance of membranes. The most effective and relevant methods for pharmaceutical wastewater treatment are certain physical cleanings, such as pneumatic cleaning (involving air) or ultra-sonic cleaning, which dislodges the particles at the molecular level from the membrane [57]. Biochemical cleaning is also useful, involving enzymes and enzymatic mixtures to stir up and dislodge the particles, but in the case of permanent fouling, chemical cleaning, using various chemical agents, is best used; chemical cleaning can be combined with physical methods as well, seeing enhancements of flux recovery up to 95% [58,59].

Given the past research discussed, I've proposed the following solution to pharmaceutical wastewater treatment:

1. Transfer the water that needs to be treated to transparent reaction vessels via pipes as normal.

2. Add the required concentration of hydrogen peroxide to the vessels, along with ferrous ions as catalysts for the radical production phase.
3. Add chelator agents to the vessels to enable the reaction to occur at a neutral pH instead of an acidic pH as is typical of photo-Fenton reactions.
4. Expose the vessels to sunlight and stir the contents of the vessels with a magnetic stirring rod so that the contents generate hydroxyl radicals for the breakdown of the pharmaceutical compounds in the water.
5. Monitor the mixture via chromatography to see if the reaction has proceeded to completion. Once it has, filter out the water using ultrafiltration membranes or activated carbon membranes.
6. Filter out this water with more membrane filters until it arrives at a small tank for observation purposes.
7. Examine the concentration of this final tank to see if it's as close to purity as possible. If so put it through one more filter and observe the purity again. If not, return it to the reaction vessels for further examination and treatment.

Wastewater treatment solutions are similar to what I have proposed, but they are less sustainable than traditional solutions like activated sludge factories or chlorination. The proposed treatment involves a sustainable energy source, either in the form of sunlight or UV-powered lights that can work efficiently and without mess. The average wastewater treatment plant uses either chlorination (primarily seen in the US) or activated sludge (as seen in India), and while they work, they require shipment of wastewater to a plant instead of being done on-site. Furthermore, not enough wastewater treatment plants use Photo-Fenton reactions due to the acidic pH requirement and the high input of chemicals and iron into the reaction. I address these issues in my experimental solution while providing an avenue for efficiency and sustainability.

We can change the source of hydroxyl radical production by instead having a 10 to 100 W UV lamp (on average) shining directly downwards into the vessel. The lamp will be more useful than sunlight in a lab setting, as it takes around 20-45 minutes to break down an API for a 400 mL aliquot.

The ferrous sludge is a semi-solid that contains ferrous compounds/ions, water, contaminants, pH adjusting agents, and other biological compounds that were initially in the vessels. The superoxide molecules for the Fenton reactions will be an aid in repurposing the ferrous sludge for Fe^{2+} catalysts. The sludge will be difficult to deal with post-repurposing, as it serves no purpose despite its nontoxicity due to the iron. Overall, this is the proposed solution, based on past research, to pharmaceutical wastewater.

Limitations to this solution could possibly be the addition of the chelating agent and maintaining the other pieces of equipment used. While the chelating agent is beneficial, the addition of another chemical to the process (and subsequently the sludge) may have an impact on cleanup. The maintenance of the equipment and potential concerns about reusability will cause the processes to be slow. To begin with, the requirement of sunlight, as this renewable source of

energy is limited depending on seasons and time, and this affects efficiency. Another limitation is the purity of the treated water, as the goal is to make this water safe for drinking, but after going through a chemical-heavy process, the amount of materials and effort involved calls the proposed treatment into question. A final limitation is a cost, as such a proposed experiment will be expensive as an on-site solution, as more conventional treatments can cost 9.56-16.88 €/m³ and 13.46–20.13 €/m³ for Fenton and PFP respectively for the Fe^{2+}/H_2O_2 ratio [60]. The criteria for success are mainly in attaining purity in an efficient process over a certain period of time.

Methods

My approach for research regarding the literature search was specific toward pharmaceutical wastewater treatment. However, initially, I focused on wastewater treatment of organic solvents and compounds due to the conventional treatments that are applied to this issue. Since wastewater treatments are largely applicable across both areas, I saw it best to start researching the less complex scenario before moving to pharmaceuticals, which can contain inorganic substances as well. The system of researching shifted from the effects of pharmaceutical wastewater on wildlife and the environment to the effects of their treatments in solving the issue. By mainly focusing on how pharmaceutical wastewater treatments have evolved, starting from using conventional methods to adding complementary reactions to make the solutions work, I was able to construct this paper. My data was collected based on the effectiveness of physical experiments, which were based on hypotheses on how different solutions would work. This is best seen with PFP, and its effectiveness at only acidic pH levels, but the addition of chelating agents such as EDTA enables PFP to work at a neutral pH, thus allowing a wider variety of pharmaceutical wastewater to be purified. These experiments were conducted based on previous experiments when organic wastewater was an issue in Asian countries. These studies first replicated older experiments to test for viability, then tweaked them to minimize the drawbacks of various treatments. This was best seen with EDTA to PFP. The papers chosen are a mix of old and new, which helps me better understand how the research has evolved over time. Overall, my methodology was choosing a mix of old and new papers that established the problem from organic wastewater to pharmaceutical wastewater, while simultaneously building up research from the past to better show how experiments and treatments have evolved.

Conclusion/Discussion

Past wastewater treatment solutions have been effective in curbing the amount of organic waste being released back into the environment, with sources being from pharmaceutical plants and even wastewater treatment plants, primarily in activated sludge. Having gone through the previously established treatment methods for APIs, the proposed experimental solution, which involves an on-site PFP solution that includes chelating agents to bring the reaction pH to neutral, seeks to combine the positives of all treatment methods mentioned while cutting back on their drawbacks by improving efficiency and lowering the time taken for reactions. The main

goal is to figure out a way to curb organic waste in the environment and in water sources, and the best way to do this is, in the long term, to make pharmaceuticals more environmentally appropriate.

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Medicinal Plants and its Efficacy in Treatment of Bone Cancer By Nikhil Kakarlapudi

Abstract

Cancer is, and has been, a problem worldwide, and it is the cause of the second most annual deaths. Though many methods already exist to help with cancer, there is no cure for all cancers, and the effectiveness of the treatment depends on the person's health. Recently, many tests done by Vivo and Vitro have found that medicinal herbs have chemicals and phytoconstituents, which may be helpful against cancers such as bone cancer in the future. Though some studies suggest its potential in the treatment of cancer, further research and clinical trials must be conducted better to understand the complex structures of thousands of medicinal plants. The current paper reviews ten herbs used worldwide and describes their potential in curing Osteosarcoma while providing the origin, background, biochemistry of cancer treatment, and research and studies. The phytoconstituents mentioned below are essential in cancer treatment as they can induce apoptosis, inhibit cell growth, reduce cell proliferation, and support autophagy and mitophagy of the cell. Further research and studies are required to uncover the true potential of these natural plants and phytoconstituents.

Keywords: Osteosarcoma, Phytoconstituents, Apoptosis, Bone Cancer, Herbs, Autophagy, Mitophagy, Proliferation

Introduction

Medicinal plants have been used for centuries because of their abundance of bioactive chemical compounds and phytoconstituents, which have therapeutic and healing properties. Many medicinal herbs have been used globally for centuries, especially in India, China, and many parts of Africa and South America. Phytoconstituents are natural chemicals in plants that are responsible for protecting the plant from bacteria, viruses, parasites, predators, and the environment. The phytoconstituents present in some of these plants have also been proven by many clinical studies to contain several health benefits, which may range from their anti-inflammatory properties to their ability to help against an array of fatal Cancers **(1)**.

Bone cancer is the term for several cancers that develop in the bones. Bone tumors can be extremely painful, and if this cancer can spread quickly, it can lead to death. The most common type of bone cancer is OsteoSarcoma, which frequently affects adolescents and young adults. Though the exact cause for all the cases of this cancer is unknown, it is believed to be caused by a mutation to the DNA inside bone cells, causing the rapid production of deformed bone cells that attack healthy body tissues **(2)**. In some cases, Osteosarcoma can develop because of radiation therapy to help against other cancers, leading to the damage or mutation of the DNA in the cells **(3)**. The most common treatments for this cancer are surgery and chemotherapy, and in some cases, radiation therapy can be used to lessen the symptoms and help against Osteosarcoma **(4)**. Though these methods may prove effective in some cases, they may also cause various side effects and problems, such as loss of organ function, blood clots, pain, fatigue, and anemia. Chemotherapy can also lead to significant amounts of permanent damage to the organs, such as

the heart, lungs, liver, kidneys, and reproductive system. To avoid the risk of surgery and chemotherapy, we can also use natural methods for curing Osteosarcoma alongside these harsher methods for more effectiveness and efficiency **(5)**. Not only have a variety of medicinal herbs been used for centuries in South America, but they have also been used for almost 5000 years in many ancient Ayurvedic and Chinese practices. These herbs have been used as a natural anti-inflammatory agent, antioxidant, antiviral, antibacterial, and to treat various bodily problems and enhance the body. A study conducted by (**6)** represents a clear correlation between a variety of Ayurvedic, Chinese, and South American herbs with the help of cancer treatment. Many in vivo and in vitro studies have even discovered the positive benefits of these phytoconstituents on various cancers and tumors.

Some of the leading herbal remedies and herbs that have shown a strong correlation against Osteosarcoma, according to **(7)** include turmeric (*Curcuma Longa*) and its bioactive compound curcumin, Japanese Angelica tree (*Aralia Elata*) and polysaccharides, and Barberry (Berberis), and Berberine(Medicinal uses of spices used in our traditional culture: Worldwide). These three herbs, like curcumin, berberine, and polysaccharides, have been shown to have phytoconstituents, which have many health benefits, including anti-inflammatory, antibacterial, and anti-cancer properties. A review article based on previous studies by **(8)** has shown that these plants are also an effective natural treatment method against Osteosarcoma and other bone cancers.

Phytoconstituents effective against treatment of bone cancer.

Turmeric- Curcumin

Curcumin Longa, or turmeric, is a traditional Ayurvedic spice used for almost 4000 years for its medicinal benefits. According to the National Library of Medicine, curcumin longa has been proven extensively in both vitro and vivo test studies, which have shown that turmeric has anti-inflammatory, anti-viral, anti-bacterial, antioxidant, and anti-cancer properties **(9)**. These properties of Curcumin Longa have been traced back to its main bioactive compound, curcumin, a phytoconstituent that can be attributed to turmeric's many health benefits. Curcumin has also been shown to inhibit apoptosis and inaugurate the p53 gene, which can cause the rapid and uncontrollable growth and duplication of deformed cells, causing cancer **(9)**. The mutation of the p53 gene is one of the leading causes of many types of cancer, and it is one of the causes of Osteosarcoma. The study conducted by (**10)** has shown the phytoconstituent of curcumin longa, curcumin to aid in apoptosis, which is cell suicide. This process is essential in maintaining control over cells and subdues tumorigenesis in many ways. It does this by gathering and killing cells at risk of mutation **(11)**.In vitro studies have shown that curcumin can decrease the proliferation of osteosarcoma cell lines and mend bone deformities. A promising option for treating osteosarcoma is curcumin **(12)**.

Cucurbitaceae- Cucurbitacins

Cucurbita is an herb belonging to the gourd family, and it is most commonly known as squash, pumpkin, or gourd. It is native to Ethiopia and has been used as a traditional herbal medicine. The ancient use of this herb can be dated back thousands of years in many parts of Ethiopia. Many of the plant species in this family contain a phytoconstituent known as Cucurbitacins, which contains many anti-tumor, anti-proliferative, antiviral, and anti-cancer properties **(13)**. **(14)** classified the naturally occurring cucurbitacins into cucurbitacin A, B, C, D, E, F, I, L, 23, 24 dihydro cucurbitacin F, and hexanorcucurbitacin F, as well as the three acetylated derivatives. The eight most active cucurbitacin components against cancer are cucurbitacin B, D, E, I, IIa, L glucoside, Q, and R **(15)**. Their modes of action include antiproliferation, migration and invasion inhibition, apoptosis promotion, and cell cycle arrest. Unlike radiation therapy, chemotherapy, and surgery, using natural herbs like Curcubrain has little to no side effects, and the side effects they do have are incredibly minor. According to a study **(16)**, Cucurbitacin E reduces osteosarcoma cell proliferation and invasion by inhibiting the PI3K/AKT/mTOR pathway, suggesting that it could be an effective potential treatment candidate against osteosarcoma in the future.

Polygonum cuspidatum- Resveratrol

Polygonum cuspidatum, also known as Japanese Knotweed, Reynoutria japonica, or Fallopia japonica, is a species in the knotweed and buckwheat family. This herb is native and cultivated in many parts of East Asia, including Japan, China, and Korea. It is an East Asian plant with many phytoconstituents and bioactive compounds, including Resveratrol, flavonoids, emodin, anthraquinones, and piceid. Although this plant contains a wide range of abundant chemical compounds, the most prevalent is Resveratrol. Resveratrol has been found to have various other medicinal benefits, including anti-inflammatory properties, cardiovascular protection, and neurological problems **(17)**. In addition, Resveratrol helps to protect against and aids in lessening symptoms of diabetes, obesity, Alzheimer's disease, liver diseases, Parkinson's disease, and many cancers, including Osteosarcoma **(17)**. According to a review by **(18)**, Resveratrol showed anti-tumor properties and hence can be thought to be helpful against Osteosarcoma. Clinical studies conducted by **(19)** displayed the ability of Resveratrol to inhibit cell growth of cancerous cells, leading to a reduction in the cell proliferation of osteosarcoma cells, which have had mutations in the osteoblasts and osteoclasts.

Banaba- Corosolic Acid

Banaba, scientifically known as Lagerstroemia Speciosa, is a part of the Lythraceae family. *Banaba* is a tree that has many bright pink flowers. This herb is native to Southeast Asia and is mainly used in many parts of India, the Philippines, and Malaysia. Tribal groups have been using different parts of the banaba tree, which includes the leaves, flowers, and bark, for medicinal purposes **(20)**. In Southeast Asia, Banaba is mainly called jarul, or Giant Grape Myrtle. The two main phytoconstituents in banaba are corosolic acid and ellagitannins, responsible for their many medicinal benefits and ability to help against osteosarcoma. The more

prevalent of the two phytoconstituents of banaba is corosolic acid, which is the main reason for its anti-cancer properties and ability to reduce proliferation and stimulate apoptosis **(21)**. An osteoblast is a cell that forms bone tissue and synthesizes and secretes bone matrix. A mutation to an osteoblast leads to cancer in bone marrow stem cells through a series of events. Studies reviewed by **(22)** have shown corosolic acid's ability to induce apoptosis, killing mutated osteoblasts or osteoclasts, which may cause bone cancer.

Barberry- Berberine

Berberine is a phytoconstituent found in many herbs, including *Berberis vulgaris, Berberis aristata, Berberis aquifolium, Coptis chinensis, and Hydrastis canadensis.* This chemical, however, is most commonly found in Berberis Vulgaris, most commonly known as European Barberry. European Barberry is a large shrub in the Berberis genus, and it is mainly found and grown in Northern Europe, Canada, and some parts of the United States. Barberry has been proven to have anti-inflammatory, immunomodulatory, anti-tumor, and anti-cancer properties through its many bioactive chemical compounds, such as berberine **(23)**. A study performed by **(24)** sought to validate the anti-cancer properties of berberine, and they used many methods and concentrations utilizing berberine in order to demonstrate its inhibitory effects when dealing with an array of cancers, mainly focusing on Osteosarcoma. They first used different concentrations of berberine for either 24 or 48 hours on Mg-63 cells, which came from a 14-year-old male with Osteosarcoma. They then found that berberine decreases the viability of osteosarcoma cells, and they deduced that berberine also had inhibitory effects on the Mg-63 cell proliferation because of its ability to decrease the viability of these cancerous cells. Next, the radiosensitivity of berberine was tested with the use of different amounts of irradiation, and the results showed that berberine lessened cell viability dramatically **(25)**. The study previously explained supports berberine's medicinal benefits against Osteosarcoma as it inhibits cell proliferation and enhances the radiosensitivity of the osteosarcoma cell.

Olive Tree- Oleuropein

The Olive Tree, scientifically known as *Olea europaea*, is a species of small tree and a part of the Oleaceae family. This tree is indigenous to the Mediterranean area, and its fruit, bark, and leaves have all been used for medical purposes. This herb is an anti-inflammatory, anti-bacterial, antidiabetic, antihypertensive, and antipyretic agent **(26)**. The olive tree's medicinal value can be traced back to its biochemistry, as it contains various chemicals and phytoconstituents present in all parts of the tree, which can be determined to understand the medicinal properties of the Olive tree. The chemicals present in the leaves include hydroxytyrosol, tyrosol, rutin, and Oleuropein; in the fruit, phenyl acids, flavonoids, and secoiridoids; and the bark, hydroxy coumarins, secoiridoids, flavonoids, LMWPs, and cinnamic acid derivatives **(27)**. The main chemical responsible for this herb's potential in the prevention and treatment of cancer is Oleuropein, a phytoconstituent extracted from olive tree leaves. A study performed by **(28)** to determine Oleuropein's medicinal properties against an Osteosarcoma cell, MG-63, discovered that when the Osteosarcoma cell was isolated, and different amounts of

Oleuropein were used to dissolve and kill it, this method proved to be effective in killing the cell while inhibiting cell proliferation. More studies regarding Oleuropein's effect on Osteosarcoma have determined that Oleuropein supports the process of autophagy, which removes the unnecessary and dysfunctional components of the cell through degradation **(29, 30)**.

Flemingia vestita- Genistein

Flemingia vestita, more famously known as sophlang, is a herb that belongs to the Flemingia genus. *Flemingia Vestita* originates from India and China and grows along the Himalayan mountain ranges. Traditionally, this plant has been used to help treat stomach ailments, menstrual problems, intestinal worm infections, and inflammation **(31, 32)**. The many medicinal benefits of *Flemingia vestita* can be traced back to its many phytoconstituents, some of which include genistein, daidzein, formononetin, and pseudo baptigenin. More studies focused on the medicinal benefits of this herb have supported *Flemingia vestita'*s potential in treating cancer and suppressing tumors through one of its main chemical compounds, genistein **(33)**. Genistein is a chemical compound that is a part of the isoflavones class, and it has been found in many studies to help against many cancers, including Osteosarcoma **(34, 35)**. A study by **(36)** used genistein extracts and performed many tests with these chemical and osteosarcoma cells. They found that genistein induces cell proliferation and helps with killing cancerous cells. The study also found that genistein can induce cellular differentiation of LM8 cells and emphasized its potential as an anti-metastatic in combating Osteosarcoma.

Garcinia indica- Garcinol

Garcinia indica, more commonly known as kokum, is a plant in the mangosteen family. This tree bears a fruit consumed by many of the natives and is believed to have anti-inflammatory and anti-viral properties. This herb originated in India and is indigenous to the many tropical forest regions in South Asia. *Garcinia indica* is mainly cultivated and grown in the Indian states of Maharashtra, Goa, Karnataka, and Kerala. Garcinia Indica is an anti-inflammatory agent that treats dermatitis and diarrhea, promotes digestion, and helps prevent many cancers **(37, 38)**. The many benefits that kokum contains can be better understood through the many chemicals and phytoconstituents present in this herb, including garcinol, hydroxy citric acid, phenolic acids, flavonoids, anthocyanins, and garcinol. The main bioactive compound present in *Garcinia indica* is garcinol, which can inhibit many vital regulatory pathways in cancer cells, such as NF-kB, which allows it to completely stop or reduce the growth of cancerous cells, including osteosarcoma cells **(39)**. A study performed by **(40)** in order to determine garcinol's effect against cancerous cells found that garcinol does have anti-cancer properties, as it was able to affect many intracellular pathways in HeLa cells. Further studies have confirmed garcinol's ability to inhibit cell proliferation and stimulate apoptosis. Studies have found that garcinol affected the cell cycle of cancerous cells from the G1 phase to the S phase, which resulted in the death of more mutated or cancerous cells in the G0/G1 phase and fewer cells that moved on to the S phase, which allows the cells to multiply. This activity

exhibited by garcinol has also been found to have similar effects on osteosarcoma, as it can kill and prevent the multiplication of osteosarcoma cells **(41)**.

Tanacetum parthenium- Parthenolide

Tanacetum parthenium, more commonly known as feverfew, is a plant that can bear flowers and is a part of the Asteraceae family. This herb originated and is native to Southeastern Europe, Central Asia, and the West Himalayas. It grows in medium-moist soil and needs plenty of sun to grow fully. This herb is now found mainly in Australia, Europe, China, Japan, and North Africa. These regions are also where *Tanacetum parthenium* is primarily grown and cultivated. Many studies and reviews on this medicinal herb have found it helpful against fevers, rheumatoid arthritis, stomach aches, infertility, menstrual problems, headaches, migraines, insect bites, and cancer **(42)**. Feverfew's array of medicinal benefits can be credited to its bioactive compounds and chemicals, some of which include parthenolide, sesquiterpene lactones, flavonoids, essential oils, pinenes, camphor, parthenolide, luteolin, and apigenin. Parthenolide is the main chemical present in Tanacetum parthenium, which is responsible for its effectiveness in treating and preventing many cancers, including osteosarcoma. Parthenolide is a sesquiterpene lactone that naturally occurs in feverfew, and it is mainly used to help against fevers, arthritis, and an array of cancers **(43, 44)**. A research study performed by **(45)** focused on parthenolide's effect on Osteosarcoma cells through many tests and experiments, and it was found that parthenolide extracts increase the autophagy and mitophagy of the cancerous cell. It was also found that this chemical compound stimulated apoptosis of the cell and enhanced the autophagy proteins, which are responsible for the process of autophagy, which is the degradation of the cell that destroys dysfunctional components of the cell.

Thunder God Vine- Triptolide

Thunder God Vine, scientifically known as *Tripterygium wilfordii* is a traditional Chinese medicinal herb, which is native to China, Japan, and Korea. These regions are also the main cultivators of this crop to obtain and use the medicinal value of this plant. This herb has an array of chemicals, which help to support its many medicinal benefits such as Celastrol and Triptolide, which both have many anti-inflammatory and aunty-cancer properties **(46)**. Focusing on Triptolide, which is a diterpenoid epoxide, we can uncover and learn of its anti-cancer properties through a review done by **(47)**. This review also outlines many of Tritolide's other medicinal benefits which may be beneficial in recovery from cancer such as its anti-inflammatory, antiviral, and anti-arthritic properties **(47)**. Studies done by **(25, 48)** demonstrated Triptolide's ability in combating cancer as it helped to reduce cell proliferation and cause apoptosis in both pancreatic and lung cancer. Regarding Triptolide's ability to combat Osteosarcoma, we understand through studies performed by **(49, 50)**, which portray this chemical's ability to induce apoptosis and support the processes of autophagy and angiogenesis.

Conclusion

Herbal medicines and remedies have been proven to have a long-lasting impact on treating Osteosarcoma and other bone cancers and tumors. Through countless research, studies, and reviews, it has been found that many of the phytoconstituents and chemicals that these natural medicines contain help fight cancer through numerous methods. Some of these methods include inducing apoptosis, inhibiting cell proliferation, and increasing the autophagy and mitophagy of cancerous cells. These herbs play a significant role in the potential cancer treatment and significantly aid against cancers. The use of herbal remedies, unlike other cancer treatments such as chemotherapy, does not cause any pain, it is less invasive, and it has minimal side effects. Although these herbs have shown extreme effectiveness in combating cancer, this method of treatment takes years of consistency to help against cancers. Further research is required to investigate these herbs' efficacy for treating Osteosarcoma.

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Unveiling the Feline Perspective: How Domesticated Cats Perceive Their Human Counterparts By Harold Xie

Abstract

This article explores the intricate dynamics of the human-feline relationship, investigating the question of how cats, as domesticated pets, perceive their human counterparts. Drawing on biological research, anecdotal evidence, and insights from animal behavior, the article investigates whether cats view humans as members of their own species, akin to companions, or as distinctly different beings. As cat owners, researchers, and animal enthusiasts maintain an intense curiosity about this interspecies connection, we embark on a journey to unravel the subtle cues, behaviors, and interactions that characterize the unique bond between cats and humans. Through a blend of scientific inquiry and meticulous observation, this article aims to shed light on the complex and mysterious world of feline cognition, offering a glimpse into the minds of our feline companions and the ways in which they perceive their place in our shared lives.

Introduction

The cat (*Felis catus*), commonly referred to as the domestic cat or house cat, has maintained an intriguing and symbiotic relationship with humans for millennia. Revered for its elegance, agility, and enigmatic demeanor, the feline species has left an indelible mark on cultures worldwide (Smith, 2019). Estimates suggest that there are hundreds of millions of domestic cats globally. In the United States, the American Pet Products Association (APPA) estimated that as of today, there are approximately 95.6 million domestic cats kept as pets, including both indoor and outdoor ones (APPA, 2022). With such an enormous population size, these enigmatic creatures have a profound influence on our lives as well as the natural world.

Beyond their role as companions, cats have also demonstrated their prowess as hunters, helping to control pest populations (Johnson et al., 2018). And as both companions and service animals, cats have been increasingly relied upon for their mental health benefits (Jones & Smith, 2020). In addition to their practical contributions, cats have captivated the interest of geneticists, behaviorists, and veterinarians, who have devised a multitude of research studies to investigate their unique traits and characteristics (Brown, 2017). Exploring the evolutionary history of the domestic cat in relation to its wild ancestors can shed light on the extent to which certain behaviors have been conserved or modified over time, providing valuable insights into the dynamic interplay between genetics and domestication (Davis & Miller, 2019).

The multifaceted nature of the human-cat relationship, from historical reverence to contemporary companionship, underscores the cultural and emotional significance of the feline. Cats have woven themselves into the fabric of human existence, playing roles beyond that of mere pet. Revered, in ancient cultures, as symbols of mystery and grace, today they share our homes as beloved companions. This enduring connection has given rise to a myriad of perspectives, as well as a corresponding wealth of roles that cats continue to play in our lives.

Pet owners have long been curious as to the seemingly puzzling behaviors in which their cats engage in their interactions with them. When looking at interactions between cats, and between humans and cats, many similarities exist that yield fascinating insights into how cats perceive humans in relation to other cats and other animals. Recent studies, as well as recently acquired knowledge regarding the early domestication of cats, suggest that due to the manner in which they were domesticated, modern-day felines likely perceive their human caretakers as larger members of the same species (Garcia et al., 2021). The subtle cues, like kneading or head-bunting, may reflect a feline attempt to establish a social bond reminiscent of their interactions with other cats. As we unravel the intricacies of feline behavior, we gain a deeper appreciation of the unique and evolving relationship between humans and our enigmatic cat companions.

Domestication

The domestication of animals has been a hallmark of human civilization, enabling the coexistence of various species for mutual benefit (Zeder, 2012). Among domesticated animals, the cat holds a unique and intriguing position. The journey from its wild ancestors to its modern status as a beloved member of the household is a story of the intricate interplay between human influence and natural selection (Driscoll et al., 2007).

Unlike many other domesticated species whose primary roles were centered around hunting, transportation, or protection, the story of the cat's domestication was intricately tied to its role as a predator of many prevalent pests in agricultural societies. The origins of the modern feline can be traced back roughly 10,000 years, to these societies in the Near East (historically referring to a geographical region that includes parts of western Asia, southeastern Europe, and northeastern Africa). Over time, wild felines adapted to man-made environments and became accustomed to hanging around people. Cats' roles in controlling pest (mainly rodent) populations had far-reaching implications for farmers, who realized the potential behind cats’ presence in fields. Consequently, a symbiotic relationship formed between humans and wild cats, which shaped their physiology as well as their behavior towards humans.

Recent advancements in scientific research have significantly deepened our understanding of the genetic transformations that coincided with the evolutionary journey from wild to domestic cats. Pioneering studies led by Dr. Eva-Maria Geigl and her research team have analyzed the ancient genetic material of cats unearthed from archaeological sites, yielding compelling insights into the process of domestication (Ottoni *et al*. 2017). Dr. Geigl’s investigations have discovered evidence of two pivotal migration waves that played crucial roles in shaping the genetic makeup of domestic cats. The first wave unfolded in the wake of the agricultural revolution, which required humans to devise ways to control the escalating rodent populations that agriculture brought with it. A second migration wave, closely aligned with the domestication of cats in ancient Egypt, unfolded as a consequence of human movement out of the region of Egypt. These migration events illuminate the dynamic nature of the domestication

process, providing a nuanced narrative of the historical relationship between humans and their feline companions.

In contrast to modern cats, modern dogs were actively domesticated by hunter gatherers for their potential as hunting aids, before the advent of agriculture in societies. In addition, canine ancestors were bred selectively in controlled environments to highlight desired traits tailored towards their use. The dog has a much deeper domestic history than the cat, which reflects the higher variation in behavior and physiology between the wild and domestic counterparts of the two species. The same goes for many other human-domesticated species, including both plants and animals. For example, modern society is a direct result of selectively bred agriculture, which produced larger and longer-lasting harvests than did societies who practiced more-rudimentary forms of agricultural production.

However, in the tangled coexistence between wild cats and early humans, a distinctive form of mutualism emerged. Unlike the structured domestication process seen in later periods, where the stability of human-animal interactions afforded humans a large degree of control over breeding, the dynamic between wild cats and humans in the ancient landscape was characterized by a more balanced reciprocity. In this unique relationship, both humans and wild cats contributed to each other's well-being. The term "balanced reciprocity" implies a situation where wild cats and humans had a relationship that was characterized by a relatively equal give-and-take. For instance, wild cats may have provided some form of pest control by hunting rodents that posed a threat to human food supplies. In return, humans may have unintentionally provided food sources or habitats that were attractive to wild cats. There may also have been a balance in the way that humans and wild cats shared the landscape, with each species finding ways to coexist without causing significant harm to the other.

This nuanced mutualism marked a departure from the hierarchical domestication observed in later centuries. Instead of a unilateral imposition of control, the collaboration between early humans and wild cats reflected a shared exchange of resources and benefits. Consequently, the wild cat retained a greater degree of autonomy, allowing it to preserve its innate wildness without succumbing to a one-sided dependency on humans. Wild cats were able to maintain their natural instincts and behaviors, contributing to a relationship where both parties found sustenance and companionship while allowing the cat to continue to be “wild.” As modern science has begun to disentangle the threads of this ancient alliance, it is becoming clear that the early chapters of human-feline interaction were characterized by a harmonious interdependence, shaping the evolutionary pathways of both species.

Phylogeny

Felis catus belongs to the family *Felidae*, which comprises the diverse and enigmatic members of the cat lineage (Fig 1). With a total of 42 cat species ranging from small domestic cats to large apex predators, the feline family offers a captivating narrative of evolution that spans millions of years (Johnson et al., 2006).

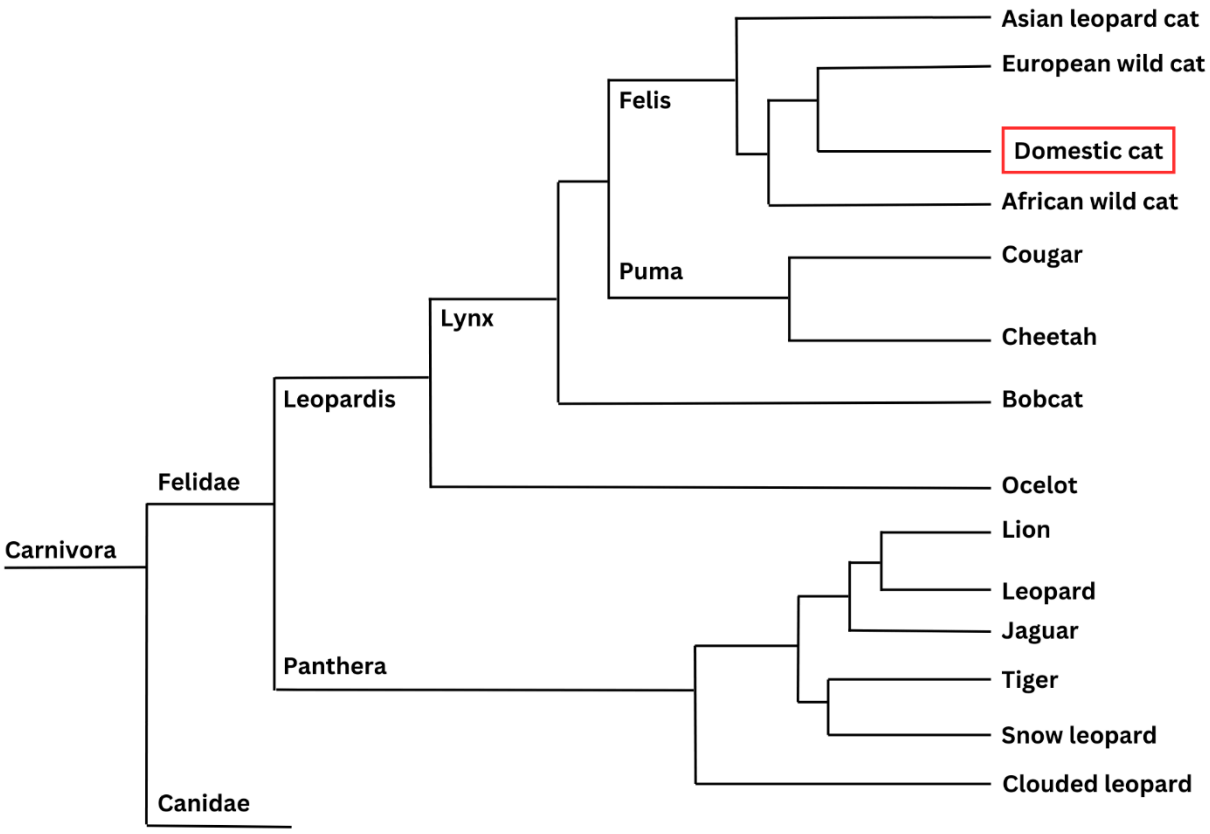


Figure 1. A generalized phylogenetic tree of the order Felidae.

The evolution of cats can be traced to its origins in the Eocene Epoch, a period between 56 and 33.9 million years ago. The Eocene Epoch contained important climatic and environmental changes that influenced the development of various mammalian lineages (Wesley-Hunt, 2005). During the early Eocene, the ancestors of modern-day cats diverged from a common ancestor with other members of the Carnivora order. These early cat-like mammals, belonging to a class of early carnivores known as miacids, were small, tree-dwelling creatures that inhabited the dense forests of the time (Morlo et al., 2004). Over time, miacids underwent evolutionary changes, adapting to different ecologies and developing features that would eventually lead to the diverse feline species we observe today.

One notable branch in the evolutionary tree of cats led to the *Nimravidae* family, often colloquially referred to as "false saber-toothed cats" due to their appearance. Nimravids and true saber-toothed cats (like Smilodon) exhibit similar morphological features, including elongated, saber-like canine teeth. In this case, nimravids are considered a parallel evolutionary experiment because, despite the fact that they are not direct ancestors of modern cats (felids), they evolved

certain features that are reminiscent of those of true cats, including the saber-toothed appearance. This is also an example of convergent evolution, where different species independently evolve similar traits to meet similar ecological challenges (Martin, 2007).

During the later Eocene and into the Oligocene Epoch, the true felids, or members of the Felidae family, continued to evolve and diversify (Johnson, et al. 2006). By the Oligocene Epoch (a period between 33.9 and 23 million years ago), the first recognizable members of the *Felidae* family emerged. These early felids displayed characteristics that set them apart from their predecessors, such as retractable claws, a key feature that distinguishes modern cats. The evolution of retractable claws represented a significant adaptation for effective hunting and climbing.

The diversity of felids increased as the Miocene Epoch unfolded (a period between 23 and 5.3 million years ago), giving rise to various genera and species. The emergence of larger cats, such as the saber-toothed Smilodon, exemplified the evolutionary experimentation that occurred during this period. Evolution and adaptation to different ecological niches and lifestyles over this period led the common ancestors of modern-day cats to diverge into distinct lineages. The subfamilies *Pantherinae* and *Felinae* are believed to have diverged from a common ancestor in the Miocene Epoch around 10 to 15 million years ago. The exact timing of the divergence is a subject of ongoing research, and different studies may provide slightly different estimates.
The subfamilies *Pantherinae* and *Felinae* are characterized by significant differences in size and morphology. *Pantherinae* comprises the big cats, including species like lions (*Panthera leo*), tigers (*Panthera tigris*), leopards (*Panthera pardus*), and jaguars (*Panthera onca*), which are generally larger and more robust. *Felinae*, on the other hand, includes smaller cats such as domestic cats (*Felis catus*), cheetahs (*Acinonyx jubatus*), and servals (*Leptailurus serval*).The divergence between *Pantherinae* and *Felinae*, which marked a pivotal moment in felid evolution, is linked to adaptations to different ecological niches. The big cats in *Pantherinae* often adapted to a more powerful and predatory lifestyle, in which they preyed on larger mammals; their larger size and strength allowed them to take on formidable prey. In contrast, the small cats in *Felinae* evolved to thrive in a variety of environments, including forests, grasslands, and deserts, in which they preyed on smaller mammals, birds, and insects. Different species adapted to various habitats and regions, contributing to the diversification of the two subfamilies.

In the *Felinae* subfamily, the domestic cat (*Felis catus*) shares a common ancestry with wildcats, including the European wildcat (*Felis silvestris* silvestris) and the African wildcat (*Felis silvestris* lybica). The wildcat and the domestic cat diverged around 4,000 years ago. This divergence occurred approximately 8,000 years after mankind's agricultural revolution, which is believed to be the primary catalyst for feline domestication.

There exist notable physical distinctions between domestic cats and wildcats, evident in various aspects such as morphology, coat patterns, size, and behavioral traits (Table 1). These differences highlight the unique adaptations that have evolved through the divergence of these two species. In comparison to wildcats, domestic cats are generally smaller, exhibit varied body structures, and showcase diverse coat colors and patterns, reflecting the outcomes of selective

breeding. The tail length and ear shapes of domestic cats also occur across a broad spectrum, influenced by the diverse breeds created through selective breeding practices. Another marked contrast is observed in the social behavior of domestic cats, as well as their ability to tolerate human interaction—a discernible outcome of the process of domestication.

Table 1. Comparison Between Domestic Cats and Wildcats: Morphological, Behavioral, and Adaptation Differences.

Aspect	Domestic Cats	Wildcats
Size	Typically smaller with varied body structures	Generally larger and more robust
Coat Colors and Patterns	Diverse due to selective breeding	Muted, camouflaged patterns for blending
Markings	Varied due to breeding preferences	Distinct markings adapted for camouflage
Tail Length	Varies widely among breeds	More uniform tails
Ear Shapes	Diverse, reflecting breed differences	Specific shapes for survival in the wild
Social Behavior	Higher tolerance for human interaction	More elusive, demonstrating survival behaviors
Hunting Behavior	May retain hunting instincts but often less solitary	Solitary hunting behaviors essential for survival
Territorial Marking	May mark territory, but often less pronounced	Intensely marked territories for survival

*Note: The information provided is a generalization, and there can be variations within both domestic cat breeds and wildcat species. Domestic cats' traits can vary significantly based on breed and individual characteristics. Similarly, wildcats encompass various species, each adapted to their specific environments, a fact that results in differences within the wildcat category.

Genome Evolution

The genomic distinctions between domesticated cats (Felis catus) and their closest relatives, wildcats (Felis silvestris), provide a fascinating glimpse into the evolutionary history, adaptation, and genetic changes that have transpired over time. In a groundbreaking study published in the Proceedings of the National Academy of Sciences (PNAS), researchers looked through the intricate genomic landscapes of both wild and domesticated cat populations. Despite significant differences in lifestyle and living environments, the study reveals minimal genetic differentiation between modern-day wildcats and their domesticated counterparts (Montague et al. 2014). This unexpected genetic similarity is attributed to the relative recency of cat

domestication and the unique, mutually beneficial relationship that blossomed between humans and cats.

The compressed timeline of cat domestication, compared to that of other domesticated species, has contributed to this limited genetic divergence. Unlike many domesticated animals subjected to prolonged selective breeding, the domestication of cats appears to have occurred within a more condensed time frame. The study underscores the mutually beneficial nature of the human-feline relationship during the early stages of domestication, where cats' sophisticated hunting skills played a crucial role in controlling rodent populations around human settlements. In return, humans likely provided a stable food source as well as protection, fostering a symbiotic bond that influenced the genetic trajectories of both species.

A comprehensive study conducted by Texas A&M University further explored the genetic variations between domestic cats, tigers, and dogs. The investigation revealed a substantially higher degree of genetic variation between domestic cats and dogs compared to the variation between domestic cats and their wild counterparts, the tigers (Pierpaoli et al., 2003). This emphasizes the genetic distinctiveness of domesticated and non-domesticated canines and felines.

The researchers proposed the domestication syndrome hypothesis, suggesting that genetic changes in neural crest cells played a pivotal role in the domestication process. Further exploration of specific genes, including ARID3B, DCC, and PLEKHH1, supported this hypothesis, indicating the importance of neural crest cell-related genetic alterations in the domestication of cats (Wilkins et al., 2014). The study also offered insights into the behavioral genomics of domestic cats, highlighting certain social behaviors acquired specifically for interaction with humans. Alterations in genes governing neural crest cells, which influence brain development and behavior, were proposed as an explanation for distinctive behavioral traits observed in domestic cats.

Advancements in molecular biology and genomics have revolutionized our understanding of cat phylogeny, allowing researchers to explore the intricacies of cat evolution at the molecular level. Studies utilizing mitochondrial DNA and nuclear markers, such as those by Dr. Stephen J. O'Brien and his collaborators, have provided a more granular understanding of phylogenetic relationships within *Felidae* (O’Brien and Johnson 2007)

The genetic and molecular distinctions between the *Pantherinae* and *Felinae* lineages have manifested across evolutionary time, influencing skeletal structure, dentition, reproductive traits, and adaptations related to hunting strategies. The study of the Birman breed's genetic makeup revealed specific genes, such as the KIT gene, which controls aesthetic traits like the "gloving" pattern (Lipinski et al., 2008). In essence, the evolving field of cat genome evolution offers valuable insights into the intricate interplay between genes and behavior, shedding light on the genetic underpinnings of domestication and the unique bond between humans and their feline companions.

Communication

Cats employ a multifaceted communication repertoire that includes vocalizations, body language, and scent marking to interact both with other cats and with their human companions (Miklósi et al., 2005). Deciphering a cat's behavior and communication cues necessitates a keen observation of these various signals. Each cat, being an individual, exhibits a unique communication style influenced by factors such as personality, experiences, and the specific context in which it finds itself (Prato-Previde et al., 2020).

Vocalization stands out as the predominant mode of communication in cats, with meowing being a versatile tool to convey various needs to humans (Shreve & Udell, 2015). Whether expressing a desire for attention, signaling hunger, or indicating distress, cats employ meows to communicate effectively with their human companions. It's noteworthy that meowing is less common among adult cats engaged in communication with each other. Purring, often associated with contentment, serves as a complex vocalization that can also manifest in situations of pain or distress. Mother cats utilize purring as a means of communication with their kittens (Eriksson et al., 2017). Additionally, growling and hissing, vocalizations laden with undertones of fear, aggression, or discomfort, are frequently employed by cats to establish boundaries or issue warnings to others.

Cats are also proficient in conveying messages through their rich repertoire of body language, including the following cues: A raised tail signals friendliness or excitement, whereas a lowered or tucked tail may suggest fear or submission. A puffed-up tail is indicative of a frightened or agitated cat. Forward-facing ears convey curiosity or friendliness, while flattened ears signal fear or aggression. Slow blinking serves as a sign of trust and affection. Dilated pupils may indicate excitement, fear, or aggression. A relaxed, upright posture generally signifies a confident and content cat. Crouching or arching the back can indicate fear or aggression. Forward-facing whiskers denote curiosity or excitement, while whiskers pulled back may signal fear or aggression.

Scent-marking and recognition represent integral components of feline communication, playing a crucial role in cats' behavioral repertoire (Schwartz, 2002). Scent glands are distributed around their bodies, and they are particularly concentrated in the muzzle area. Through scent, cats mark their territory, distinguish between potential threats and friendly individuals, and convey a variety of features such as health and identity. A notable behavior in cat communication is allorubbing, whereby cats greet each other by rubbing noses and cheeks. Domestic cats extend this behavior to their human counterparts. Commonly rubbed areas on humans include the feet and ankles, highlighting the significance of scent-marking in establishing a sense of familiarity and connection.

Cats are adaptable communicators, adjusting their communication behaviors based on the intended target of them—whether a fellow cat or a human caregiver. Notably, cats exhibit distinct communication styles when interacting with their human caregivers. For instance, meowing emerges as a prevalent form of communication with humans—there are specific meows for attention, hunger, or joyful greetings upon their caregiver's return. In feline

interactions, however, adult cats are less likely to utilize meows, instead favoring vocalizations such as growls, hisses, and trills. Purring stands out as another expressive tool through which cats convey trust and affection toward their human caregivers. This mirrors the dynamics among cats, especially between mothers and kittens, where purring becomes a shared language communicating security and comfort during grooming or nursing. Additionally, cats deftly utilize body language to communicate with humans, as exemplified by gestures like slow blinking, which signifies trust and affection.

While cats may not necessarily view humans as members of the same species, they undeniably form profound social bonds with them, adapting their communication styles for interaction. Cats can develop strong attachments to their human caregivers, recognizing them as social companions, providers of sustenance, and sources of comfort. This perspective often leads cats to regard their human caregivers as integral members of their social group, and their behaviors reflect a discernible level of social bonding.

Social Behaviors

Cats display various social behaviors, including allogrooming and play behavior, which reinforce social bonds within their groups (Nagasawa et al., 2021). Mutual grooming among cats fosters a sense of communal scent and establishes strong social connections within a group. Play behavior serves not only as a form of entertainment but also as a means of communication and bonding among feline companions.

Contrary to the common perception that cats are less affectionate than dogs, studies suggest that the social behaviors exhibited by cats may indicate a recognition of humans as part of their social circle (Turner, 2017). Domesticated cats often treat their human caregivers in a manner similar to the way in which they interact with other felines. While cats may display independence, their social behaviors with humans reflect a deeper connection as well as a level of trust.

Research indicates that cats perceive being pet by humans as a form of grooming, akin to how they groom each other. Grooming involves exposing vulnerable areas, signifying trust and companionship. When humans pet cats, felines may reciprocate by rolling and lying flat, revealing areas normally groomed by other cats. Studies on preferred petting areas align with this hypothesis, showing that cats favor petting in harder-to-reach regions, mirroring co-grooming areas such as the belly, sides, and rear back.

The tendency of domestic cats to form social bonds with humans echoes the behavior of wild cats. Observations of cats following their owners, both indoors and outdoors, and greeting them upon return, suggest that there are parallels with the group behavior observed in wild cats. This behavior, reminiscent of colony living, was likely an evolutionary necessity for ancient wild cats and reflects the enduring social nature of domestic felines.

In essence, the behaviors exhibited by cats, both in their interactions with each other and with humans, suggest a nuanced and intricate social structure where trust, companionship, and shared activities play pivotal roles in fostering strong social bonds. Table 2 compares the various

cat behaviors toward human caregivers and toward other cats. The social behaviors exhibited by cats point toward the conclusion that humans are viewed as part of their species. It is generally said by pet owners around the world that cats are less affectionate toward owners than dogs, a likely consequence of how cats were domesticated. Domesticated felines treat humans as they would other felines.

Table 2. Comparison of Cat Behaviors towards Human Caregivers vs. Other Cats.

Behavior	Interaction with Human Caregivers	Interaction with Other Cats
Meowing	Specific meows for attention, hunger, greetings	Less reliance on meowing; favors growls, hisses, trills
Purring	Conveys trust and affection	Shared language for security, comfort in group dynamics
Body Language	Gestures like slow blinking (trust and affection)	Allogrooming, play behavior reinforces social bonds
Social Bonds	Strong attachments, regard as social companions	Allogrooming, play behavior fosters communal scent
Perceived as Part of Group	Recognizes as social companions	Views humans as part of their social group
Petting Behavior	Perceives as a form of grooming	Reciprocates by exposing vulnerable areas
Following and Greeting	Similar to group behavior observed in wild cats	Reflects colony living, evolutionary necessity
Independence	Displays moments of independence	Distinctive independence, less eager to please
Mother-Cat Relationship	Reflects nurturing comfort of mother cat	Mimics behaviors from kittenhood, deep-seated association

It is imperative to acknowledge that cats have retained many of their innate instincts and behaviors. Their spectrum of behaviors encompasses everything from seeking affection and companionship to asserting moments of independence. Cats' interactions with humans are intricately shaped by the individual personalities of their human companions. While cats may form robust bonds with humans and perceive humans as crucial social companions and providers within their environment, this adaptation doesn't necessarily imply a perception of humans as members of their own species.

However, in a recent research report by renowned cat behavior scholar John Bradshaw, a fresh perspective emerged: Bradshaw posited that cats are more likely to view humans as companion cats rather than simply as larger entities of their own species. Bradshaw supports his

hypothesis with two key pieces of evidence: daily interactions and the mother-cat relationship. Unlike dogs, which often seek guidance and orders from their owners, cats display a distinctive independence. Bradshaw contends that cats are less inclined to please their human companions and are more likely to view them as companions on equal footing. While some cats can be trained to perform specific behaviors, they typically do so without the same eagerness displayed by dogs. Cats tend to follow the lead of their human companions but without the native desire to please.

Cats express their affection and bond with humans through behaviors that mirror feline-to-feline interactions. The acts of rubbing against feet, clinging to legs, and using their barbed tongues to lick are akin to the ways in which cats interact with each other. Even behaviors such as slapping paws (PP) in a human's face resemble actions seen in cat-to-cat interactions. Bradshaw emphasizes that these behaviors are reminiscent of the way cats interact with their mothers during kittenhood. As adults, cats understand that rubbing against sweaters or quilts won't yield milk, yet they persist in these actions when around their human companions, suggesting a deep-seated association with the nurturing comfort of their mother cat.

Bradshaw acknowledges that it would be difficult to conclusively prove the theory that cats see humans as other cats. While cats may possess the intelligence to recognize visual differences, their behavior seems unaffected by these distinctions. However they perceive the human form, their interactions with humans mirror the dynamics observed in feline social structures. The hypothesis proposed by Bradshaw offers a compelling lens through which to explore the intricate and often enigmatic relationship between cats and their human companions.

Comparison to Other Domesticated Animals

Differences in social behavior with humans between cats and other domesticated animals are apparent consequences of the development of animals within human culture. Three of the most common domesticated animals (excluding livestock and agriculture) are cats, dogs, and horses, each of their traits being tailored toward their use by humans.

The most ancient of these animals is the dog, the first animal to have been domesticated by humans, an event that occurred an estimated 30,000 years ago. The dog was initially domesticated by accident, and was later used as an aid to early hunter-gatherers—a use that in some respects continues to this day. Recent theories suggest that dogs were not initially domesticated by humans, but found interaction within early human settlements, where they went in search of excess meat. As the dog’s role in early human society evolved, they were used as both companions and hunting tools, and as such were actively domesticated by humans. Over time, the domestic dog and the wolf, from which the dog diverged, split further and further, and the social interactions between humans and dogs evolved. In modern times, there exists a wide variety of dog breeds, and dogs occupy an important place in human society. Over their time with humans, dogs have learned a variety of social behaviors and have become more or less dependent upon humans. Dogs form strong bonds with their owners, and openly express their affection, embracing their role as companions.

The horse is an animal that has less of a companion role than others. The clear main use being a mode of transport. The horse is estimated to have been domesticated 6,000 years ago, in the Ural Mountains of Eurasia. The story of the domestication of horses is a relatively simple one. Humans found out that they could ride horses as a means of transport, making hunting and travel greatly more efficient. As more and more uses of the horse were pioneered, in daily life, trade, and war, more and more breeds emerged, and the horse became a more central part of society. In modern times, the domestic horse is much more docile than it was at the advent of domestication.

It is important to note that the domestication of cats occurred earlier than that of horses but later than that of dogs. The first interactions between humans and cats were likely pragmatic, revolving around cats' natural inclination to hunt and control the rodent population in fields and granaries. Unlike some other domesticated animals, cats were not actively bred for specific traits or behaviors during their early association with humans. This lack of directed breeding might explain why cats did not adopt as many social behaviors as some other domesticated species. Cats, in their semi-feral state, continued to lead more independent lives even as they became accustomed to living in close proximity to human settlements. This contrasts with the close bonds formed between humans and dogs, which were actively bred for traits that enhance companionship and cooperation.

The hypothesis that cats haven't evolved to perceive human owners as well is reasonable given their unique domestication history. Unlike dogs, which have undergone selective breeding for social traits and close cooperation with humans, cats retain a more independent nature. The relatively recent transition from being pest controllers to companions has meant that cats may not have developed the same level of social cognition with respect to humans that dogs have. However, this does not mean that cats lack the ability to form deep connections with their human owners. The behaviors mentioned earlier, such as head-bunting, purring, and slow blinking, are examples of how cats express their connection with their human companions, albeit in a more subtle manner. While they may not have evolved to perceive their human owners in the same way dogs have, cats have developed their own ways of forming bonds, and understanding these nuances is essential for fostering a meaningful and mutually satisfying human-cat relationship.

Decoding Cat Behaviors

In a pivotal 2017 study by Italian researchers, a detailed analysis of behaviors exhibited by both wild and domestic cats revealed intriguing patterns that shed light on the impact of domestication. The study involved observing and recording the behaviors of 21 cats, comprising both domestic and wild animals, over two-hour sessions (Vitale 2022). The findings illuminated significant nuances in behavior, with wildcats demonstrating heightened levels of "vigilance" and "scent marking" compared to their domestic counterparts, who engaged more in resting behaviors.

A remarkable revelation from this study was the fact that there were many similarities between the behaviors of wild and domestic cats, and these similarities outweighed the

differences. Despite the distinct lifestyles imposed by domestication, the fundamental traits and behaviors observed in both species suggested a deep-seated connection rooted in their shared evolutionary history (Lecis et al., 2005).. However, a notable variance emerged in the level of alertness displayed, a fact which emphasizes the impact of environmental and genetic factors.

Wildcats, in response to the challenges of survival in the wild, exhibited a heightened state of alertness. This was manifested through vigilant behaviors and a robust inclination toward scent marking, crucial for territory establishment. In contrast, domestic cats, living in an environment devoid of the immediate threats faced by their wild counterparts, displayed a propensity for more relaxed behaviors, particularly resting. The stark environmental differences, such as the availability of readily provided food and the absence of natural predators, significantly accentuated the behavioral contrasts between the two groups.

Further insights into the disparities between domestic and wild cats were gleaned from a study conducted by South Korean researchers which explored genetic variances. The investigation revealed that domestic cats exhibited enriched pathways related to social behavior and neurological function. Moreover, domestic cats displayed adaptations in their digestive systems, which were equipped to process a wider variety of foods and marked by longer intestines; this was in distinct contrast to the protein-centric digestion systems of wildcats.

The genetic disparities the researchers found were attributed to the increased social interactions of domestic cats with humans and, potentially, other animals in their surroundings. Daily interactions with human owners and, in some cases, encounters with other neighborhood creatures fostered the development of more-intricate communication systems and heightened perception skills in domestic cats. These genetic adaptations underscore the plasticity of cat behavior, which has been shaped by the unique environments and interactions encountered in domestication.

These studies illuminate the intricate interplay between genetics, environment, and behavior in domestic and wild cats. The findings underscore the remarkable adaptability of domestic cats, reflecting not only behavioral traits that they share with their wild ancestors but also unique genetic adaptations driven by their distinct living conditions and social interactions. This comprehensive understanding provides valuable insights into the complex dynamics of the human-feline relationship and the multifaceted nature of cat behavior.

What do Owners Think?

Many cat owners wrestle with the idea that their feline companions perceive them primarily as oversized cats rather than cherished human companions. This notion can be unsettling, especially for those who desire the overt displays of affection often associated with canine companionship. The concern stems from the belief that if cats primarily see their owners as providers of shelter and sustenance, the depth of the human-feline bond may be compromised. However, it is necessary to explore the intricacies of the behaviors of domestic and wild cats in order to comprehend the complex dynamics at play in the human-cat relationship.

The belief that cats regard their owners as fellow felines is not entirely unfounded. Domestic cats, descendants of solitary hunters and territorial wildcats, may perceive their human caregivers as part of their social group (Clark, 2022). While the human-feline connection may lack the overt displays of affection typical of dogs, it does not diminish the profound bonds cats form with their owners. Rather than a merely transactional relationship based on housing and food, cats often view the humans in their environment as an extension of their familial group.

The notion that cats exclusively see their owners as other big cats may trouble many domestic cat owners. They may wonder if their pets genuinely love them, and invidiously compare the aloofness of their cats' to the open affection displayed by dogs. While the idea that cats only view their owners as other cats does suggest a practical aspect related to shelter and food, it is also true that cats perceive the humans around them as family, an integral part of their group. Thus, while cats may not exhibit love in the same demonstrative manner as dogs, they do form deep connections with their owners.

Recognizing that feline expressions of love and affection differ from those of dogs is crucial. While the behavior of dogs may be marked by exuberant greetings, tail-wagging, and overt displays of loyalty, cats express their attachment through more-subtle behaviors. Head-bunting, purring, slow blinking, and the presentation of their vulnerable belly for petting signify trust, contentment, and a sense of belonging. These actions, as distinct from canine displays, underscore the depth of the bond between cats and their human companions.

These subtle feline behaviors not only dispel the misconception that cats are indifferent or aloof but also facilitate improved communication and comprehension of their needs. Recognizing the nuanced ways in which cats express affection enables owners to build stronger connections with their feline friends, fostering a more enriching and mutually satisfying relationship.

In essence, while the idea that cats perceive humans as fellow cats carries a kernel of truth, it is crucial to appreciate the complexity of feline social dynamics. Cats form genuine and meaningful connections with their owners, viewing them as an integral part of their social circle. The subtlety of feline expressions of love underscores the unique nature of the human-cat relationship, enriching the lives of both parties.

Conclusions

The domestication of the modern cat is a fascinating journey that is closely linked to the dawn of the agricultural age. Unlike many domesticated animals that underwent intentional selective breeding, cats transitioned into domesticity through prolonged social interaction with humans. What sets cats apart is their relatively recent and ongoing domestication, a fact which contributes to a unique dynamic whereby they retain a degree of "wildness" compared to other domesticated animals.

Various social behaviors exhibited by domestic cats towards humans provide compelling evidence for the hypothesis that cats perceive their human caregivers as members of their own species, akin to "larger cats." These behaviors, often mirroring those displayed in interactions

with fellow felines, imply a level of social integration and recognition that extends beyond a simple provider-pet relationship.

To further explore and substantiate this hypothesis, future studies may employ controlled experiments that compare the behaviors of modern domestic cats with their wild counterparts. An extensive investigation could encompass the measurement and analysis of interactions involving domestic cats, wild cats, and humans. This research would not only aim to illuminate the perception of humans by domestic cats, but also seek to provide insights into the degree of "wildness" retained by domesticated felines.

Critical areas for exploration include investigating the similarities and differences in scent communication between domestic and wild cats, revealing the mechanisms through which cats convey information, establish territory, and form social bonds. A nuanced understanding of how domestic cats navigate relationships with humans as against their interspecies interactions could be gleaned by analyzing the nature of physical interactions, such as grooming, play, and communication through body language.

Exploring the hierarchical structure within cat colonies, both domestic and wild, would be essential to revealing parallels and distinctions in how cats perceive and interact with individuals of their own kind as well as humans. Additionally, assessing behavioral responses to various stimuli, such as social cues, environmental changes, and the introduction of novel elements, could yield valuable data on the adaptability and social dynamics of domestic cats vis a vis their wild counterparts.

Conducting multifaceted studies holds the potential to significantly contribute to unraveling the complexities of the human-cat relationship. By delving into shared and distinct behaviors exhibited by domestic and wild cats, researchers can gain a deeper understanding of how domestic cats perceive their human owners and the evolutionary underpinnings of their social behaviors.

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Unraveling the Migraine Mystique: A Comprehensive Review of Population Dynamics, Biological Triggers, and Therapeutic Avenues by Eleanor Day

Author Bio

Eleanor Day is a junior at Unionville High School with a strong interest in neuroscience and a future career in medicine. As a migraine patient for the past ten years, she decided to research migraines to learn more about her subject of interest and herself. In her free time, she enjoys writing and pursuing scientific endeavors. Eleanor is the Executive Manager of her school newspaper and created a Science Column to further explore areas of science through writing. She also is the co-head of an international nonprofit called WriteCause, in which she helps run a writing competition and started a STEM Spotlight in which individuals can submit scientific writing for publication. To experience the medical field in some capacity, Eleanor is also taking courses to become an EMT. When not partaking in academic activities, she also participates in field hockey and track & field. Overall, Eleanor has a passion for science and hopes to continue to pursue this interest in future aspirations.

Abstract

Migraines are a relevant and prevalent neurological disorder that effect millions of people globally. The disorder is prevalent throughout the world, with rates dependent on various populations and locations. The prevalence of cohorts can further highlight potential triggers in migraines, relating to economic instability, hormones, geographical features, and more. Through biological factors migraine triggers are discussed and identified. Genetic, hormonal, and receptor related triggers are discussed and related to population prevalence and future treatment options. Future biomarker targets are identified and show promise for increased diagnostic rates. Diagnostic and treatment measures are discussed, and improvement is needed. To refine treatment, use of modern, affordable technologies and medicine is necessary. Barriers to migraine care exist and are exacerbated by current conditions. To make progress, migraine education, reduction in care costs, and funding for research must be promoted. This review provides a modern outlook on migraines to examine the disorder from a scientific perspective.

Migraine Prevalence Throughout the World

Migraine prevalence is dependent on different cohorts of populations, highlighting potential causation factors. Since the neurological disorder effects millions of people, it is essential to gain an improved understanding of migraines to address the problems they present.

Migraines are prevalent globally, affecting around one in ten people (Woldeamanuel *et al.*, 2017). The Global Burden of Disease Study, surveying 204 countries, provided evidence indicating the rate of migraine is rising (Li *et al.*, 2019). Data from this study further found that although there was only a ~1% increase in Global Age-Standardized Prevalence Rate, the Global Incidence Rate rose by ~37% from 1990 to 2019. The Global Prevalence of migraines grew to 582 million cases, a 16% increase since 1990 (Li *et al.*, 2019). While the upward trend could be associated with a rise in migraine prevalence, it is likely that the rise could be due to improved diagnosis tools.

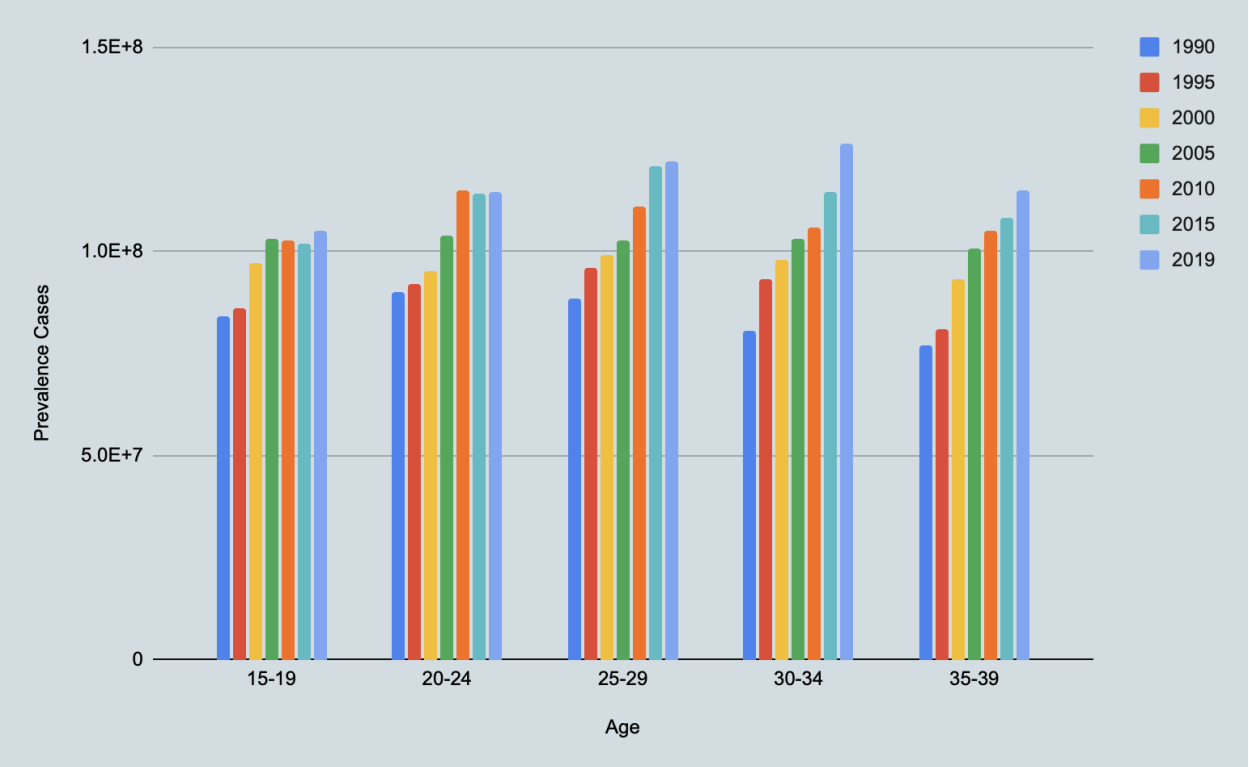


Fig 1: Prevalence of Cases in Respect to Age and Decade (Li *et al.*, 2019)

The study conducted by Li and colleagues (2019) identified regions that experience higher migraine prevalence. European countries (Belgium, Norway, and Italy) comprised the highest age-standardized point prevalence rates for the disorder averaging ~1,100 while Eastern African countries (Ethiopia, Somalia, and South Sudan) showed the lowest point prevalence rates, averaging ~450. Belgium seemed to have the highest incidence rate with 32,500 cases per 100,000 people, and Ethiopia had the lowest with 11,100 cases per 100,000 people. South Asia was shown to have the highest total prevalence of migraines, at ~154,000,000 people experiencing migraine while Oceania had the lowest at ~1,022,000 (Li *et al.*, 2019). Overall, the prevalence of migraine differs among countries and was found to be relatively high in East African countries and South Asia.

Another meta-analysis study (Burch *et al.*, 2021) provided information about the prevalence of migraines in different continents. Although this study detected an overall prevalence of ~12%, individual regions differed in rates. South America had the highest prevalence at ~16%, Europe was at ~11%, and Africa, Asia, and North America were all ~10%. While these statistics could be significant to the actual prevalence, the rates may not account for those with undiagnosed migraine.

This study (Burch *et al.*, 2021) also examined migraine prevalence in relevance to rural (~8.5%) and urban (~11%) areas. Urban residents typically experience higher exposure to potential triggers such as loud sounds and bright lights, which could account for the heightened prevalence rate. The lower prevalence rates in rural areas could be associated with under diagnosis of migraines because of reduced access to medical care.

Burch and colleagues (2021) also demonstrated an increased prevalence in females in comparison to males (13.8% to 6.9%), indicating that women may experience a greater burden of migraines than men. While this could be associated with diagnostic factors, it could also be attributed to females' drop in estrogen. As a decline in estrogen levels can lead to migraines, this trigger could potentially account for the higher prevalence of migraines in women. This analysis also showed that students experience more migraines (~12% prevalence) than non-students (Burch *et al.*, 2021). Increased stress from classes could be a potential reason for the increased prevalence because stress-related factors are indicated to play a role in migraine pathogenesis (Fernanda *et al.,* 2022).

Data from another study (Stovner et al., 2022) illustrated that migraine estimates were more prevalent in females than in males and it reinforced a view that migraine prevalence seems to be increasing each year. However, this study also linked the increase of prevalence with an increase in diagnostic measures, which indicates that this rate is likely due to improved detection. This research exemplifies how technological advancements can lead to improved diagnostic measures for migraines and related medical conditions.

In the example of the United States, the Government Health Studies' statistics showed that the country's burden of migraines is high, affecting about one in six Americans and one in five women. This study reinforced earlier data indicating a higher migraine incidence among women, as the prevalence rate for women (~20%) compared to men (~10%) was higher, with an overall prevalence rate of ~15%. Throughout the years, the data showed that the incidence rate of migraine has remained stable, which contradicts other studies - this could be due to better diagnostic measures in the US compared to other countries. Additionally, Americans aged 18 to 44 were shown to have the greatest occurrence of migraine (~18%). Economic factors also played a role as the unemployed and those with an annual family income of less than $35,000 showed a higher prevalence rate (~20% and ~21%, respectively). The economic components could be attributed to financial stress as well as the inability to afford high-quality preventative medicine to treat migraines (Burch *et al*., 2018). Further, if the best treatments for migraines remain costly, then it is likely that economic inequities will continue to grow.

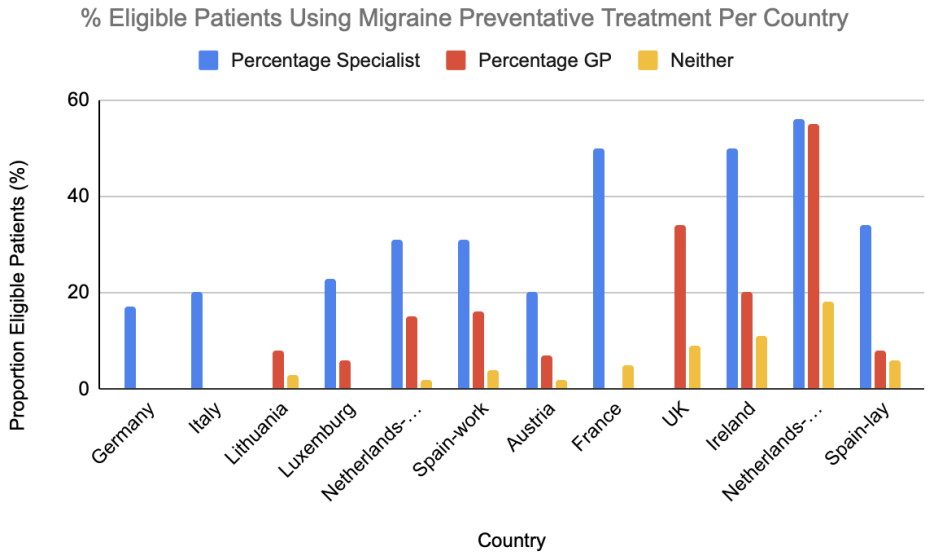


Fig 2: Percentage of Patients Using Migraine Preventative Treatment Around the World (Katsarava *et al.*, 2018)

Estimates from government health surveys also provide insight into other cohorts of migraine patients. People that experience this neurological condition tend to be disadvantaged in gaining migraine prevention tools. As one of the previous studies (Burch et al., 2021) asserted that 40% of United States adults that suffer from migraines are unemployed and many are also low-income patients. One in five migraine patients were shown to lack health insurance while one in three had no high school education. This could be because people experiencing periods of financial instability are less able to afford the high-quality care and medicine that they need to prevent migraines. Further, the stress from economic issues could play a causal role in migraines. As many of those who suffer from migraines are less financially stable, it is unfortunate that many of the best treatments for migraines are costly, with estimated costs of ~$6,600 per patient (Bonafede *et al.*, 2018), thus exacerbating the inequities in migraine. Hence, attention and funding for more accessible and affordable treatment is necessary.

There are also potential connections between migraines and mood disorders. A survey (Orr *et al.*, 2017) was conducted to see if there was a tie between the neurological condition and mental illnesses. Through this, a strong and consistent association was found between migraine and mood disorder prevalence. Hence, a potential correlation between the two was discovered. This may suggest that migraines can lead to anxious or depressive tendencies. As migraines cause an increase in cell activity, they also impact serotonin levels which might lead to symptoms of anxiety. Anxiety may also trigger migraines due to its stress-related symptoms.

Cycle	Sample Size	Prevalence of Migraine	Prevalence of Mood Disorde	Depressed Range CIDI-SF Scor	Prevalence of Anxiety Disorder	Low Mental Health Perception	High Mental Health Perception
2003-4	11,616 (4,840)	1,113	344	254	256	413	8,838
2005	11,787 (6,204)	1,121	313	263	356	379	9,156
2007-8	10,088 (3,599)	1,096	293	209	416	341	7,849
2009-10	10,037 (4,544)	982	285	245	418	347	7,692
2010	5,025 (2,293)	466	126	117	205	155	3,841
2011-12	12,822 (2,188)	1,299	452	143	651	497	9,723

Fig 3: Prevalence of Migraine, Mood Disorders, and Mental Health Perception Over Time (Orr *et al.*, 2017)

Population outbreaks can also have connections to migraines. In one study (Al-Hashel *et al.*, 2020), it was found that there may have been a connection between migraines and COVID-19. Around 60% of the people surveyed had an increased frequency of migraines after the pandemic of 2019, with ~10% of the participants developing chronic migraines during the outbreak and ~64% reporting increased severity. During this time, most of the people (~62%) did not communicate with neurologists and ~59% reported an overuse of analgesics. Although only 4% of those participants were diagnosed with COVID-19, the majority (63%) experienced worsened migraines during this time. It was also found that there was a significant correlation between migraines and depression, anxiety, screen exposure, and lack of exercise during the span of the outbreak. This may indicate multiple potential reasons for the increased migraine severity and frequency. Firstly, as COVID-19 contributed to an increased financial instability, many may not have been able to afford high quality migraine preventative treatments or to see neurologists. Along with this, the stress associated with both economic struggles and the pandemic-related crisis could have also triggered migraine cases.

Variables	Total Number	Increase in Migraine Days, N (%), N=607	p-value	Increase in Migraine Severity, N (%), N=653	p-value
Age			0.913		0.363
<20	38	22 (3.6%)		29 (4.5%)	
20-40	733	438 (72.2%)		469 (72.2%)	
40-60	235	141 (23.2%)		145 (22.3%)	
>60	12	6 (1%)		7 (1.1%)	
Gender			0.004*		<0.001*
Male	858	79 (13%)		82 (12.6%)	
Female	160	528 (87%)		568 (87.4%)	
Occupation			0.069		0.563
Unemployed	208	112 (18.5%)		124 (19.1%)	
Student	116	60 (9.9%)		73 (11.2%)	
Part Time Job	107	67 (11%)		69 (10.6%)	
Full Time Job	526	331 (54.5%)		347 (53.4%)	
Retired	61	37 (6.1%)		37 (5.7%)	
Marital Status			0.163		0.748
Single	324	185 (30.5%)		204 (31.4%)	
Married	629	386 (63.6%)		403 (62.0%)	
Widow	4	4 (0.7%)		4 (0.6%)	
Divorced	55	30 (4.9%)		35 (5.4%)	
Other	6	2 (0.3%)		4 (0.6%)	
Education			0.179		0.099
High School	456	215 (47.1%)		248 (54.3%)	
Primary School or Less	282	143 (50.7%)		136 (48.2%)	
University	280	161 (57.4%)		144 (51.4%)	
Difficulty in Getting Medication	256	179 (29.5%)	<0.001*	190 (29.2%)	<0.001*
Compliance to Migraine Treatment			<0.001*		<0.001*
Yes	477	330 (54.4%)		305 (46.9%)	
No	541	277 (45.6%)		345 (53.1%)	
Communication with Treating Physician	392	182 (30.0%)	<0.001*	182 (27.9%)	<0.001*
Sleep Disturbance	794	535 (88.1%)	<0.001*	562 (86.5%)	<0.001*
Eating Habits Disturbance	593	418 (68.9%)	<0.001*	443 (68.2%)	<0.001*
Symptoms of Anxiety/Depression	809	523 (86.2%)	<0.001*	561 (86.3%)	<0.001*
Increased Screen Time Exposure	905	545 (89.8%)	0.274	584 (89.8%)	0.201
Working During Pandemic	465	295 (48.5%)	0.0042*	312 (48.0%)	0.039*
Lack of Regular Exercise	812	270 (44.5%)	<0.001*	498 (61.3%)	<0.001*
Medication Overuse	597	544 (66.9%)	<0.001*	504 (77.5%)	<0.001*

Fig 4: Trends Between Variables and Migraine During the COVID-19 Pandemic (Al-Hashel *et al.*, 2020)

As another case (Huang et al., 2021), Chronic Periodontitis (CP) in Taiwan may also have a role in triggering migraine. This disease causes inflammatory disease that is triggered by bacterial products. This inflammation further serves a role in the pathogenesis of migraines. A study in Taiwan examined over 68,300 people that had CP and determined that 785 of them also were burdened with migraines. Compared with the healthy patients, the number of people with migraine was significantly higher in those with CP suggesting a possible correlation. It was also found that those that at one point had the disease were likely to develop migraines within the following thirteen years. Although there is not enough data to generalize the relationship between migraines and CP. It was suggested that the possible mechanisms include leptin as an inflammatory mediator, which could be potentially used as a biomarker (Huang et al., 2021).

Biological Causes and Implications

Migraines have various biological causes and implications, from genes to hormones and their receptors. With these known factors, treatments and biomarkers can be developed to improve current diagnosis and drug design. On the genetic level, migraines can be triggered due to various mutations in corresponding genes. Multiple kinds of migraine disorders can be caused by mutations from a single (monogenic) or multiple genes (polygenic). The mutation in *CACNA1A, ATP1A2,* and *SCN1A* genes, for example, can intervene in the regulation of glutamatergic neurotransmission leading to an exhibitory or inhibitory balance deviation in the brain. This in turn lowers the threshold for Cortical Spreading Depression (CSD). The depolarization that results from this is thought to be related to migraine initiation. The mutations in NOTCH3 proteins can cause a hereditary cerebrovascular disease called CADASIL which tends to result in migraines. Additionally, mutations in TREX1 and COL4A1 genes result in vascular disorders that could trigger migraines. As for polygenic genes, polymorphisms at the 38 loci are associated with migraine risk. This is because the genes near these loci tend to be associated with vascular and neuronal pathways, and mutations of those genes could interfere with the pathways and lead to the pathophysiology of migraines (Sutherland *et al.*, 2017).

Migraines can also result from mutations in the CACNA1A gene which codes for a Central Nervous System Cav2.1 voltage-gated neuronal calcium channel subunit. Within the gene, it has been found that there are 21 mutations that can affect the clinical course of migraine. Mutations in the MTHFR gene can also result in this neurological disorder. This gene acts as a catalyst for Hcy (an amino acid that can remodel vascular tissue in excess) metabolism. The C677T polymorphism of MTHFR causes alanine substitution for valine at amino acid position 222, resulting in a new quaternary structure that further reduces enzymatic activity. Hence, with the mutation, the Hcy levels in the bloodstream increase causing a disfunction that reduces the flux of oxygen to the brain. This effect can in turn trigger migraines. For those who may

experience migraines due to a mutation in the MTHFR gene, daily vitamin B supplements can help ease the prevalence of headaches (Kowalska *et al.*, 2016).

ATP1A2 can also contribute to migraines. This gene encodes for an isoform of the catalytic subunit of Na+, K+-ATPase (which is vital in the activity associated with ion channels and transport due to its ion gradients). Mutations in ATP1A2 can cause dysfunction of the Na+, K+-ATPase pump. Lack of the pump's function can result in an increased concentration of K+ which may cause depolarization that could lead to CSD. As CSD is known to be able to cause aura phases associated with migraines, ATP1A2 and its effects play a role in migraine formation (Friedrich *et al.*, 2016).

Immune response and oxidative stress can also assist migraine pathophysiology due to hormones (like serotonin) and other factors. Specifically, serotonin hinders hypocretin neuron activity, potentially causing auras (Kowalska *et al.*, 2016).

Receptors like CGRP can also trigger migraine development. This peptide is created through the alternative splicing of CALCA and has been thought to be a mediator that helps preserve correct cardiovascular function when under stress. However, it also releases trigeminal neurons, and the stimulation of these neurons is thought to relay the migraine pain signal, further creating a sense of pain during migraine. Important for treatment, CGRP can be used to develop antagonists and antibodies in clinical treatment for the relief of migraines. Currently, many of these antagonists and antibodies are shown to be faring well in the trials, with ~32% of patients reporting that their symptoms have been remedied (Kee *et al.*, 2018). While this receptor can ultimately cause migraine symptoms, it is also promising for future migraine treatments.

In the regions known to cause central and peripheral migraines, both CGRP and estrogen receptors are expressed. Hence, both may play a role in the pathogenesis of migraines. High levels of CGRP and low levels of estrogen, likely caused by hormonal fluctuations in females, can influence migraine neural networks, causing migraines. To treat migraines, estrogen agonists (or oxytocin agonists) can help in treatment (Krause *et al.*, 2021). This relation of migraines to estrogen can help explain the increased prevalence of migraines in females compared to male patients. The hormonal fluctuations of estrogen and higher levels of estrogen in women may be the reason that more migraines occur in females than males. Reducing the drops of estrogen that trigger migraines in turn helps prevent the menstrual related migraine and reduces the frequency of migraine auras (Chai *et al.*, 2014).

Since many people are unsure of their migraine diagnosis and individual triggers, future biomarkers show promise and can help with targeted treatment. Using biomarkers in cerebrospinal fluid (CSF) can help diagnose migraines. By tracing the amino acid glutamate, which is thought to play a role in the pathogenesis of migraines in increased levels, within the fluid, one can potentially determine if they are experiencing migraines (Ashina et al., 2021).

Another potential biomarker in CSF is CGRP due to the significant evidence relating the receptor complex to migraines. Since CGRP is shown to be elevated as migraine attacks occur, by using it as a biomarker and tracing the levels in which it fluctuates one can potentially

diagnose migraines (Ferreira *et al.*, 2021). Further, with the use of CGRP as a biomarker, accurate diagnosis may increase, allowing people to seek proper treatment.

Pituitary adenylate cyclase-activating polypeptide (PACAP), found in CSF, shows promise as a biomarker because of its positive correlation to migraines at increased levels. By using PACAP as a biomarker, patients can further identify potential cues to see if they experience migraines. Interleukin can also be an appropriate biomarker in CSF as it is thought to be a marker for inflammation in the central nervous system (a trigger of migraines) (Ferreira *et al.*, 2021). Overall, both show promise in the development of biomarkers for migraine.

Biomarkers and other treatments inspired by biological factors in migraines further show promise in the improvement of drugs and accurate diagnosis. Since there is a call for improved treatment options, new options may present the future of migraine medicine.

Treatment Options and Future Growth

There is a call for improved and affordable options for migraine remedies. With promising new medicines and diagnosis procedures, treatment options can be refined. While many current migraine treatments are outdated, drugs targeting the CGRP and 5H-T1F receptors show promise. Since their antibodies decrease levels of these compounds in the blood, drugs containing their antagonists have been shown to effectively combat migraine pathogenesis. Treatments like Erenumab and Fremanezumab (approved in 2018) are examples of remedies for migraine that target CGRP, illustrating a breakthrough in migraine therapy. In the example of 5H-T1F, the compounds role in triggering migraines by releasing neuropeptides and neurotransmitters like CGRP and glutamate can be combatted. Targeted treatments to decrease 5H-T1F show promise as possible therapeutics for migraine (Lambru *et al.*, 2018).

Acute treatment options also help fight off migraine, including ergots, triptans, and anti-inflammatory drugs. These FDA-approved remedies help raise levels of serotonin as drops in the neurotransmitter can trigger migraines. Neuromodulation, or technology that acts on nerves, can also help modulate the CNS or PNS to fight migraine pathogenesis and attacks (Digre, 2019). This neuromodulator treatment may be advantageous as an alternative to drugs. Due to individual preferences, different remedies are used by different people. For those who do not want to medicate through drugs, neuromodulation may be a better option (American Headache Society 2019).

Identifying the appropriate treatment for a patient mandates an individualized approach given the broad array of migraine causes and personalized preferences. Medication can take the form of acute and preventative treatment. Both modalities are important; preventative treatment helps reduce migraines from occurring in the future, and acute treatment targets migraine attacks short-term with low recurrence. The individualized component of migraine medication can correlate to individual triggers, preferences, current medications, and symptoms (Ong & De Felice, 2018).

Barriers to treatment such as lack of a proper regimen, correct diagnosis, consultation, and preventative treatment, along with the overuse of medication, can prevent individuals from receiving the help that they need (Buse *et al.*, 2021). Many of these barriers correlate to

populations with higher migraine prevalence. For example, migraines are more prevalent in individuals with economic instability that may not be able to afford consultations or adequate and effective care. This dynamic, combined with growing costs in medicine, threatens to exacerbate inequities in migraine prevalence within certain cohorts.

Country	n	Using triptans (%)	Migraine >5 Days/Month (%)	Patients with Migraines >5 Days/Month Using Preventative Medicine	Consulting health professionals (%	Not Consulting (%
Germany	109	11	38.5	2.4	23.8	76.1
Italy	221	6.3	27.6	1.6	22.6	77.4
Lithuania	149	3.4	41.6	3.2	27.4	72.5
Luxemborg	669	7.2	32.7	4.6	25.5	74.4
Netherlands-population	815	9.2	20.8	6.4	20.5	79.5
Spain-workplace	401	22.4	38.2	13.7	40	60.1
Austria	263	14.1	40.3	6.6	32.8	67.3
France	337	13.6	27	4.4	32.6	67.3
UK	49	24.5	44.9	9.1	36.7	63.3
Ireland	152	61.8	51.3	29.5	55.9	44.1
Netherlands-lay	195	68.2	61.5	41.7	58.1	42.1
Spain-lay	106	46.2	47.2	16	58.5	41.5

Fig 5: Use of Consultations and Preventative Treatment for Migraine Around the World (Katsarava *et al.*, 2018)

A study (Buse *et al.*, 2021) illustrated the difference in treatment experience between episodic and chronic migraine patients. Although episodic (EM) patients received consultation for their migraines less frequently then chronic (CM) sufferers (~28% vs ~40%), these patients were more likely to receive a correct diagnosis (~76% vs. ~33%) and to receive proper treatment (~60% vs. ~54%) then CM sufferers. Perhaps consequentially, EM sufferers were less likely to overuse medicine (~32% vs ~75%). Overwhelmingly, only ~9% of EM and ~2% of CM patients showed that they were able to overcome the tested treatment barriers (lack of consultation, correct diagnosis, proper treatment and normal use of medication). This study, regardless of the type of migraine, indicates that there are many people who experience migraines who are unable to correctly and effectively receive correct health care.

To address these barriers, there are several ways in which the healthcare system can improve global treatment of migraines. Proper education about migraines can better equip individuals to seek help from professionals when they are suffering. Future biomarker use could also increase accurate diagnosis and direct patients to physicians that can help them find appropriate treatments. Although economic factors drive disparity in those who seek diagnosis and consultation, by establishing more affordable consultation and diagnosis options, more people could get necessary help allowing for a reduction in migraine prevalence inequities. Further, health care systems should develop methods for making drugs more affordable to all. This improved and affordable treatment of migraines is necessary, as those who suffer from migraines experience indirect costs of over $8,000 / year from loss of productivity and related health-care costs of over $6,000 compared to those without migraine (Bonafede *et al.*, 2018).

Psychological barriers can also affect migraine care. The lack of motivation, knowledge of triggers, control, proper self-efficacy, and acceptance can prevent patients from seeking proper help (Matsuzawa *et al.*, 2019). With an increase in the education of migraines, these factors can be fought. Additionally, research in developing improved strategies in trigger diagnosis can help

overcome this barrier since more sufferers would be able to identify the causes of their migraine and seek personalized treatment.

Location can also play a factor in access to care since some regions have less access to treatment and primary headache providers (Matsuzawa *et al.*, 2019). Therefore, proportions of people are disadvantaged for migraine care. If the area in which an individual lives does not promote migraine education, populations can face an additional drawback as many people may not have the knowledge to know to get treated or diagnosed.

Overall, there is a call to action to increase research and education, while decreasing costs associated with migraine. With this, more people may be able to consult professionals, be correctly diagnosed, and afford effective treatment.

Conclusion

Migraines are prevalent globally and effect specific population cohorts, especially individuals from low-income, female, and middle-ages backgrounds. The implication in prevalence suggests underdiagnosis and causation factors related to biological factors and access to care. Biological triggers hold implications in population prevalence and suggest new treatments and diagnostic tools. The future, improved treatments and technologies are necessary. Further, there must be an emphasis on providing affordable treatment and consultation options so that migraine care is accessible by everyone, and barriers can become overcome.

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Introduction to CDKN2A By Aliya Nagaria

Abstract

This literature review explores the unique details and properties of CDKN2A. This is a suppressor gene known for coding the p16 protein. This paper will dive into the molecular structure, regulatory mechanisms, and the association with a variety of cancers that this gene has. During these aggressive cancers, there is usually a change in the cell cycle so CDKN2A plays a role in this as well. There is a focus on the clinical implications of alterations of CDKN2A that range from genetic testing to personalized therapeutic interventions. There is a lot of progress that has been made but despite this there are a lot of challenges such as understanding the complete regulatory network. This review ends with CDKN2A's potential to change cancer diagnostics and strategies for treatment in the great field of precision oncology.

Introduction

The process of cells and their regulatory mechanisms has been the topic of scientific research for a long time. One of the main questions in medical research tends to focus on cancer research. This research paper will cover the basics on the tumor suppressor gene, CDKN2A, which encodes the p16INK4a protein. This protein tends to act as a central orchestrator for cancers. This review will focus on the molecular structure, regulatory mechanisms, association with cancer and clinical implications of this tumor suppressant (Li 2011).

CDKN2A is located on chromosome 9p21 and is in a central position in the complexity of cell cycle regulation. Its gene product, p16INK4 controls the G1 to S phase by inhibiting cyclin-dependent kinase 4 (CDK4) and cyclin-dependent kinase 6 (CDK6). This would then lead to a prevention in phosphorylation of the retinoblastoma protein (pRB). This serves as an important checkpoint to prevent excessive cell growth (Wu 2020).

The CDKN2A on a molecular level is characterized by its dynamic interactions with various elements. Promoter hypermethylation is also an important mechanism that blocks off CDKN2A which eliminates p16INK4 expression in a cell. In addition, the fate of this gene is tightly linked with microRNA and long non-coding RNA networks. This adds to the multiple layers of post-transcriptional regulation that betterifies its expression (Shima 2011).

CDKN2A, known to have profound significance, plays a role in various types of cancers. Melanoma, pancreatic cancer, lung cancer, brain cancer and countless others that usually show abnormalities in the CDKN2A gene. These changes could appear in the form of mutations, deletions or promoted hypermethylation, which can disrupt the equilibrium of cellular homeostasis. This disruption can cause cells to be susceptible to excessive and uncontrolled growth which ends up resulting in tumorigenesis, producing or tending to produce tumors (Chan 2021).

Although the details of CDKN2A molecular architecture have been studied to a certain extent, its functional impact on human disease and their manifestations cannot be measured on any scale. This would mean that genetic testing for CDKN2A mutations may allow patients to take control over their genetic makeup to determine what cancers they are more prone to having.

This will allow for a more personalized plan of treatment. In addition, as CDKN2A's status as a cancer biomarker is continuously gaining importance, it can possibly allow for the success of targeted cancer therapies (Zocchi 2021).

However, as medical research continues to make progress in figuring out the nuances of CDKN2A, there are still challenges. Deciphering the intricate regulatory networks, understanding interactions with signaling pathways, and figuring out the true role of CDKN2A will allow researchers to determine its true impact on cancer biology. This would basically mean that CDKN2A acts as a sentinel. This would protect the cellular regions from proliferation and tumorigenesis. Finally, this literature review will address the complexity of CDKN2A, more specifically its complexities and how it affects cancers (Chen 2021).

Molecular Structure & Function

The gene locus CDKN2A is located on chromosome 9p21 and codes for a cyclin-dependent kinase inhibitor 2A, p16INK4a (p16). The protein structure of p16 is known by its ankyrin repeat domain. This domain is a key feature of its function as a cell cycle regulator and mediated interactions with other cyclin-dependent kinases (CDK's), more specifically CDK4 and CDK6 through a specific binding interface (Minami 2023).

The primary function of p16 is its ability to act as a inhibitor of CDK4 and CDK6, both which play important roles in promoting cell cycle progression. By binding to these kinases, p16 interferes with the formation of active cyclin-CDK complexes which hinders the phosphorylation of the pRB (Jiang 1998).

The phosphorylation of pRB is an important event that promotes cells from the G1 phase into the S phase of the cell cycle, which promotes DNA replication and subsequent cell division. Without a functional p16 protein, CDK regulation comes to a halt which results in uninhibited pRB phosphorylation. All of these lead to uncontrolled cell cycle progression and this opens the door to abnormal cell proliferation; a sign of several kinds of cancers (Rizzolio 2012).

In addition to its role as a cell cycle regulator, p16 is also known for its involvement in cellular senescence, an irreversible state of paused cell growth. When cells experience stress or reach their replication limit, p16 is upregulated which can lead to the activation of signaling pathways that induce senescence. This should be a protective mechanism that prevents damaged cells from possibly transforming into cancer cells (Rayess 2012).

P16 has a complex structure due to its ankyrin repeating domain, and its specific interaction with CDK's show its complexity as a molecular switch in a complex network of cell cycle control. These precise molecular events position p16 as a sentinel that monitors the cellular environment and determines cell division fate based on the regulatory checkpoints in the cell cycle (Boice 1996).

All in all, the molecular structure of p16, coded by the CDKN2A gene, is precisely made for its important role in cell cycle regulation. Its ankyrin repeat domain-mediated interaction with both CDK4 and CDK6 acts like a checkpoint on a molecular level. They made sure the transition from the G1 to S phase in the cell cycle is going as planned. Understanding the complex

molecular details is important to figuring out the impact of alterations to CDKN2A on cancer initiation and progression (Zhang 1998).

Regulatory Mechanisms

The regulation of CDKN2A involves an array of different molecular mechanisms. This makes the control of its expression and the function of p16 a lot more complicated than other cancer causing genes.

Promoter Hypermethylation:

The main mechanism involves epigenetic modifications, more specifically the DNA methylation inside the CDKN2A promoter region. This promoter hypermethylation can result in a restricting chromatin state that will most likely result in CDKN2A silencing. This will in turn make the gene less accessible to the transcription machinery. The epigenetic change is due to a loss in p16 and is common in cancer cells. Aberrant hypermethylation in the promoter region of CDKN2A is a common sign of countless cancers and primarily stems from disruption in the cell cycle (Casalino 2020).

MicroRNAs and Long Non-Coding RNAs (IncRNAs):

Posttranscriptional regulation of CDKN2A ties in the complex world of noncoding RNAs. MicroRNAs (miRNAs) and long noncoding RNAs (IncRNAs) are both involved in making sure the expression levels of CDKN2A are within normal limits. miRNA, known as small RNA molecules, usually bind to the 3' end of the CDKN2A mRNA. This is the untranslated region (UTR) so, it could lead to its degradation or translational inhibition. On the same line, IncRNAs can also interact with CDKN2A at different levels which in turn can affect stability or translational efficiency. The mutations of the noncoding RNA-mediated pathways could possibly lead to irregular CDKN2A expression under certain conditions (Ratti 2020).

Transcription Factors:

When CDKN2A transcriptionally regulates, it involves the coordination of multiple transcription factors that bind to specific parts in gene promoter regions. To activate CDKN2A, proteins such as p53 are released in response to stress on the cells and possible DNA damage. On the other hand though, oncogenic transcription factors can promote uncontrollable cell cycle/growth progression. This intricate equilibrium between regulators affects the amount CDKN2A is expressed in which then determines cell fate (Rodriguez 2022).

Histone Modifications:

Not only does DNA methylation help regulate CDKN2A but so do histone modifications. Some examples of histone modifications include acetylation and methylation. They can affect the accessibility of DNA to the transcription machinery. These changes can either make CDKN2A transcription better or worse by allowing for another level of epigenetic control (Lee 2020).

Association with Cancer

CDKN2A looks over the cell cycle and is now being viewed as significant in the field of cancer biology research. Any changes to this gene could allow for the development of various kinds of cancers. The association between CDKN2A and cancer is not completely direct but, any

subtle changes or modifications have the chance of messing up the balayage of regulation in the cell cycle (Danishevich 2023).

Melanoma:

CDKN2A is mainly known for its role in melanoma, which can be an aggressive form of skin cancer. In melanoma that is passed down from family members, there are small mutations that are almost always observed in the CDKN2A gene. Even before a melanoma is present, the individuals with a mutation in the CDKN2A gene are at higher odds of forming a melanoma. Somatic mutations and deletions of CDKN2A are very likely in sporadic melanomas which means the gene is very important to protect against uncontrolled cell proliferation in the skin (Zocchi 2021).

Pancreatic Cancer:

Another type of cancer that can be associated with CDKN2A alterations is pancreatic cancer. This cancer tends to not show up until diagnosed in the late-stage malignancy. Homozygous deletions and inactivations of CDKN2A tend to be more prevalent in pancreatic ductal adenocarcinoma (PDAC) which also contributes to the loss of p16 function. Without this protein, there is a loss of control with the progression of the cell cycle. This would result in the aggressive and unforgiving traits of pancreatic cancer (Lin 2020).

Lung Cancer:

CDKN2A can also have links to lung cancer. In this particular scenario, lung cancer is multifaceted but has alterations in both non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC). Frequent inactivations of CDKN2A can stem from genetic mutations, deletions or promoter hypermethylation, which is primarily seen in lung cancer. This would all lead to the loss of p16 function so, in lung cancer it can allow the evasion of checkpoints in the cell cycle which allows for uncontrollable growth, similar to pancreatic cancer (Gutiontov 2021).

Synergistic Effects with Other Oncogenic Pathways:

CDKN2A can synergize with some oncogenic pathways which can amplify the potential that cells will turn cancerous. An example of this could be that the inactivation of CDKN2A along with mutations in a regulator such as TP53 can lead to a more resistant and aggressive cancer. This is a great example of how an alteration in CDKN2A doesn't just affect the cell but all the connections in the body (Pacifico 2007).

There needs to be further more detailed research done so scientists can understand the association between CDKN2A and different kinds of cancer. By understanding this, there could be more specific treatments and strategies to tackle the cancer. Figuring out the alterations in levels of CDKN2A will allow for a diagnostic marker but also see what vulnerabilities are introduced but the loss of p16 function (Danishevich 2023).

Clinical Implications

The implications of alterations in CDKN2A extend across a variety of cancer management including diagnosis, prognosis, risk assessment and the development of targeted interventions. The importance and usefulness of CDKN2A is usually undermined because

researchers primarily view the gene as a tumor suppressor that is associated with a lot of different kinds of cancers (Zhao 2016).

Genetic Testing and Risk Assessment:

Mutations to the CDKN2A are usually a hereditary trait that is passed down in families. As stated before, there is a higher chance of developing melanoma and countless other cancers. Genetic testing for CDKN2A mutations is key to identifying whether an individual has a family background of specific cancers. This information will allow for possible early cancer detection and intervention which as a result can lead to better outcomes. It can also allow families to create a specific treatment plan for them (Rossi 2019).

Cancer Diagnosis and Prognosis:

Determining the severity of the mutation on the CDKN2A gene will open the doors to understanding the prognosis of different cancers. In fact, any alterations such as mutations, deletions, or promoter hypermethylation can serve as a molecular marker for any cancer diagnosis. The alterations can also be a sign for an aggressive tumor possibility with a bad prognosis. Although this isn't the best news it can allow both the doctors and patients to plan for an aggressive treatment before the cancer gets bad (Foulkes 1997).

Predictive Biomarker for Therapy Response:

CDKN2A is now being recognized as a predicting biomarker for therapeutic response in those with cancer. The loss of the p16 function, that is commonly associated with this gene, alters the way the cell cycle functions. This could lead to an unprecedented response to specific targeted treatments. Understanding how the CDKN2A truly affects the p16 protein can allow for a more effective and personalized treatment which leads to a more favorable outcome (Luo 2021).

Immunotherapy Considerations:

The use of immunotherapy has revolutionized cancer treatment in the past couple of years. This directly affects the assessment of CDKN2A because alterations in this gene may show unique immunological profiles which influences their response to immune checkpoint inhibitors. By incorporating CDKN2A status into the greater molecular landscape of tumor aids, it can improve patient response to immunotherapeutic intervention (Adib 2021).

All in all, the possible clinical results from CDKN2A alterations are endless. They could include better genetic testing, cancer diagnoses, prognoses and more personalized treatment strategies for aggressive cancers. Incorporating CDKN2A studies into clinical practice will not only further our understanding on cancer progression but will also open new doors in the department of precision medicine (Chan 2021).

Challenges & Future Directions

There have been significant discoveries made in truly understanding the role that CDKN2A has in the world of cancer. There are still many challenges to the unknown complexity of this gene. The main future that studying this gene has is probably developing more targeted interventions for cancers affected by CDKN2A (Chen 2021).

Elucidating Regulatory Networks:

The specialized mechanisms concerning CDKN2A expression and function are currently only partially understood. By figuring out how the regulatory networks, which include, transcription factors, non-coding RNAs and epigenetic modifications, there will hopefully be a more complete understanding of CDKN2A's role in maintaining cell equilibrium. This will also lead to figuring out what happens to the cells when homeostasis is disrupted (Kaikkonen 2011).

Functional Characterization of CDKN2A Variants:

The functioning consequences of different variants of CDKN2A include mutations and polymorphisms that aren't completely understood yet. Figuring out how these abnormalities affect the p16 protein's function and how this messes with cell cycle regulation is key for deciphering its role in cancer progression (Kimura 2022).

Tumor Microenvironment Interactions:

Exploring the interactions between both CDKN2A and the tumor's microenvironment is a new point of interest for research. Figuring out how alterations to the gene can have an influence on immune response, angiogenesis and stromal interactions could open a pathway into tumorigenesis and possible targeted treatments (Soltan 2023).

Integration of Multi-Omics Data:

Using data from genomics, transcriptomics, proteomics and epigenetics will enhance our understanding with the new molecular structure of CDKN2A with alterations. Thorough multi-omics analyses can provide a more complete understanding of the connected signaling pathways associated with the mutations that come with the CDKN2A gene (Athanasopoulou 2022).

Therapeutic Targeting Strategies:

Coming up with therapeutic strategies specifically to make more tumors that stem from the altered CDKN2A gene will pose a considerable challenge. Researching synthetic lethality, combination therapies and possible new drugs created to specifically target the issues introduced by CDKN2A mutations (Zhang 2021).

Exploring CDKN2A in Precision Oncology:

By incorporating the current knowledge of CDKN2A into precision oncology it would require researchers to figure out the challenges concerning diagnostic testing, data interpretation and clinical decision-making. By figuring out what groups of patients will be most benefited from personalized treatment from CDKN2A will be a huge step to personalized cancer treatment (Schmidt 2016).

Functional Cross-talk with Other Pathways:

Understanding how CDKN2A reacts with other important pathways used in cancer is important. Learning how alterations in CDKN2A counteract with mutations in other genes such as TP53, KRAS or BRAF will provide key insights to how complex the tumorigenesis really is (Hu 2021).

Patient Stratification in Clinical Trials:

By designing clinical trials that use the CDKN2A status as a stratification factor will allow for a more accurate patient selection and a better assessment of treatment efficiency. By using this

approach, it will be important for creating new and better therapies during the research phases (Rosenzweig 2023).

In conclusion, figuring out the challenges and future directions in CDKN2A research needs to be looked at from many different angles. It needs to combine genomics, biology and clinical oncology. By combining these 3 main factors we can further understand CDKN2A's role in cancer to figure out better diagnostic tools and treatments for a better outcome for cancer patients.

Conclusion

The uniqueness of CDKN2A would allow the gene to play a key role in regulating the cell cycle and tumor suppression which has already been proven through clinical research. Due to its specific molecular structure and functions will lead to specific regulatory mechanisms and associations with many different kinds of cancers. This literature review focuses on the complex nature of CDKN2A and offers insight on its role in cancer and cell function (Danishevich 2023).

Within the gene CDKN2A is a protein called p16. This protein has an Ankyrin repeat domain with specific interactions with CDKs that can mess with the way the cell cycle progresses on a molecular level. The regular mechanisms that control CDKN2A expression, which include promoter hypermethylation, non-coding RNA interactions, and transcription factors, focus on all the different factors that control its expression levels (Zhang 1998).

There are similarities between alterations in CDKN2A and different kinds of cancers such as melanoma, pancreatic cancer and lung cancer. Although these are the main ones, there are still many cancers that have the probability of being affected with a mutation in the CDKN2A gene. Understanding the clinical implications of altered CDKN2A from genetic testing will allow for a better risk assessment to diagnose cancer. Once a diagnosis and prognosis is made, precise treatments could possibly be created that are more personalized to the patient and how they are affected (Chan 2021).

Aside from this, there have been challenges that come up in trying to understand how regulatory networks, functional characterization of variants and the development of targeted therapies can change depending on the alterations to the CDKN2A gene. Exploring and understanding how CDKN2A interacts with the tumor's microenvironment, integration of multi-omics data, and how it communicates with other cancer-associated pathways is crucial for understanding for research (Jiang 2019).

By figuring out solutions or making major leeway on these questions will open the doors to understanding the role of CDKN2A in cancer. By having a basic understanding of how the fundamentals of the gene work will not only answer some of the greatest burning questions about cancer but also lead the way for better diagnostic tools which lead to a better patient outcome (Danishevich 2023).

As one answer is found in the world of cancer research, two more arise but throughout all of this, CDKN2A continues to remain a central focus for many researchers. This is because the gene is supposed to act as only a tumor suppressor but has shown to have more influence than just this one role. It combines all kinds of aspects of medicine such as molecular biology, clinical

oncology and translational medicine. The 3 put together along with CDKN2A hold the future to cancer diagnostic treatment and even prevention in the field of oncology.

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Pickleball's Quest for a David Beckham: Leveraging Star Power for Expansion By Neel Mathur

Introduction

From its modest beginnings in a suburban driveway in Washington, where Joel Pritchard and his family created the game to entertain his family and friends, to its present-day status as a nationwide phenomenon, pickleball is one of the world's fastest-growing sports.[180] This unique blend of tennis, badminton, and ping pong has captivated the hearts of enthusiasts across generations and geographies. Its surge in popularity has largely been fueled by various factors, including its accessibility to players of all ages and skill levels, the sense of community it fosters, and the adaptability that has allowed it to infiltrate schools, retirement communities, colleges, and professional sports arenas.[181] It is hard to determine precisely how many people have flocked to pickleball — by some accounts[182], as many as 4.8 million people in the United States are playing, and some say that figure is more than 36 million.[183] As we explore below, despite pickleball's widespread appeal among players of all ages and skill levels, its media popularity and business potential remain largely untapped.

Pickleball's low barrier for entry is what draws many to play the sport. The equipment is affordable and relatively easy to learn, and the game does not demand exceptional height, strength, or speed, making it suitable for a wide range of physical abilities. It's a low-impact sport, making it popular with older adults looking to stay fit without straining their joints.[184] Pickleball can be played in singles or doubles, fostering a sense of camaraderie and community among players. Many followers cite the game's social aspect as a significant draw, allowing them to meet new people, stay active and healthy, and have fun. Parks, schools, and retirement communities have recently added dedicated pickleball courts and facilities. Pickleball courts are also being integrated into existing tennis and sports facilities, reflecting the rising prominence of the sport. According to the USA Pickleball Association (USAPA), there are over 8,000 pickleball courts in the United States, with thousands more planned or under construction.

Pickleball's comparison to tennis stems from their shared characteristics and the former's burgeoning status as a beloved racket sport.[185] While tennis boasts worldwide fame, extensive media attention, and a solid professional framework, pickleball is swiftly making its mark. Major

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[185] Hirsch, Lauren, et al. "Pickleball Went pro. Can It Profit?" *The New York Times*, The New York Times, 19 Aug. 2023, www.nytimes.com/2023/08/19/business/dealbook/pickleball-business.html.

League Pickleball, one of the sport's two professional leagues, has grown from one event and eight teams in its 2021 debut to six events and 24 teams in two years.[186] Organized competitions, including national and international championships, like the US Open Pickleball tournament, attract players who seek competitive play. Media coverage of pickleball is also growing, raising its profile and attracting new participants. Highlighting this growth, the inaugural Pickleball Slam last April 2023 featured a pair of singles matches and a doubles showdown pitting Andre Agassi and Andy Roddick against John McEnroe and Michael Chang.[187] The event garnered an average broadcast viewership of 237,000 adults under 50, demonstrating the sport's entertainment value and competitive edge.[188]

As pickleball continues to gain popularity, and with high-profile personalities like Tom Brady, Kim Clijsters, Kevin Durant, and LeBron James purchasing teams, enthusiasts and investors are contemplating its future trajectory. Will pickleball go the route of ping pong, where even though almost 300 million worldwide play the sport, the masses in the United States do not watch it?[189] Or can pickleball develop the television deals and star power of tennis? We analyze the popularity of pickleball, comparing it with tennis. Both these sports have a marquee event, the US Open, and I analyzed if each sport's popularity increased during this event. Tennis's popularity is partly from its players, many of whom are household names, whereas Pickleball today is similar to American soccer, which did not attract a mass audience like other popular sports, such as American football or hockey until the LA Galaxy team hired the famous English player David Beckham. According to the Associated Press, compared to a 422,000 household viewing rating a few weeks prior, Beckham's inaugural American debut against Chelsea F.C., where he only played 18 minutes, was watched in 947,000 homes.[190] To analyze if the presence of famous players results in an increased interest in a sport, I also analyzed Pickleball's popularity during the Pickleball slam, which featured several celebrities, including former tennis players.

Research Methodology

I analyzed pickleball's popularity using Google Trends data spanning the last two years. Google Trends is a tool that provides data on the relative frequency of searches for a specific term relative to the total volume of searches done on Google.[191] Numbers don't represent absolute

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[186] Ibid

[187] Crupi, Anthony. "Has David Levy Cooked up Sports' next Big IP Play? You Can Bet on It." *Sportico.Com*, Sportico.com, 19 Jan. 2023, www.sportico.com/business/media/2023/david-levy-cooks-up-sports-next-big-ip-play-1234706873/.

[188] "Pickleball Slam on ESPN Beats out MLB, NHL, NBA in TV Ratings Race." *Yahoo! Sports*, Yahoo!, sports.yahoo.com/pickleball-slam-espn-beats-mlb-204453860.html. Accessed 21 Feb. 2024.

[189] EmRatThich, Coach. "Why Table Tennis Struggles to Gain Popularity in the US." *PingSunday*, 15 Feb. 2023, pingsunday.com/why-table-tennis-struggles-to-gain-popularity-in-the-us/.

[190] Dewhurst Contributor, Paul. "David Beckham Forever Changed Soccer in America." *The Pioneer*, thepioneeronline.com/16920/features/david-beckham-forever-changed-soccer-in-america/. Accessed 23 Feb. 2024.

[191] "FAQ about Google Trends Data - Trends Help." *Google*, Google, support.google.com/trends/answer/4365533?hl=en. Accessed 23 Feb. 2024.

search volume numbers; the data is normalized and presented on a scale from 0-100, dividing each point by the highest point, or 100.[192] Figure 1 shows the Interest over time for the search term Pickleball. The graph shows that Pickleball searches saw a considerable spike in July 2023. An upward line indicates that a search term's relative popularity is increasing.

Figure 1: Interest over time for Pickleball



Genoe, Rousseau, and Rousseau (2021) used Google trends to analyze the main events in the Tour de France 2019 on cyclists' online popularity in twelve countries and globally.[193]

When comparing two distinct terms in Google Trends, the process involves more than merely entering both phrases into the search bar. At times, a data value of less than one may emerge, leading to potential inaccuracies in the comparison. To mitigate this, I examined the trend of each term separately and then calculated the change relative to the original term for an accurate comparison.

A vital aspect of the comparison is the selected timeline. Pickleball's growth has occurred mainly within the last few years, mostly during the COVID-19 pandemic.[194] Therefore, it is not feasible to look back five years and compare tennis with pickleball because pickleball was only a shadow of what it is now. The two years of data provide a reasonable timeframe to analyze and

[192] "Google Trends: Understanding the Data." *Google News Initiative*, Google, newsinitiative.withgoogle.com/resources/trainings/fundamentals/google-trends-understanding-the-data/. Accessed 23 Feb. 2024.
[193] Genoe, Alexander, et al. "Applying google trends' search popularity indicator to professional cycling." *Journal of Sports Economics*, vol. 22, no. 4, 27 Jan. 2021, pp. 459–485, https://doi.org/10.1177/1527002520988329.
[194] *2023 USA Pickleball Fact Sheet*, www.usapickleball.org/docs/USA-Pickleball-Fact-Sheet-2023.pdf. Accessed 21 Feb. 2024.

make conclusions about pickleball's growth. Additionally, to measure the impact of the US Open Tennis and the US Open Pickleball, each sport's most popular event in the United States, had on the sport's overall popularity, I created a five-week timeline most relevant to the event. I conducted an event study where I examined the searches two weeks before the event occurred, the week during the event, and then two weeks after the event completion. As the US Open Tennis is a two-week event, I analyzed the data values for the tournament's second week. Additionally, I limited the search results to within the United States, as pickleball's presence abroad is minimal. For example, I calculate the Increase in popularity of Pickleball during the US Open using the formula below: % Change in popularity = [(Average search results during last 2 years US Open) - (Average search results two weeks before the last two years US Open)] / (Average search results two weeks before the last two years US Open) * 100

In addition to utilizing Google Trends, I used Infegy Atlas to query the Twitter API for tweets pertaining to pickleball and tennis between 1 January 2023 and 13 December 2023. In line with our Google Trends analysis, our data collection focused on social media conversations in the United States that contained the words "pickleball" or "tennis." I filtered out retweets to not skew the dataset toward viral posts and non-representative views. For my analysis, I focused on 200 randomly sampled tweets containing the word "pickleball" and 200 randomly sampled tweets containing "tennis." Each set of tweets was categorized into one of four groups: competitors, non-competitors, event, and non-event. The "competitors" category includes tweets about players participating in the US Open and other professional athletes associated with the sport. An "event" tweet pertains to details about the venue, dates, competition, or any aspect directly related to the event. An example of each type of tweet is shown below in Table 1.

Table 1: Example of Tweets using Infegy Atlas

"Competitor" tennis	"Tennis star Naomi Osaka welcomes baby girl with boyfriend Cordae"
"Competitor" pickleball	"I think about this point on the regular. Best pickleball game I've ever witnessed. I miss it. 🥹 @AnnaLeighWaters @LeaJansenPB @AndreaRemynse @MajorLeaguePB"
"Event" tennis	"it's 10:30 pm in NYC & they're still playing tennis"
"Event" pickleball	N/A

Results

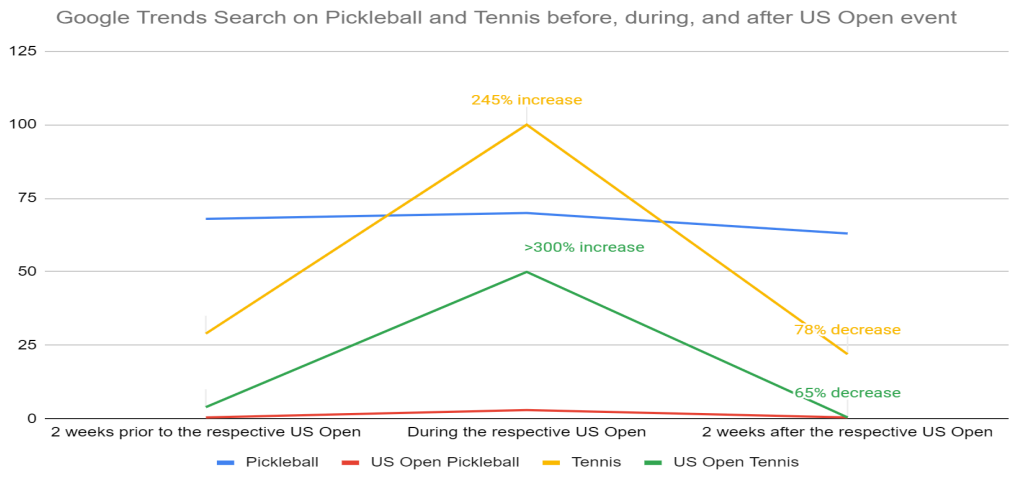
The most notable distinction between pickleball and tennis is their popularity levels during their respective US Opens. Tennis reached its peak popularity in both years, scoring a perfect 100, while pickleball did not, averaging a score of 70, as depicted in Table 2 below.

Moreover, the surge in tennis popularity from two weeks before the event to the week of the event averages an increase of 245%, in contrast to pickleball's more modest average increase of 3%. This disparity in peak popularity and the growth in interest underscore the relative significance of each event. The US Open has a far more substantial effect on tennis's overall popularity compared to its impact on pickleball. There is a noticeable decline in popularity two weeks post-event, with pickleball experiencing a modest decrease (average 10%) and tennis witnessing a more pronounced drop (average 78%). This trend suggests that after the US Open tennis tournament concludes, there is a significant reduction in overall tennis interest, highlighting the US Open as a major draw for fans and a period when tennis interest peaks.

Table 2: Google Trends Search Results for the last two years during the US Open Pickleball and US Open Tennis

	During US Open Pickleball		During US Open Tennis	
Search Results for keyword =	"Pickleball"	"US Open Pickleball"	"Tennis"	"US Open Tennis"
2 weeks prior to the respective US Open	68	<1	29	4
During the respective US Open	70	3	100	50
% Change	3%	>300%	245%	>1000%
2 weeks after the respective US Open	63	<1	22	<1
% Change	-10%	-65%+	-78%	-97%+

Figure 2:



The low popularity of US Open pickleball, with only 40,000 viewers, highlights the challenges facing pickleball - it's a new sport with low viewership featuring professional players who do not

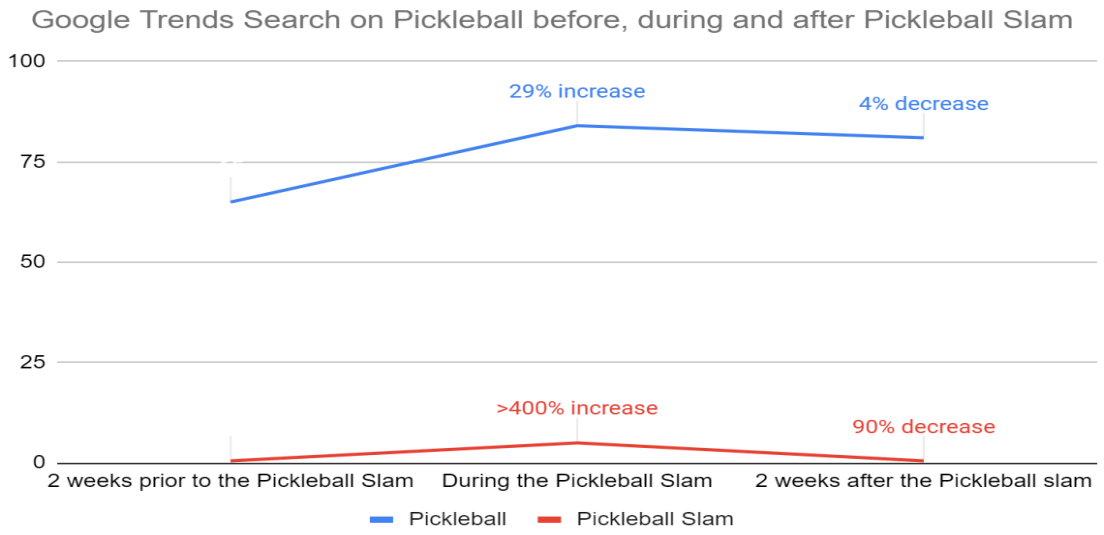
have much following.[195] Recently, pickleball introduced the Pickleball Slam. The event featured retired star tennis players John McEnroe, Michael Chang, Andre Agassi, and Andy Roddick. The event was largely successful, with viewership numbers peaking at 669 thousand, beating out several nationally televised MLB, NBA, and NHL games that day. The Pickleball Slam tackles the central issue of garnering attention for the sport, a primary concern for the US Open Pickleball event. From two weeks before the event to the week of the event, the popularity of Pickleball increased by nearly 30%, ten times greater than the increase that the US Open Pickleball brought (see Table 3.) If Pickleball wants to create a following similar to tennis, where events dictate most of the sport's popularity, they must continue involving celebrities in events similar to the Pickleball Slam or attempt to raise the profile of top professional pickleball players.

Table 3: Google Trends Search Results for last two years during Pickleball Slam

	During Pickleball Slam	
Search results for keyword =	"Pickleball"	"Pickleball Slam"
2 weeks prior to the Pickleball Slam	65	0.5
During the US Open	84	5
% Change	29%	>400%
2 weeks after the Pickleball slam	81	0.5
% Change	-4%	-90%+

[195] "US Open Pickleball Championships." *US Open Pickleball Championships*, www.usopenpickleballchampionship.com/. Accessed 21 Feb. 2024.

Figure 3:



While Google Trends can tell us how many people are searching for a particular item, it does not allow us to evaluate what aspect of that sport they are most interested in. By contrast, we can use Twitter data to delve deeper into what people are talking about when discussing pickleball and tennis. Specifically, I compared the frequency of tweets discussing competitors engaging in these sports and those focusing on the specifics of the competitive events themselves. The results of this analysis, comparing the content of the random sample of 200 tweets with the keyword pickleball and 200 tweets with the keyword tennis, are shown in Table 4.

Table 4: Analysis of the content of 200 Random Tweets, with keyword tennis and pickleball

4A: Competitor and No Competitor Analysis

	Competitor	No Competitor
Tennis	39 (expected 26.5)	161 (expected 173.5)
Pickleball	14 (expected 26.5)	186 (expected 173.5)
Chi-squared	13.6* (p-value 0.0035)	

Table 4B: Event and No Event Analysis

	Event	No Event
Tennis	10 (expected 5)	190 (expected 195)
Pickleball	0 (expected 5)	200 (expected 195)

Chi-squared	10.26 (p-value 0.0165)	

The most notable distinction in content between the tennis and pickleball datasets lies in the volume of tweets about competitors. Tweets related to competitors, defined as individuals participating in the US Open or professional athletes, are almost three times more frequent for tennis than for pickleball. Additionally, as shown in Figures 4A and 4B, I created a chi-squared test statistic for independence, a test used to determine if a difference between observed data and expected data is due to chance or if it is due to a relationship between the variables being studied. In testing for independence, I ensured that our tweets were acquired from a random sample, all expected counts were greater than 5, and all observed values were in counts. The test results are the following: chi-squared values of 13.6 and 10.26 and p-values of 0.0035 and 0.0165, proving our test to be statistically convincing as our p-values are less than the significance level of 0.05. I proved that a relationship exists between the sport and the number of tweets about competitors or the respective event.

This disparity further demonstrates that pickleball could benefit from enhancing the visibility of its leading players, such as Anna Leigh Waters, Ben Johns, and Lee Whitwell, to match the level of engagement tennis fans exhibit towards their stars like Rafael Nadal, Novak Djokovic and Naomi Osaka. Furthermore, in the timeframe, there were no tweets about the US Open Pickleball event, whereas 5% of the tweets in the tennis dataset (equivalent to 10 tweets) mentioned the US Open for tennis. This comparison underscores the greater significance and impact of the US Open within the tennis community compared to its pickleball counterpart.

In my analysis of engagement between tennis and pickleball tweets, I found that while the collective followers of the 200 pickleball tweeters surpassed those of tennis tweeters, the engagement levels for tennis tweets (8,013) significantly exceeded those for pickleball (3,455), more than doubling the latter's figure. Specifically, 64% of tennis tweet engagement, amounting to 5,164, involves tweets about sports competitors. In contrast, only 29% of engagement with pickleball tweets, or 1,013, is attributed to competitors.

Table 5 reveals that engagement for tweets about competitors is considerably higher for both sports—seven times higher for tennis and 5.5 times for pickleball. However, the disparity is more pronounced in tennis, with about 83% higher engagement levels than in pickleball. This disparity underscores the greater popularity of tennis professionals compared to pickleball players, resulting in higher engagement levels. The increased engagement with tennis competitors fosters more discussion about the event, amplifying the sport's overall popularity.

Table 5: Engagement

Average engagement	Competitor	No Competitor	Competitor compared to No Competitor
Tennis (8,103)	5164/39 = 132.4	2849/161 = 17.7	7.5x

Pickleball (3,455)	1013/ 14 = 72.4	2442/186 = 13.1	5.5x
Tennis compared to pickleball	83% Higher	35% Higher	

Conclusion

Analyzing tennis data and comparing it to Pickleball provides invaluable insights for the development and promotion of Pickleball. The results show that the popularity of tennis is due to its high-profile players. It surges during its marquee event, the US Open tennis tournament. Analysis of tweets further cements this conclusion, as we observe more tweets about tennis players that also have significantly greater engagement as compared to pickleball players.

I conclude that Pickleball needs to enhance the profile of its professional players. Furthermore, the leading sports organizations, such as Major League Pickleball (MLP), the Professional Pickleball Association (PPA), and the Association of Pickleball Professionals (APP), need to collaborate to promote pickleball by organizing more high-profile events akin to the Pickleball Slam held last year, could significantly boost the sport's visibility. Such events, especially featuring celebrities from diverse backgrounds, draw new audiences to Pickleball and enhance its appeal. Moreover, these occasions are a magnet for sponsors, pivotal in the sport's expansion.

The recruitment of David Beckham by the Los Angeles Galaxy towards the end of his soccer career is a prime example of how integrating renowned athletes can elevate a sport's profile. Beckham's arrival sparked increased interest in American soccer, leading to a surge in viewership and sponsorship.[196] Drawing on this model, pickleball leagues should engage retiring tennis professionals as active players or mentors. This approach can elevate Pickleball's status significantly, fostering growth and broadening its appeal across different demographics.

[196] Dewhurst Contributor, Paul. “David Beckham Forever Changed Soccer in America.” *The Pioneer*, thepioneeronline.com/16920/features/david-beckham-forever-changed-soccer-in-america/. Accessed 21 Feb. 2024.

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Exploring Jurisprudential Challenges in Psychiatric Injury By Darrell Pui

Over the past century, tort doctrine in English law has coalesced around a robust law of negligence, anchored in both contemporary concerns about fairness and considerations of loss spreading and safety promotion.[197] Yet, this evolution of tort law has also seen a rise in the difficulty of pinning down injury with changing social perceptions of injury being derived over time.[198] One manifestation of this can be seen through the deprioritisation of psychiatric injury compared to material injury.[199]

While existing literature on psychiatric injury exists, there is a lack of research covering the just nature of such laws, and whether the more stringent criteria met out is principally justified. This article argues that current criteria for claims to psychiatric injury are jurisprudentially unjustified, go against basic principles of fairness and accessibility that are enshrined in law, and are largely arbitrary. Instead, the paper will give recommendations on how psychiatric injury can be reimagined, drawing references to other jurisdictions. Furthermore, the paper will argue that practical concerns are insufficient to justify these trade-offs, and that more appropriate criteria could, instead, also address these practical concerns.

Section 2: Redefining Psychiatric injury in tort law

This section would seek to prove that deprioritisation of psychiatric injury as compared to material injury is unjustified. This claim will be demonstrated by discussing the parameters of establishing psychiatric injury in tort law and offer potential reasons of why they have come to be, and thus evaluating the legitimacy of these criteria.

Generally, there are two criteria that must be met in order to claim psychiatric injury in tort law:

(1) Recognised psychiatric illness; and
(2) Sudden shock

These two criteria are unique to psychiatric injury and there is no equivalent in other areas of tort law[200]. However, as Teff pointed out in his article *Liability for Negligently Inflicted*

[197]Stephen D. Sugarman, 'A Century of Change in Personal Injury Law' (2000) 88 California Law Review 2403

[198] CJD litigation *2406.*

[199]Margaret Fordham, 'PSYCHIATRIC INJURY, SECONDARY VICTIMS AND THE 'SUDDEN SHOCK' REQUIREMENT.' (2014) Singapore Journal of Legal Studies

[200] Rachel Mulheron 'Rewriting the Requirement for a "recognized Psychiatric Injury" in Negligence Claims' (2012) 32 Oxford Journal of Legal Studies

Psychiatric Harm: Justifications and Boundaries published in the Cambridge *Law Journal,*[201] the devastating impact that psychiatric illness can have on people's lives is beyond dispute.[202] It would be uncharitable, then, to claim that psychiatric injury is intrinsically less serious that physical injury, when over many years, medical research has pointed to the artificiality of characterising it as lacking physical manifestations.[203] This chapter will thus examine these two criteria and set out reasons of why the threshold is as it is in the status quo, and their principled legitimacy.

Recognised Psychiatric Illness

It is essentially axiomatic in English law that for the purposes of a negligence claim in which no physical injury is claimed, mere grief, distress, and horror are not compensable.[204] This is emblematic in many decisions of the courts, where in one instance, the court claimed that 'emotional responses to unpleasant experiences of even the most serious type do not found a claim for damages'.[205] Instead, the claimant must establish—as a minimum threshold requirement— that he or she was suffering from some 'recognized psychiatric illness' in order to found a claim for negligently inflicted pure psychiatric illness.[206] This 'Traditional Rule' was first established in by Lord Bridge in *McLoughlin v O'Brian* who stated that:

> the first hurdle which a plaintiff claiming damages of the kind in question must surmount is to establish that he is suffering, not merely grief, distress or any other normal emotion, but a positive psychiatric illness.[207]

This rule has been imposed in English courts and has thus resulted in a preclusion of a vast number of claims of psychiatric injury. Take for instance the case of *Reilly v Merseyside HA (1994) 23 BMLR 26 (CA)* where Mr Reilly, a hospital visitor who was trapped in a jammed

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[201] Harvey Teff 'Liability for Negligently Inflicted Psychiatric Harm: Justifications and Boundaries' (1998) 57 The Cambridge Law Journal 91

[202] Cf. "There is no justification for regarding physical and psychiatric injury as different 'kinds of damage": Page v. Smith [1996] A.C. 155 at p. 190, per Lord Lloyd of Berwick

[203] Teff (n 5) 91.

204 Mulheron (n 4) 77-78.

[205] *RK v Oldham NHS Trust* [2003] Lloyd's Rep Med 1 (QB) [20]

206Mulheron (n 4) 78.

[207] *McLoughlin v O'Brian* [1983] 1 AC 410 (HL) 431

hospital lift for considerable time suffered an anxiety disorder as a result. In the decision, Lord Mann LJ stated that:

> "there must be an identifiable psychiatric condition. The sound policy of the law is that the excitement of a normal human emotion, together with its normal physical consequence, is not compensable. Here there was no recognisable psychiatric injury, but only normal emotion in the face of a most unpleasant experience".

This is not a one-off instance, but rather a clear trend of tort precedent over the years. See the cases[208] of Ms Bancroft, a patient who alleged that she was treated for cervical cancer too conservatively for the first years of the disease and that she suffered 'anxiety and a neurotic depression' as a result (*Bancroft v Harrogate* 1997)[209]; little baby MK, who was wrongfully diagnosed as having sustained an 'inflicted' and 'non-accidental' leg fracture (she suffered from brittle bone disease) and was separated from her parents for eight months, following which she displayed behavioural disturbances and reduced development of 'the attachment dynamic' between parents/child (*RK v Oldham NHS Trust* 2005s);[210] and Ms Younger, who was incorrectly diagnosed with coeliac disease, as a result of which she claimed that being instructed to follow a gluten-free diet (which the court said '[did] not arise consequent upon physical injury') meant that she 'suffered a real effect on her enjoyment of life', amounting to psychological harm (*Younger v Dorset and Somerset HA* (2006).[211] In none of these cases did the respective claimants overcome the threshold of a recognized psychiatric injury, and hence, all failed in their claims.

In recent years, recognition for mental health has increased and there have been more calls for reform. The Negligence and Damages Bill, which was presented to the House of Commons on 13 October 2015, sought to change the threshold for bringing a claim for psychiatric injury.[212] However, the Bill continued to specify that a claimant must suffer from a recognisable psychiatric illness.[213] Thus, there is still general unwillingness from legislators and politicians to admit other forms of psychiatric harm as injury as seen in the caveat of the Bill. Evidently, this 'traditional rule' has precedent and has been widely applied in courts. The question, then, is why exactly there seems to be such a rigid application of this criteria?

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[208] Mulheron (n 4) 81.

[209] *Bancroft v Harrogate HA* [1997] 8 Med LR 398 (QB)

[210] *RK v Oldham NHS Trust* (n 10)

[211] *Younger v Dorset and Somerset HA* [2006] Lloyd's Rep Med 489 (Southampton CC)

[212] Moore Barlow, 'Psychiatric Injury – Time for Reform?' (Moore Barlow LLP, 8 October 2021) <https://www.moorebarlow.com/blog/psychiatric-injury-time-for-reform/.> accessed 24 August 2023

[213] Mulheron

The requirement for a claimant to prove a genuine psychiatric disorder, as opposed to something less, has been judicially said to operate as a 'powerful control mechanism'[214] for these types of claims. Such a mechanism was seen to be needed due to the nature of psychiatric injury – that it was hard to prove empirically to file for claims. Since psychiatric injury can only be determined based on the credibility of claimants, given the lack of objective empirical evidence, it seems necessary to have a healthy amount of judicial scepticism[215] for there to be fair adjudication. As Chief Justice McEachern established in *Devji v. District of Burnaby et al, 1999 BCCA 599*[216]:

> "The law in this province, as formulated by Rhodes, requires that the plaintiffs, in order to succeed, must experience something more than the surprise and other emotional responses that naturally follow from learning of the death of a friend or relative. Instead, there must be something more that separates actionable responses from the understandable grief, sorrow and loss that ordinarily follow the receipt of such information."

While this case occurred in British Columbia, Canada, the same logic has been applied in English courts as seen in the case law presented above.

Furthermore, when the damage is mental or emotional, there is a reluctance to compensate the victim due to policy considerations.[217] This is because courts fear that such an action would open the floodgates of litigation, and such large number of claims could place disproportionate burdens on defendants. Probably the most important of the policy justifications, the Traditional Rule ring-fences the potential number of claimants (arising, say, out of a large group of spectators who witness a horrific accident) and, thereby, reduces the risks of 'indeterminate liability'[218] (which will be discussed in the next section).

What constitutes mere psychological harm is said to be 'more captive to shifting medical theories and conflicting expert evidence'[219]—especially given that 'medical science has so far been less successful in demonstrating the nature of psychiatric illness and the processes whereby

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[214] CJD Litigation; Group B Plaintiffs v UKMRC [2000] Lloyd's Rep Med 161 (QB) 163 (Morland J)

[215] Devji v. Burnaby (District) et al., (1999) 129 B.C.A.C. 161 (CA) (McEachern CJ)

[216]. Katsivela (Common Law)

[217]Katsivela M, 'The Notion of Injury in the Tort of Negligence (Common Law) and the Personal Extra-Contractual Liability (Civil Law) in Canada: A Comparative Study' [2019] SSRN Electronic Journal

[218] Eg *Tame v New South Wales* [2002] 211 CLR 317 (HCA)

[219] *White v London Fire & Civil Defence Athy* [1999] PIQR P314 (CA)

it is brought about by the psychiatric route.'[220] Furthermore, there is a placebo effect at play, as Morland J put it,

> "the existence of the belief to such entitlement might well create the psychological injury which otherwise would not have occurred".[221]

Since psychological harms are more widespread than physical ones, "[e]very man and woman is expected to face such situations with such fortitude as he or she can muster".[222] Overwhelmingly, injury is usually tied to material and tangible harm like economic losses or bodily harm,[223] with general perceptions of 'mental harms' or 'emotional damages' being seen as trivial in comparison to more tangible damages, since the Common Law was met out to "lay down rules of general application, and not to provide for every exceptional contingency".[224] This is exacerbated since claims for psychiatric injury were historically regarded with scepticism, and even today courts demonstrate considerable caution when asked to extend the parameters of such actions.[225] However, it is worth noting, that this specific justification is not as applicable as times change – current awareness on mental health and increased information on the potential destructive nature of psychiatric harms have caused individuals to be less dismissive of mental health concerns.[226]

Such justifications seek to comply to the 'Policy Principle' which as Atiyah puts it in his book *Accidents, Compensation and the Law:*

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[220] Page v Smith (n 7) 181 (Lord Browne-Wilkinson)

[221]The Creutzfeldt-Jakob Disease (CJD) Litig, Andrews v Sec of State for Health (Damages Assessments) (1998)

222

[22327]Fordham (n 3) 55-58.

[224] Francis Bohlen,' RIGHT TO RECOVER FOR INJURY RESULTING FROM NEGLIGENCE WITHOUT IMPACT.' (1902) Penn Carey Law: Legal Scholarship Repository

[225] Fordham (n 3) 41-42.

[226] Grace Yeoh, 'The Rise of Mental Health Awareness – and the Stigma That Remains Attached to Certain Conditions' (CNA, 5 June 2021) <https://www.channelnewsasia.com/singapore/singapore-mental-health-awareness-stigma-conditions-depression-1973166> accessed 24 August 2023

> "The legal rules which determine who is liable for accidental harm are not just arbitrary rules of private law; they are also influenced by public policy considerations. ... The policy principle requires that the law of torts be evaluated not just in terms of the private interests of the parties involved, but also in terms of its broader social goals and values." [227]

Ostensibly, strict criteria as seen in needing to have a recognised psychiatric illness is substantiated by a jurisprudential backdrop:

1. Tort law should promote broader societal values
2. Society, historically, has not and does not value psychiatric injury to the same regard as material injury.[228]
3. Therefore, there must be a strict threshold when administering such injury.

However, I argue that such line of reasoning is often contradictory to this jurisprudential principle in the first place. If it was true that tort law should be concerned with broader social goals, such strict criteria would go against the fundamental principle of deterrence because it makes it far easier for perpetrators to get away with psychiatric harm. Crucially, the purpose of tort law, as explained by American legal scholar William Prosser,[229] and echoed by many others in the sphere of legal academia:

> "to provide remedies for the invasion of various interests that are not protected by criminal law and that are not exclusively addressed by contract law"

[227] Atiyah PS and Cane P, Accidents, Compensation and the Law (Butterworths 1999)

[228] Jonathan Herring, "The Devaluation of Psychiatric Injury in Tort Law," in Tort Law: Text, Cases, and Materials, ed. Mark Lunney and Ken Oliphant (Oxford: Oxford University Press, 2017), 709-728.

[229] Keeton WP and Prosser WL, Prosser and Keeton on the Law of Torts (West 1984)

Given so, intentionally treating psychiatric harm differently from material harm seems to defeat the aim of providing remedies for the invasion of *various* interests, and arbitrarily administers a value judgement. A rather apt analogy would be the idea of incommensurable values, popularised in the field of law by legal scholar Ronald Dworkin.[230] Since we do not have epistemic access to another person's conscious or experiences, we cannot arbitrarily adjudicate the moral worth of injury based on its type – thus, it would be unfair to pre-emptively make it harder for psychiatric harm to be recognised, and instead should go by a case by case basis, since the 'value' of harm is different for every individual.

Detractors to this claim often make a common refutation: that the traditional test is, at the very least, able to lay out standardised and consistent frameworks for adjudicating psychiatric injury, even if such adjudication may start out biased. When expert psychiatric testimony is required to establish the existence of a recognized psychiatric injury or to disprove its absence, one of two diagnostic manuals—DSM-IV by the American Psychiatric Association (used in the States), which outlines diagnostic criteria for mental disorders, or ICD-10 by the World Health Organization (used in the UK), which is a statistical classification of all diseases with a separate section on mental disorders—is commonly used. The presence of these classifications thus ''represent the two main diagnostic classificatory systems used by the psychiatric profession".[231]

However, such classifications have not been consistent in the slightest. In *Dickie v Flexcon Glenrothes Ltd*[232], for example, Sheriff Braid commented that:

> [t]he complexity of psychiatry and the difficulty of diagnosing a condition in any given case were illustrated by the fact that each of the doctors held a different view as to what condition the pursuer was suffering from.

Since classification systems do have their flaws as well, perhaps such a high threshold would not be needed. Instead, as noted by Maurice Kay LJ in *Hussain v Chief Constable of West Mercia Constabulary,*[233]

> [I]t seems to me that what Lord Bridge was concerned to discount in *McLoughlin v O'Brien* was 'normal human emotions', not significantly abnormal manifestations of non-physical sequelae.

[230]Martijn Boot, 'Problems of Incommensurability' (2017) 43 Social Theory and Practice 313

[231] Law Commission, Liability for Psychiatric Illness (Law Com No 249, 1998) ('English Report')

[232] *Dickie v Flexcon Glenrothes Ltd* [2009] Scot (D) 3/11 (Sheriff Court, Kirkcaldy, 4 Sep 2009) [129]

[233]Hussain v West Mercia Constabulary [2008] EWCA Civ 1205

Thus, the presence of the traditional test can be seen to be principally confused, since the purpose of tort law was never meant to arbitrarily place value judgements on different types of harms but rather give recourse to those who have suffered injury, in general, in the first place. Practically, international standards seem to not be consistent nor reliable[234] and adopting a lower threshold may be healthier for the legal system to more consistently and reliably adjudicate claims of psychiatric injury. I posit that instead, we can and should adjudicated based on 'mere grief or distress', as it would be more principally aligned with jurisprudential norms. At first glance, this claim is unintuitive - as distress is nebulous – it could range from a youth stressing over an examination or a parent crying over the passing of their loved one. However, there have been claims in other jurisdictions made to support this – something that English law can draw upon.

In Canadian law, there has been precedence of harms that fall short of the traditional rule to still be considered injury, thus being successful in gaining recourse[235]. Specifically, the difference is that such claims result in lower quantum of compensation. In *Mason v Westside Cemeteries Ltd*[236], the defendants lost the cremated remains of the plaintiff 's parents. The plaintiff "lost peace of mind" but did not require psychiatric care. In making a modest damages award, judge Molloy J remarked:

> It is difficult to rationalize awarding damages for physical scratches and bruises of a minor nature but refusing damages for deep emotional distress which falls short of a psychiatric condition. Trivial physical injury attracts trivial damages. It would seem logical to deal with trivial emotional injury on the same basis, rather than by denying the claim altogether.

Thus, lowering the quantum of monetary compensation seems to be a plausible way of reconciling this gap.

Principally, this coincides with other justifications for lowering the threshold. In the Scottish case of *Dickie v Flexcon Glenrothes Ltd*, the court agreed that anxiety and psychiatric injury although legally distinct, were not actually different types of injuries[237]:

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235See Vanek v. Great Atlantic (1999), 127 O.A.C. 286 (CA)

[236]Mason v Westside Cemeteries Ltd (1996) 135 D.L.R (4th) 361

[237] Dickie v Flexcon Glenrothes Ltd [2009] (n 37)

> anxiety and psychiatric harm are both, in my view, conditions with a similar aetiology, both sharing similar symptoms but with one being more serious than the other. ... it seems quite artificial to attempt to draw a borderline between anxiety and psychiatric illness caused by harassment. If the victim's emotional reaction to the harassment is of such a degree as to amount to psychiatric illness there is no logic to treating it differently from anxiety. ...the victim of harassment is not entitled to damages for a label, but for what he has actually suffered.

Hence, the current distinction could in fact make the law seem inconsistent to medical consensus,[238] and thus principally detached from reality. The conclusion, then, is that perhaps we ought to allow increased judicial discretion cases of psychiatric injury, with the option of lowering the quantum of compensation being far more viable than denying the claim altogether.

Section 3: Second Victims and the Sudden Shock Requirement

As established earlier, 'sudden shock' is also a requirement for claims to injury. This was introduced, in tandem to even more stringent criterion for secondary victims, who are those who suffer psychiatric injury from witnessing sudden, shocking events to others, of whom they have a close tie of love and affection.[239] As argued in the first section, strict distinctions purely for practical reasons can be seen to go against the principles of the law in the first place. This section will zoom in on the requirements specifically and point out potential flaws.

This section will prove two things:

(1) The sudden shock requirement is illegitimate
(2) Despite this, there is a need for a distinction between primary and secondary victims due to practical concerns for the law

Given that the law, as previously established, has sought to restrict the cases of recognised psychiatric injury, it is not a surprise that there have been more distinctions drawn between the *types* of victims – primarily primary and secondary victims. A primary victim is a person who has been physically injured, or was within the zone of physical injury, and has suffered a psychiatric illness consequent on that physical injury or from fear of suffering a physical injury[240]. A secondary victim is a person who suffers a psychiatric illness consequent on (eg by

[238] Teff H (Cambridge Law journal)

[239] Paul and another v Royal Wolverhampton NHS Trust (Respondent) [2022] EWCA Civ 12

[240] White v Chief Constable of South Yorkshire Police [1999] 2 AC 455

seeing) physical injury to someone else[241]. As a result, establishing a claim is far harder for secondary victims, as there are more stringent burdens of proof placed upon them (as explained below). Should they meet this proof, however, the consideration for compensation would apply symmetrically as that of primary victims.

The need for such a distinction first appeared in the landmark case of *Alcock v. Chief Constable of South Yorkshire Police* where a joined action was brought by Alcock (C) and several other claimants against the head of the South Yorkshire Police. C and the other claimants all had relatives who were caught up in the Hillsborough Stadium disaster, in which 95 fans of Liverpool FC died in a crush due to the negligence of the police in permitting too many supporters to crowd in one part of the stadium. The disaster was broadcast on live television, where C and a few others alleged they had witnessed friends and relatives die. Others were present in the stadium or had heard about the events in other ways. All claimed damages for the psychiatric harm they suffered as a result. The nature of psychiatric injury permits there to be multiple victims to any single injury, with there being a far higher propensity than that of material or economic injuries. A pragmatic approach towards administering harm is thus taken via this distinction.

In the case of *Alcock v. Chief Constable of South Yorkshire Police,* the House of Lords laid down that a claimant who is a secondary victim must show[242]:
(i) that he or she had a close tie of love and affection to the primary victim;
(ii) that he or she was close in time and space to the incident or its immediate aftermath; and
(iii) that he or she saw or heard the incident through his or her own unaided senses rather than, for example, being told about it by a third party.

Implicitly, there was also a fourth requirement (that would be established as sudden shock) mentioned in the judgement of the case, where Lord Ackner[243] clarified:

> 'Shock', in the context of this cause of action, involves the sudden appreciation by sight or sound of a horrifying event, which violently agitates the mind. It has yet to include psychiatric illness caused by the accumulation over a period of time of more gradual assaults on the nervous system.

Perhaps the most controversial of the four, due to its arbitrary application in courts, is the sudden shock requirement Its use in courts has already been inconsistent with various judges

[241] Munro (A state Monopoly on Violence)

[242]Sugarman (California Law Review)

[243] See also at 401 (per Lord Ackner) and at 411 (per Lord Oliver).

applying it vastly differently. In the case of *Sion v Hampstead Health Authority*[244], the plaintiff's son was involved in a motorcycle accident and subsequently admitted to the hospital. Throughout this period, the plaintiff remained by his son's side, observing a gradual decline in his health, culminating in a heart attack, coma, and eventual demise. The plaintiff alleged that the hospital had acted negligently in their treatment and sought compensation for the atypical emotional response experienced upon his son's passing. However, the hospital successfully contested the claim by asserting that the father's psychiatric condition was not precipitated by a sudden and shocking event. Rather, it was argued that the son's deterioration and subsequent demise had occurred gradually over an extended timeframe. On the other hand, *North Glamorgan NHS Trust v Walters*[245] presented a rare instance in which a medical negligence claim made by a secondary victim for psychiatric illness was successful. The case established that a mother's pathological grief reaction, which followed the death of her 10-month-old baby while in hospital, constituted a coherent narrative with a clear beginning and end, as described by Ward LJ[246]. Specifically, he came to the decision that:

> Her appreciation of the horrifying event was sudden within the temporal context in contradistinction to more gradual assaults on her mind. It was that sudden appreciation of that event that caused the pathological grief reaction.

Despite the events unfolding over a span of 36 hours, they were deemed to constitute a sudden and shocking occurrence. This presents a problem: it seems generally unclear what 'shock' *is*. If it is possible for the sudden shock requirement to be interpreted as it has been in this case, the law then become deeply unclear. It can be argued that it in fact goes against the fundamental principle of law to be "accessible and so far as possible intelligible, clear and predictable[247]".

This problematic as the law being unclear not only goes against this principle of the law but also complicates practical proceedings. The justification for the fourth requirement, particularly in relation to factors causing psychiatric illness beyond Post Traumatic Stress Disorder (PTSD), is then difficult to establish. Even if one agrees that there should be control mechanisms for secondary victims to avoid an excessive influx of litigation, these controls should not be arbitrary. However, the need to demonstrate a sudden and shocking event appears to be precisely that. If an individual has experienced a psychiatric illness, the distinction between

[244] Sion v Hampstead HA [1994] 5 Med. L.R. 170

[245] Walters v North Glamorgan NHS Trust [2002] EWCA Civ 1792

[246]Sion v Hampstead HA [1994] 5 Med. L.R. 170

[247]Sir Thomas Bingham, The Rule of Law (Penguin Books 2011)

whether it was induced by a sudden shocking event or a series of unpleasant events over time seems arbitrary. The impact on the claimant is ultimately the same, as they have suffered a psychiatric illness. It is acknowledged that the specific types of psychiatric illness may differ.

In its 1998 Report, following the 1995 consultation paper, the Law Commission[248] extensively examined the arguments both for and against retaining the sudden shocking event requirement. The Commission recommended its abolition, citing reasons such as the requirement being a crude method of limiting potential claimants, lacking medical rationale, and receiving significant support for abandonment from 66% of respondents to their consultation paper on the issue.[249] According to the Law Commission, they concluded that it is possible to address all the arguments favouring retention of the shock requirement[250]. However, the government subsequently rejected the Law Commission's recommendations for statutory reform, asserting that the liability for psychiatric illness arising from negligence is a contentious area of law best left for judicial development through common law[251].

However, I argue that this rebuttal is problematic on multiple fronts. Firstly, the only defence the government gives is that the requirement is "controversial"[252]. However, this ignores the huge medical consensus on the illegitimacy of the criterion.[253] Miles Mandelson, a clinical psychologist, wrote in response to this and aptly summed up the consensus of the medical world, claiming,

> Psychological reactions to a traumatic episode do develop over time partly as a result of the subject's ability to reflect on past events and anticipate future events and to consider their implications (processes which themselves take place over time) and partly because the traumatic episode may be protracted before the final outcome is known.

Given this, controversy itself does not seem to be a sufficient response. This is in addition to the government already historically having overturned controversial laws like Section 28 of

[248] Law Commission Consultation Paper No. 137.

[249] Yego (The Rise of Mental Awareness) Para 5.38 - 5.40

[250] Law commissions at para. 5.31.

[251] See Law Commission, Forty–Fourth Annual Report (2010), Law Com No. 323, at para. 3.11.

[252] Law commission consultation

[253] Sion v Hampstead HA [1994] 5 Med. L.R. 170

the Local Government Act 1988[254]. In this specific instance, the government overturned the law prohibiting the promotion of homosexual content, despite it being controversial, given the perceived public benefit of preserving positive morality, and potential influx of deviant behaviour. Likewise, the sudden shock requirement is also currently preserved due to public considerations as outlined earlier.

This seems to also detract from the second principle in Bingham's principles of the rule of law[255]. Importantly, the rule of law prevents the abuse of state power, requires the law to be followed by all, and ensures that legal rights are fulfilled in practice. Rule of law necessitates the consistent application of laws, free from arbitrary discretion. According to Bingham, judges should fulfil their role by interpreting and applying the law rather than making subjective decisions based on personal inclinations.[256] Such a stance is not new and can be traced back to the works of Professor A.V. Dicey in the late 1800s, the person who coined the very expression, 'the rule of law', that discretionary decision-making powers should not be conferred unto officials[257]. He believed it would open a can of worms that is arbitrariness, which is the antithesis of the rule of law. This approach ensures that legal outcomes are predictable, transparent, and firmly rooted in established legal principles. Judicial discretion should, then, operate within the confines set by the law itself. While judges possess some leeway in applying the law to individual cases, it is imperative that they do so in a manner that aligns with legal principles, precedents, and statutory provisions.

The rule of law ensures equitable treatment, safeguards individual rights, and provides a framework for impartially resolving disputes. Embracing the application of law rather than judicial discretion contributes to the preservation of a fair and consistent legal system that maintains the principles of justice and fairness in society. Applying the sudden shock requirement is inconsistent, as shown earlier, and thus would go against the principle of legal certainty.

Given this, it may seem that the distinction between primary and secondary victims is arbitrary. However, the concerns that established this distinction in the first place still stand. The

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[254] Section 28 of the Local Government Act 1988 prohibited local authorities from promoting homosexuality or teaching about same-sex relationships in schools. It was repealed by the Labour government in 2003, following significant opposition and campaigns from LGBTQ+ rights activists.

255 Bingham (n 52)

[256] Boot (Problems of Incommensurability) Page 57

[257] Walters, Mark D. "The Spirit of Legality: A. V. Dicey and the Rule of Law." The Cambridge Companion to the Rule of Law, edited by Jens Meierhenrich and Martin Loughlin, Cambridge University Press, Cambridge, 2021.

nature of psychiatric injury would allow a flood of claims by individuals who simply witnessed the event.

Principally, the distinction is required for two reasons. First, as the extent of causal harm is different. As established, primary victims have suffered physical injury or developed psychiatric ones from the fear of physical injury. This notion of physical injury being a precondition is significant as their close proximity to the negligent act creates a stronger connection between the negligent act and the resulting harm. This proximity makes it relatively easier to establish a causal link between the negligence and the harm suffered. Recognising this distinction allows for a more straightforward determination of liability and compensation for the primary victims.

Secondly, primary victims are typically more foreseeable in terms of the harm they might suffer due to the negligent act. This foreseeability establishes a clear duty of care owed by the defendant towards the primary victims. Secondary victims, however, may not be as foreseeable or directly impacted by the negligent act. Recognizing the distinction acknowledges the difference in the duty of care owed to primary and secondary victims.

In conclusion, while current requirements for secondary victims are problematic, the need for a distinction does exist. The problems discussed that plague the fourth requirement similarly also apply to the second and third requirement. Given so, it seems that only the first requirement of having a close tie with the primary victim, stands. On the other hand, the other three requirements of sudden shock, temporal and spatial closeness, and having seen or heard about the incident through one's own unaided senses seem to be unsound. However, this feeds into the issue of legal resources. Given the limited courts and barristers available, the wide influx of claims to injury as a result of removing these criteria would strain the legal system, and cause huge amounts of backlog, further exacerbating current issues of backlog in the UK. A default to the first requirement would enable many more cases being filed, and even more succeeding.

Section 4: Balancing concerns to achieve a more just legal system

Given that the law considers not only principled concerns but also practical issues, the question then is on how to balance both sets of concerns, whilst ensuring the legal system is fair and efficient. Thus far, I have shown that most of the criteria set in the arena of psychiatric injury have been incongruent to the principles of the law. This chapter will therefore set out the different considerations the legal system has and reconcile the conflicting interests from both sides.

Current strict criteria are grounded in a few practical concerns:

1) The subjectivity of psychiatric injury makes it difficult to quantify or measure compared to material harms
2) To act as a control mechanism given the widespread nature of injury
3) To promote broader societal values of being 'resilient' given that every individual is expected to have more 'fortitude' against mental damages

Adopting Canadian and Scottish approaches of injury (as established in Chapter 2) could cause the control mechanism in point (2) to be jeopardised. However, the lack of a fair, albeit efficient, legal system runs counter to our principles and ideals of what it means to have just access to legal recourse. Fairness is an a priori condition that needs to be met. The reason for this is because the state has a monopoly of violence over us[258]: it can imprison us and restrict our positive freedoms. The only way that this can be a justified system of governance is that if there are outlets for individuals to seek redress for injustices and that there are just proceedings that precede any punishment. Therefore, if the legal system is arbitrary and inconsistent, as established earlier, then it becomes an unjustified branch of governance that tips the equilibrium of power between individuals and the state.

Furthermore, this issue would also be solved with time. A temporary influx of claims to injury also sets more just precedent which can be used and enforced by Justices and courts in the future, thus making the standard for claims to psychiatric injury more transparent.

Therefore, practical concerns cannot justify trading off principled standards of the legal system – for an unfair legal system is one that detriments individuals who are already subject to a monopoly of violence. The loosening of criteria and adoption of frameworks from other jurisdictions can ease logistical burdens, with the passing of time also creating more transparent standards that thus reduce the number of unfounded claims.

Conclusion

The evolution of tort law has reflected the changing social norms and views society hold. However, the area of psychiatric injury has been held back by logistical concerns which make real and valid claims disappear due to the overwhelmingly high thresholds placed on establishing a claim.

Despite longstanding tradition, the criterion of having a recognised psychiatric illness is unjustified due to it going against the very own broader societal goals that it aimed to achieve, for it reduces deterrence towards these acts. Furthermore, it showed how there was not a similar system in place for material injury and given the fact that we ought not to place a value judgement on the types of injury, this criterion was moot. In addition, the use of internationally standardised frameworks seemed to be inconsistent, as psychiatric injury could differ vastly from case to case. Thus, it ought to be left to the court to decide on a case-by-case basis how the injury should be judged. Through other successful frameworks like those found in Scotland and Cananda, English courts could learn from them and adopt those methods of administering financial recourse and judging injury. This serves to make the law fairer, which throughout the article, has been shown to be the most important outcome.

While there is a legitimate need to differentiate primary and secondary victims, the criteria used currently are often arbitrary in nature and provide little justification. This extends to

[258]Munro A, ‘State Monopoly on Violence’ (Encyclopedia Britannica, 6 March 2013)

<https://www.britannica.com/topic/state-monopoly-on-violence> accessed 24 August 2023

the sudden shock requirement, which historically has made it difficult for victims to seek recourse, despite there being little medical grounds to justify its existence, as proven earlier. Having a close tie to the victim thus should be the only criterion used as it aligns itself with other tort principles like duty of care and foreseeability.

The rule of law enshrines accessibility and fairness to all, promising individuals the right to seek redress in a just manner. However, practical concerns regarding logistics and efficiency have stifled our ability to act upon this, with the realm of psychiatric injury being hurt more than other areas of tort. While efficiency is an important question, it pales when considering the larger questions about making the law fair and just, because a legal framework that is efficacious yet arbitrary bears no meaning to what we truly value as a society. It may be naïve to claim that every practical concern can be ignored currently, yet a shift to a more principled framework and an increase in discourse on the nature of the criteria that have been set in stone is the only way to ensure that victims can get the closure and recognition they deserve.

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Injustice of Released Prisoners By Bill Cui

Abstract

Imagine that 100 people were released from prison in 2021; by 2023, how many would have ended up back in prison? An astonishing 40% of the original 100 are back in prison after just three years of release.(“Recidivism and reentry”) In our modern society, we often forget what people do after being released from prison. But as shown above, the general population tends not to help these individuals upon release. More importantly, society as a whole doesn't help make this rehabilitation process any easier, as shown by the statistics. With such a high recidivism rate, we have to ask ourselves if society’s treatment of released prisoners is fair or unfair. This essay explores the injustice faced by released prisoners, which has contributed to the increase in recidivism rates over the past decade. These individuals face many challenges, like access to employment, housing, and government support. These concerns stack on each other to create an environment where released prisoners are set up to fail.

Introduction

The injustice of released prisoners has critiqued our criminal justice system for its credibility and effectiveness. Some prevalent issues in this topic are the conscious bias in the workforce and the judgment of society towards people with criminal records. Another issue is the lack of government aid and loss of rights after release, such as the right to vote and hold public office. Finally, the risk of recidivism is another critical issue in the injustice of the formerly incarcerated.

In the workforce, many formerly incarcerated prisoners face a social stigma from their peers, and this can translate into discrimination. More often than not, finding a job is the hard part for these individuals with a criminal history. Many employers discriminate against people with a criminal background. Even if formerly incarcerated people are accepted into a job, their expectations will be much higher than the general population. According to an article written by the PPI(prison policy initiative), “We become the scapegoat of all of their problems,”(Katie Rose Quandt) says one formerly incarcerated individual. The high expectations can be traced back to the belief that formerly incarcerated prisoners are second-class to the general population. This belief causes some employers to treat ex-convicts harshly. This is also reflected in their salary, as formerly incarcerated prisoners with stable jobs, on average, earn 30% less than their counterparts (Kelly Parker “Employment after Prison: The Importance of Supporting Workers Who are Seeking Work after Incarceration”). The employers will also be more strict on any little problem that revolves around these individuals, as they have a criminal history. These issues are reflected in the statistics revolving around employment, as a study done by the Prison Policy Initiative (PPI) shows that out of all the prisoners released from 2010-2021, an alarming 33% of the people released never found stable employment in the past decade. Of the 66 percent of the freed prison population that once found a stable job, on average, they get paid 200 dollars less than the general population per month. Although this pay gap decreases over time, after four

years, the general population makes 100 dollars more than the average released prison population(Leah Wang, “New data on formerly incarcerated people’s employment reveal labor market injustices”). This shows how injustice in the workforce is a critical issue in the injustice of released prisoners.

Furthermore, the lack of support that the government gives to these prisoners is surprising. Most prisoners are offered just 200 dollars upon release. The rehabilitation programs that the government does provide often fall short of addressing the needs of released prisoners, and the programs often fail to address individual needs. The government believes in a “one size fits all” motto for rehabilitation programs. While according to an article on recidivism by Eric Martin and Marie Garcia, this is the thinking that worsens the credibility of our prison system. The prisoners often receive aid they don’t need, or it's in an area where they don’t need help or need more assistance. In an article from the New York Times, 60 percent of released prisoners are shown to be unemployed six months after release. As time goes on, it gets harder and harder for former prisoners to keep their jobs, as 65 percent of prisoners are unemployed four years after their release date(Talmon Joseph Smith, “Ex-Prisoners Face Headwinds as Job Seekers, Even as Openings Abound,” New York Times). Jobs are not the only thing released prisoners have to worry about, as pre-existing health issues are another concern. Prisoners have access to healthcare while incarcerated, but healthcare can be a long and tedious process to qualify for after reentry to society. This can lead to the worsening of health problems. Mental health is also a huge issue, as reentry into society puts a significant amount of stress on the formerly released prisoner. Who is suddenly placed into a whole new environment with close to no resources. This can lead these individuals to develop PCIS (post-incarceration syndrome). PCIS can develop into PTSD (Post-traumatic stress disorder) without proper treatment or therapy, which is considered a mental health disorder. The lack of government aid to released prisoners is very present for all the reasons stated above. This shows how vulnerable released prisoners are to financial and health setbacks. Lack of government aid is a serious issue concerning the injustice of released prisoners.

The final issue concerning the injustice of released prisoners is recidivism. This is the act where released prisoners reenter prison because they have committed another crime. Recidivism rates are an excellent way to measure how effectively a nation's prison system rehabilitates prisoners. America is one of the countries leading in recidivism rates, with 40 percent of prisoners coming from state prisons returning within three years of release. This is an issue we have to address as recidivism rates have hovered around 40% for the past decade. According to the World Population Review article, 95% of convicted felons will ultimately return to their communities after their sentence. But with 40 percent of the released returning to prison, the effectiveness of our prison system is at stake(“Recidivism rates by country 2023”). Most of the problems stem from the lack of assistance released prisoners have once they are released. These issues all fall under the category of injustice of released prisoners, with the most significant problem being recidivism. In my research essay, I will be mainly focusing on recidivism in

America and other countries around the world and what we can do to help our released prisoners stay in society.

Conscious bias in the workplace

The conscious bias in the workforce has been a prevailing issue for ex-prisoners for a long time. According to the University of Chicago, conscious bias is an "attitude of bias towards a person or group of people that the person is aware of."("Researchers guide, learn and unlearn conscious bias") Conscious bias for ex-prisoners in the workforce could come in many different forms. One of the most common forms of bias is revealed during the hiring process. Many ex-prisoners earn a valid credential for a profession in prison. The state issues these documents, holding the same weight as a degree from a trade school or college. The government is helping prisoners acquire credentials for future employment, potentially aiding their reintegration into society post-release. Still, these degrees do come with a significant setback. The person submitting this degree to an employer has to disclose that they have been to prison before. More often than not, when employers see a person who has a degree in a profession of imprisonment, it drives them not to hire that person. According to the Institute for Research and Poverty (IRJ), the most accepting industries for ex-felons are in the unskilled labor category, with less than 10% of businesses unwilling to take an ex-felon as a laborer. But the huge problem is that unskilled labor is one of the lowest-paying jobs in America, with an average salary of 17 dollars an hour; according to the American government census, the average annual salary for people with a felony charge is around 20,000 dollars a year, which is well below the poverty line(Keith Finley, "Great Recession Had Long-Term Economic Impact on People With Felony Convictions, Prison Time," United States Census). The minimal income that prisoners do get can lead the released prisoners to experience housing instability and is often the catalyst for prisoners to dip back into illegal activities. This is considering that ex-prisoners do get stable jobs, as according to a study released by the Bureau of Justice Statistics (BJS), around 60 percent of released prisoners struggle with employment(Kelly Parker "Employment after Prison: The Importance of Supporting Workers Who are Seeking Work after Incarceration"). This is further proven by an article written by "Changing America." A non-profit foundation whose goals are to bring awareness to the injustice in and out of the American legal system. Changing America interviewed 50 prisoners at an Ohio state prison, and all 50 said that finding jobs is their number one priority when they are released("Lack of jobs for released prisoners "). This shows the importance of income for a formerly incarcerated person and how, without a stable income or any income at all, it can be easy to turn back to a life of crime just to have basic necessities. According to Brookings, a non-profit organization dedicated to non-partyism research to improve policy in the global and local areas, If released prisoners are allowed to hold a stable job, they are 20% less likely to commit another crime(Love Hanna, "A better path forward for criminal justice: Training and employment for correctional populations," Brooking.edu). Data has shown that a lack of employment leads to financial instability, which can ultimately lead to recidivism.

Loss of rights

The loss of legal rights after prison is a critical injustice for released prisoners, even when people complete their felony prison sentence and are released back into society. They lose their right to vote, their right to hold office, and their right to own a gun. The loss of rights after prison also presents another change in the daily lives of released prisoners. This change is where released citizens are treated as second-class citizens. This belief that the general public has stems from the thought that this group of people shouldn't be given a second chance. Which in turn comes from their loss of rights. The social stigma against formerly incarcerated prisoners can also be a barrier to reentry into the workforce. The unemployment rate in America is at an all-time low, with about two jobs available to every unemployed person, according to the New York Times. However, the unemployment rate of released prisoners is still at 60 percent and has been unchanged over the past decade(Talmon Joseph Smith, "Ex-Prisoners Face Headwinds as Job Seekers, Even as Openings Abound," New York Times). The loss of rights is also contributing to the physiological damage on released prisoners, according to Edward Johnson, a 57-year-old ex-convict and convicted felon. He says, "To other people, we are the crime we commit. " This quote further shows the view that the general population has on ex-convicts as second-class citizens. This view is detrimental to the success of prisoners outside of prison as they already face a stigma in the workplace, and with the general population treating released prisoners as second-class citizens, this often induces a physiological belief that former felons can never change. According to an article by the Prison Policy Initiative, "Being incarcerated for a long period can induce physiological damage"("Mental health") The physiological damage induced in prison often carries over when prisoners are released. This added to society's pressure, leading to beliefs of self-doubt. As stated, "The loss of rights accompanied by released prisoners are designed to make them feel like second-class citizens "(Prison Policy Initiative). The environment created by the loss of rights and treatment like second-class citizens leaves released prisoners in a state of vulnerability, and according to the Census 2018, released prisoners made, on average, nine thousand dollars less than the general population. Another pressing issue regarding the financial situation of released prisoners is government aid.

Government support

200 dollars is how much a person gets when released from federal prison in 2023. 200$ was the exact amount that the prisoner got in 1973. For 50 years, every released prisoner from a federal prison has received 200 dollars ("California gives just 200 dollars to released prisoner "). This money is often used on transportation, as most state prisons are in rural areas. The lack of government aid to release prisoners is a pressing issue regarding the injustice of released prisoners. The money these prisoners receive when released is the least of their problems. According to the Office of Justice Programs (OJP), over 51 percent of prisoners in state prisons and 43 percent of federal prisoners have some sort of chronic condition (conditions that last more than a year and require constant medical attention). The lack of jobs available to released prisoners, as stated above, puts a financial strain on released prisoners. This often puts them in

the balance of not buying medication and risking severe health issues or just purchasing necessities like food. According to the AAMC, an educational website about statistics and interviews concerning the prison system, Edward Johnson, a 59-year-old ex-convict who has spent 29 years in prison, said, “One of the major things that are needed [when leaving prison] is adequate medical attention. In prison, they give you enough just to get by (Stacey Weiner, “out of prison but struggling to stay healthy, AAMC”) This statistic from the AAMC further backs up this quote that inmates transitioning from jail to society have a 13 percent higher chance of dying from health complications than a person who is similar physically and who spent their time in society rather than prison (Stacey Weiner, “out of prison but struggling to stay healthy, AAMC”). This illustrates an apparent lack of medical aid and support from the government. Who are putting the lives of these inmates at risk by not giving them the right services to understand their medical conditions and not providing enough financial support for medication. According to the Justice in Aging Foundation, prisoners who have been convicted of a felony crime can only receive Medicaid Plan B, compared to Medicaid Plan A, which most of the general population is on (“Reentry for Older Adults”, Justice in Aging Foundation). However, the government provides insurance for certain hospital visits and physician check-ups in plan b. The government doesn't pay for prolonged hospital stays, home healthcare, or skilled nursing facilities/hospice care. These small services might seem insignificant, but with over 40 percent of incarcerated prisoners having some sort of chronic condition, millions of released prisoners have prevailing health problems from their time in prison. According to an article on ethics by Joseph E Paris, a leading researcher in correctional medicine. , “Prisoners should be the targeted population for free medical care.” Joseph backs this up by stating that the general public should have some ability to pay in any form to the doctors, and the government will spend the rest. However, the target population for free medical care should be prisoners, as they cannot pay for medical care when they are released and have even less ability to pay for medical care in prison. As stated above, lack of government aid, loss of rights, and unconscious bias are all unjust things that can happen to released prisoners. These will increase the risk of a released prisoner's chance of recidivism.

Recidivism

Recidivism is a huge issue in the American justice system, as recidivism is a statistic commonly used to measure how effective the rehabilitation program of a justice system is. The recidivism rate for released prisoners who have been convicted of felony crimes is 40 percent after three years. Many factors can lead to an ex-convict committing another crime or the same crime. One of these factors is the environment they are returning to. According to a research map of trends of imprisonment done by the prison policy initiative, the city of Compton in Los Angeles is notorious for having a lot of gang affiliation and violence. Compton, 1,000 out of every 100,000 people are imprisoned. This might seem like a small amount of people, but it is three times the state (California) average. This shows how the environment you grow up/live in can directly affect whether you go to jail or return to prison, according to a research paper by

Susan Mcneely, a Ph.D. student from the University of Cincinnati (research analysis at Minnesota Department of Corrections). The return of a person back to the same community where they were convicted often results in reconviction and recidivism, as the peer pressure often engages them back into illegal activities and often results in recidivism. This quote shows the importance of the environment people are brought up in and live in. As the people we surround ourselves with have a great impact on our lives.

Problems with education

Another factor of recidivism is education. As stated above, educational programs are offered in most federal prison facilities, but bias issued when submitting a prison-issued certificate is often a big turn-off for prisoners. This results in low usage of this program. The return of released prisoners back into society with some sort of education is detrimental to their success, as, according to the U.S. Department of Justice, 43 percent of people without a high school diploma were unemployed in 2019. Annually, 40 percent of prisoners above 18 who are released don't have a high school diploma upon their release date. This situation puts the prisoner in a terrible position, as only 57 percent of people who don't have a high school diploma have stable jobs (Caroline Wolf Harlow, "Education and correctional policy," Bearu of justice statistics). The job market for a formerly incarcerated person who doesn't have a high school diploma would be minor, no none. Without a steady income, prisoners are sometimes forced back into a life of crime to have necessities. Another factor for recidivism is mental health issues and drug abuse. According to SAMHSA, a staggering 53 percent of prisoners in federal prisons have mental health issues ("About criminal and juvenile justice"). The treatment of mental health issues is low to none in federal prisons. Prison puts enormous amounts of stress on the body and, more often than not, leads to the worsening of mental health issues. A paragraph from the National Library of Medicine states that "Offenders with untreated mental illness have a higher recidivism rate and a greater number of criminogenic risk factors than those without mental illness (Kwanele ShiShane, "Mental health disorder," National Library of Medicine). Previous research has demonstrated that the likelihood of appetitive aggression increases in violent contexts where individuals perpetrate aggressive acts." Recidivism is one of the biggest injustices released prisoners face, as the point of the American justice system is to rehabilitate prisoners in their facilities. With America's recidivism rate at 40 percent, we have to ask ourselves if our justice system is working as efficiently as it could or if it is even working. Just under 50 percent of released prisoners return to federal prison within three years of release (Liz Benecchi, "Recidvism imprison American progress", Harvard political review).

Counter-argument

Many would say, why should we care so much about released criminals? It was their fault for committing a crime in the first place. Helping another person out and rehabilitating people are our natural responsibilities as humans for the betterment of our society. Everybody should have the right to a second chance. As history has shown us, many convicted felons have turned

their lives after release with the right help and left a positive mark on society. A great example is the actor Robert Downey Jr. Having been arrested for possession of heroin and driving under the influence, Robert Downey Jr was sentenced to 3 years in a federal state prison. With his life seemingly over and all hopes of his young acting career lost, many would have given up on him. But not his future wife, Susan Levan, who gave Robert Downey Jr a chance in a significant casting role that would kickstart his acting career again and steer him away from drugs and jail. His roles in many blockbuster hits have inspired millions of young Americans to stay clear of the legal system. Roberts' active role in the Anti-Recidivism coalition has also helped numerous prisoner turn their lives around after prison. Robert Downy Jr is just one of millions of released prisoners who have turned their lives around and achieved remarkable transformations, embodying the belief that everyone deserves a second chance and showcasing the ability to overcome adversity and successfully reenter society.

In conclusion, the lack of adequate support for released prisoners is a significant factor in the recidivism rate. This lack of support must be addressed to create a better environment where released prisoners in the future can have successful reentry back into society without the worry of having to go back to prison. This would require a comprehensive support system, including job training, housing assistance, and mental health services. Additionally, access to education and resources is essential for successful reentry into society. Governments should also ensure released prisoners can access legal services that help them navigate the complex legal system. Finally, support for reintegration should be tailored to the individual needs of each person released from prison, as to a general standard for everyone. This is a critical issue to address as the ever-rising recidivism rate is gaining popularity as overcrowding is another issue popping up in multiple prisons around the U.S. With the prison population increasing every year and the return of prisoners accounting for a massive chunk of the prison population. Recidivism is an issue we have to address now.

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Investigating The Role of Bach-1 in Triple Negative Breast Cancer Cell Migration and Proliferation By Catherine Zeng, Melinda Wong, Jolie Shen, Peter Kang

Abstract

Breast cancer is the most prevalent type of cancer found in women, and approximately 1 out of 8 women will develop breast cancer in their lifetime. Triple negative breast cancer (TNBC), a subtype of breast cancer, makes up about a fifth of all breast cancer diagnoses. This type of breast cancer is more aggressive, lethal, and difficult to treat compared to those of other breast cancer types, and its metastasis is complex and poorly understood. TNBC is known for its higher rates of metastasis, the spreading of a tumor from its origin of growth to a secondary site, as well as their lack of responsiveness to drug treatments. According to previous studies, the Bach-1 gene promotes cancer metastasis by activating the gene called matrix metalloproteinase-1 (MMP-1). This activation, in turn, triggers the protease-activated receptor 1 protein (PAR1), and upregulates the expression of proteins involved in the epithelial-mesenchymal transition. Our study utilized the 4T1 mouse cell line to model TNBC and investigate the impact of Bach-1 knockout on cell migration and proliferation. Employing a scratch assay technique, we observed the healing process in Bach-1 knockout and wildtype cell cultures, grown in both 5% and 10% serum media. By monitoring wound closure and cell behavior across varying time intervals, we aimed to elucidate the role of Bach-1 in TNBC progression. Initial findings indicate that Bach-1 knockout cells exhibited a reduced rate of migration compared to wildtype controls, particularly in the initial stages of wound healing. This observation supports the hypothesized role of Bach-1 in facilitating metastasis. However, subsequent stages showed a complex pattern, suggesting an intricate interplay of genetic and environmental factors in TNBC metastasis. Through this study, we aim to deepen the understanding of TNBC's molecular underpinnings, potentially guiding the development of more targeted therapies.

Introduction

Over 250,000 women in the United States alone develop invasive breast cancer each year, making it the most common malignant cancer in women and the second leading cause of cancer death[1]. Triple-negative breast cancer (TNBC), a particularly aggressive subtype, accounts for 12-20% of all breast cancer cases. Unlike other forms, TNBC lacks expression of the human epidermal growth factor receptor 2 (HER2), estrogen receptor (ER), and progesterone receptor (PR)[2]. TNBC's resistance to endocrine therapy and HER2-targeted treatments necessitates reliance on chemotherapy, which, while reducing recurrence by about 33%, often fails to eradicate TNBC cells completely[3]. This therapeutic challenge contributes to TNBC's lower survival rates and higher recurrence probability. The 5-year survival rate for stage 1 TNBC is only 85%, compared to 94% for stage 1 hormone receptor-positive and 99% for ERBB2-positive breast cancers[4]. TNBC is also more prone to undergo metastasis, the spread of cancerous cells by breaking away from the primary tumor, moving from organ to organ without vessels, and forming a secondary tumor in a new organ[5]. Studies have found that it has an increased risk of

distant recurrence such as in lungs, brain, and bone, and results in results decreased survival rates due to a higher rate of visceral metastasis compared to other types of breast cancer, with especially high rates of brain metastasis[6]. The cellular mechanisms underlying TNBC metastasis, involving the transition of cells from an epithelial to a mesenchymal phenotype (EMT), are complex and poorly understood. This transition, regulated by the TGFB signaling pathway, leads to cytoskeletal remodeling, breakdown of cell junctions, and loss of cell polarity, facilitating cancer cell colonization in distant tissues[7]. To model the metastasis of TNBC cells, we experimented with the TNBC cell line known as 4T1. These cells were procured from the mammary gland tissues of BALB/c, a strain of laboratory house mice[8], and it is comparable to stage 4 human TNBC. 4T1 contains BTB and CNC homology 1 (Bach-1), a transcription factor that activates the gene matrix metalloproteinase-1 (MMP-1)[9]. The MMP-1 gene codes for matrix metalloproteinases (MMPs), which hydrolyze components of the extracellular matrix (ECM) and are involved in reshaping of tissues in events such as wound healing, embryonic development, and ovulation. However, increased expression of MMP-1 is also associated with elevated invasiveness of various types of cancer, including breast cancer, through degradation of ECM, increased angiogenesis, osteoclast activation, and production of cytokines, which promote metastasis of cancer cells[10]. The ECM is the sticky tissue found between cells that prevent cells from migrating past the tissue[11]. Without this layer, cells will have the ability to travel and settle in different parts of the body. Further, angiogenesis, the development of new blood vessels, is critical to the proliferation of cancer cells as they feed off this accumulating blood supply[12]. Osteoclast activation is the process by which receptors on osteoclast lineage cells are activated through the binding to the RANK ligand. Overexpression of this ligand can lead to abnormally fast rates of cell division[13]. The MMP-1 gene also encodes for higher proliferation and metastasis of breast cancer cells by activating the protease-activated receptor 1 (PAR1). The PAR1 receptor upregulates macrophage secretion of growth factors that promote tumor growth and metastasis of cancer cells[14]. Previous studies have found that Bach-1 is upregulated and overexpressed in TNBC tumors[15], and knockdown of Bach-1 inhibits expression of epithelial-mesenchymal transition (EMT) related proteins such as C-X-C chemokine receptor type 4 (CXCR-4), matrix metalloproteinase-9 (MMP9), and vascular endothelial growth factor receptor (VEGFR), as well as cancer cell proliferation, invasion, and migration[16]. In light of these, inhibition of Bach-1 is a promising treatment to TNBC by reducing cell migration and proliferation to contain the tumor growth and reduce metastasis.

Our research aims to explore Bach-1's role in TNBC, hypothesizing that its inhibition can slow cell migration and proliferation, potentially containing tumor growth and reducing metastasis. By comparing 4T1 wildtype and Bach-1 knockout cells grown in 5% and 10% growth media and analyzing their behavior through scratch assay wound healing, we seek to uncover insights that could pave the way for novel therapeutic approaches in TNBC treatment. This study's methodology and results, which we detail in the following sections, represent a step towards a deeper understanding of TNBC's complex biology.

Materials and Methods–Cell Suspension and Splitting

To isolate the cells being used, most of the media from the original stock cell flasks was pipetted away. 10mL of Phosphate Buffered Saline (PBS) was added into the flask and the solution was discarded. 5mL of trypsin was added and repeatedly "washed out" of the flask by pipetting trypsin over the bottom of the flask constantly. Roughly 0.5 mL of trypsin was left in the flask, and the rest was removed. The flask of cells was then incubated for no more than 3 minutes at 37 degrees Celsius. 10mL of FBS was added to wash any residual trypsin out. The suspended cells were transferred into another tube, centrifuged, and pelleted.

Cell Culturing

10µl of cells and 10µl of Trypan blue dye were mixed in a sterile microfuge tube in a 1:1 ratio. 10µl of this cell/stain mixture was loaded onto a Countess slide and placed in a Countess Cell Counter. The volume of media and cells needed to prepare a 13mL solution of cells at $1x10^5$/mL was calculated using the dilution calculator on the counting machine. The cells were plated at concentration of $1x10^5$/mL in four 6-well plates with 2 mL of cell solution in each well. This step was repeated for both plates of the Bach-1 wild type and Bach-1 knockout cells (2 plates for each cell line).

Scratch Assay[14]

The required number of cells for confluence depends on the cell type & well size, in which the density for the 6-well plates should be at least 80%. Once the plates have formed a monolayer on the bottom of the well and have little to no space between the cells, the scratch assay can proceed. The media was removed from each of the wells to invert the plates for marking. With a fine-point sharpie and a ruler, a cross was drawn through the bottom of the plates that divides each well into four as a reference for taking the pictures. 2 mL of warm PBS was added into each well. Following this, a scratch perpendicular to the sharpie line was made with the tip of a p200 pipette tip. The plates were then tilted to allow all of the PBS to fall to the edge of the plate for easier access when being removed. The PBS was discarded, and it simultaneously removed any dead suspended cells in the liquid. The wells were then rinsed again with PBS to eliminate excess floating cell clumps. The plates can be washed as much as needed, although washing more than twice may affect the adhesiveness of the cells. 2 mL of media was added into each well, with the 5% serum in the two migration plates and the 10% serum into the two proliferation plates.

EVOS FL Image Capturing

These two variables were observed under the EVOS FL amf-4301 microscope on the 4x objective by aligning the cross-section of the sharpie lines to the corners of the microscope field of vision. Each time a picture is captured, the Sharpies should be in a relatively similar position to the previous picture. For example, all of the pictures could be taken with the Sharpies along the edge of the bottom left corner. Additionally, other settings, especially light intensity, should

remain constant for all photos taken to ensure the visibility of the results. The plates should be observed at least twice a day (the times should be a few hours apart) for a period of two days to have noticeable differences while comparing photos. Depending on the growth speed, the cells were checked every few hours to get a grasp on how fast they proliferate. The cells may be able to be photographed more than twice a day if the speed is relatively fast and if the wound healing is visible, but these check-up intervals can be adjusted accordingly.

Fiji Data Measurement

Fiji was used to annotate and measure the distance between the two sides of the wounds in the uploaded photos. A wound healing size tool plug-in was added to the Fiji extension to allow proper measurements of the injuries. This plug-in can be used to calculate the area and distance between the two sides of the wound by highlighting the edges of the cells surrounding it. If any uneven edges are not accurately depicted in the figure, the lines can be redrawn and adjusted to include the desired cells for area measurement. The area percentage of the highlighted region in comparison to the area of cells as a whole is shown at the bottom of the plug-in and can then be used to calculate the percent area change in time. However, despite the area calculation feature, using Fiji had its own limitations as well. When the cells proliferate and migrate to grow into the scratch wound, instead of staying by the edges of the wound, some cells would migrate towards the center of the wound. This posed a problem when measuring the area of wound, since Fiji is unable to eliminate the cells in the middle from the total area. Although it can be argued that the presence of a few small cells cannot affect the scratch wound area by much, it is still important to recognize that the results procured from Fiji may not be completely accurate.

Results

Image 1-WT 5% Right Well 0 hours

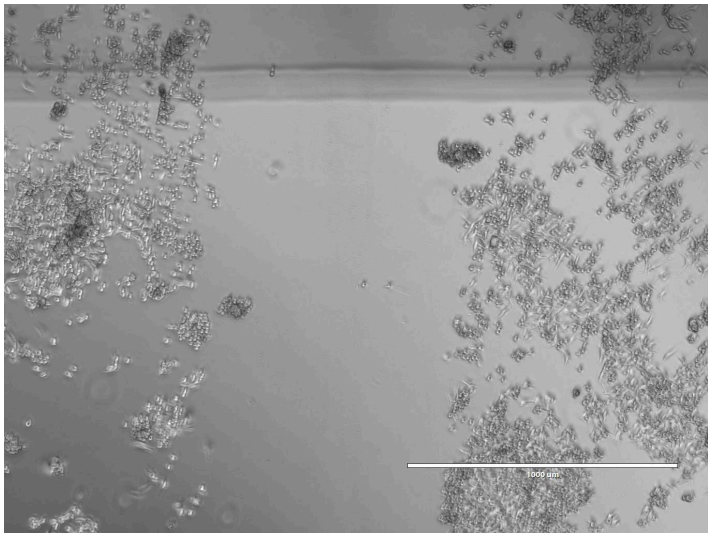


Image 2-WT 5% Right Well 19 hours

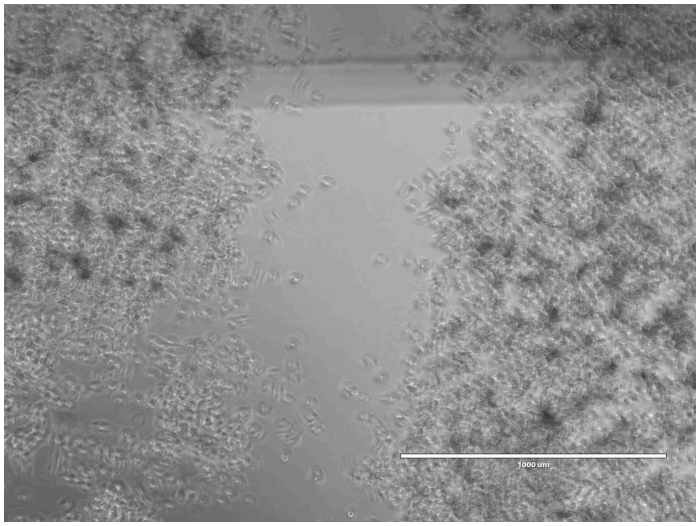


Image 3-WT 5% Right Well 48 hours

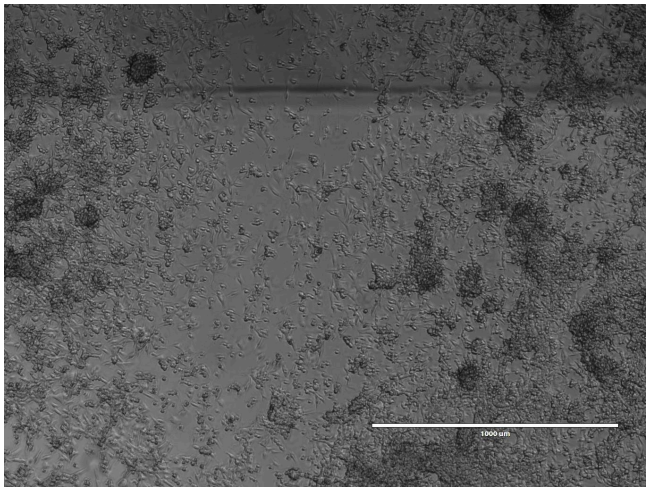


Image 4-KO 5% Left Well 0 hours

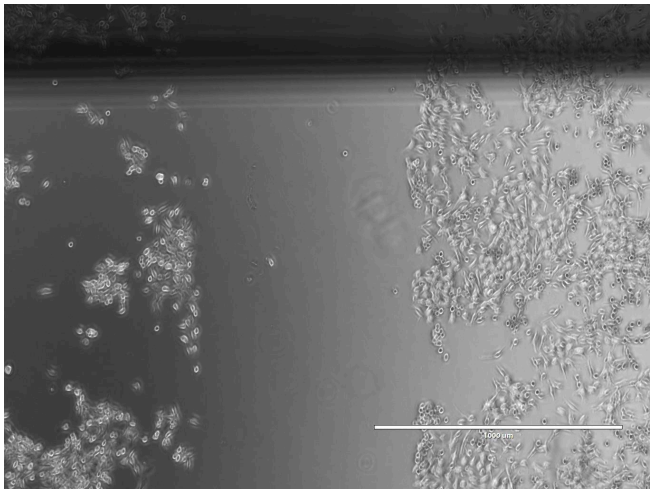


Image 5-KO 5% Left Well 19 hours

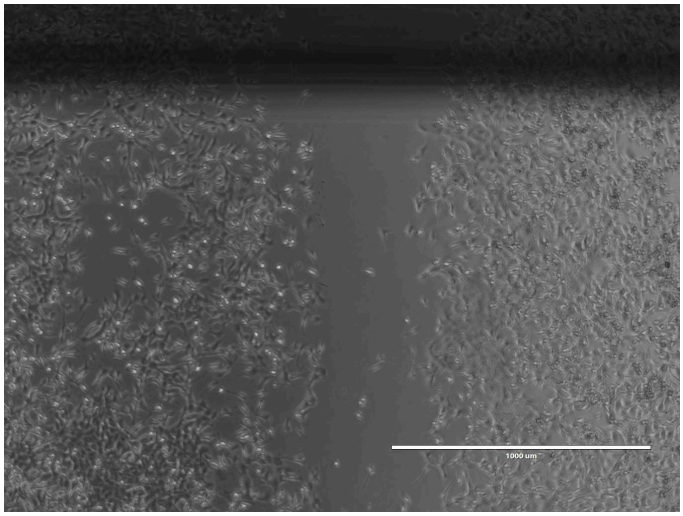


Image 6-KO 5% Left Well 48 hours

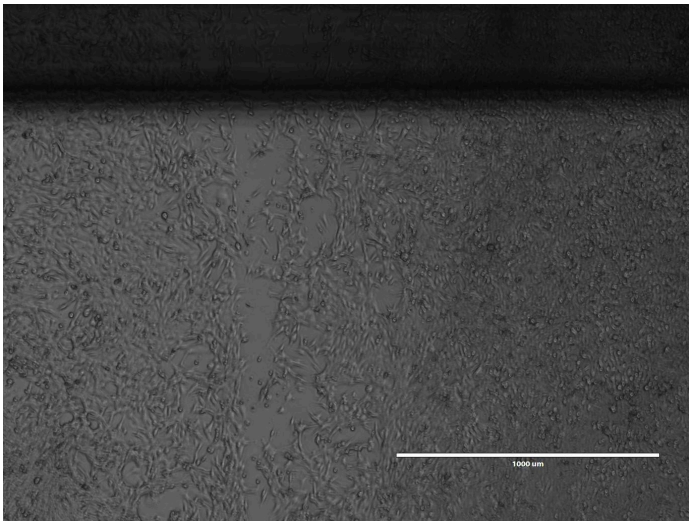


Image 7-WT 10% Right Well 0 hours

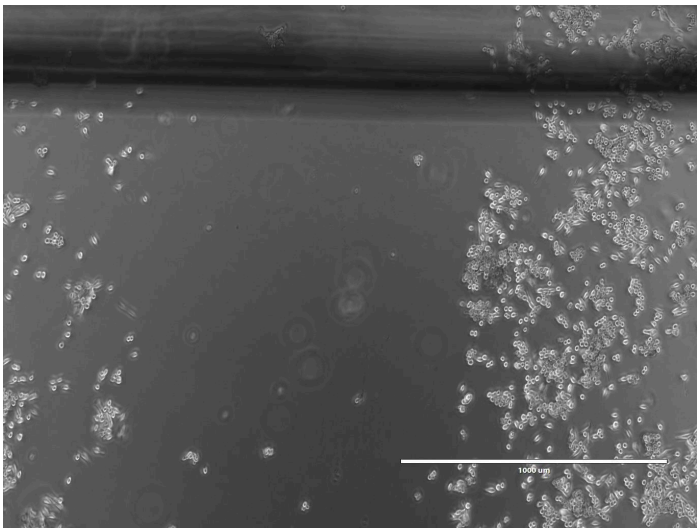


Image 8-WT 10% Right Well 19 hours

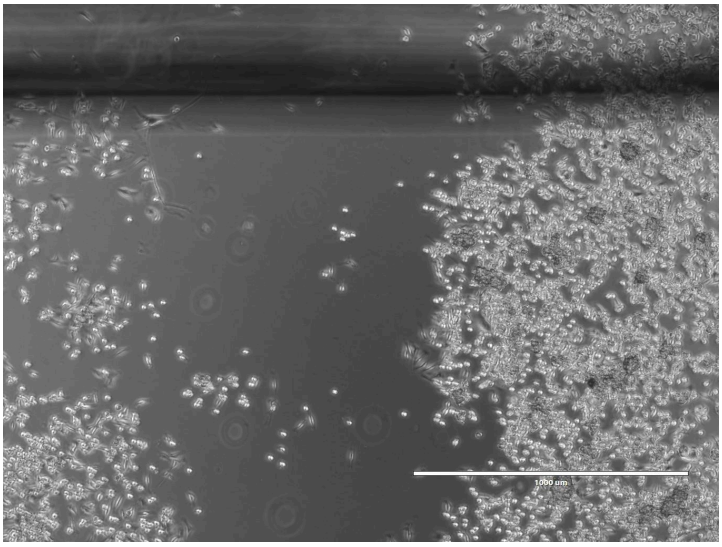


Image 9-WT 10% Right Well 48 hours

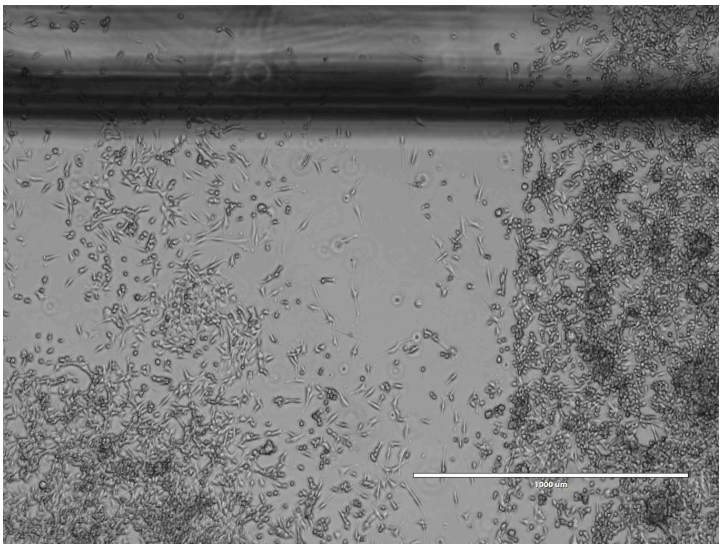


Image 10-KO 10% Left Well 0 hours

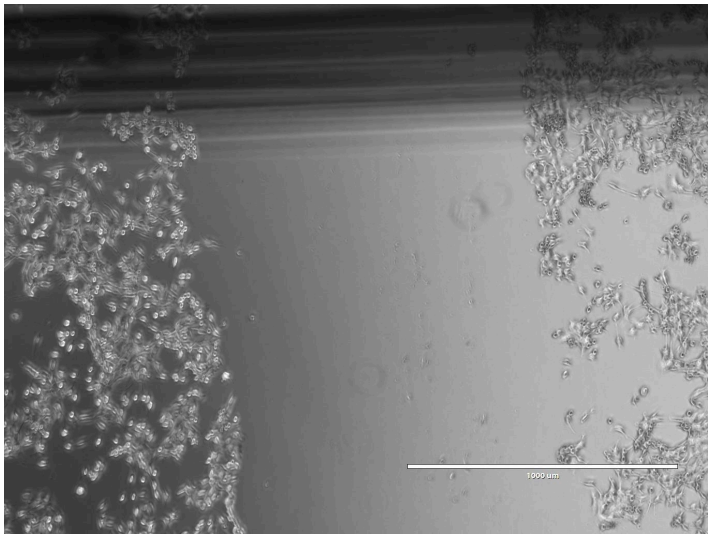


Image 11-KO 10% Left Well 19 hours

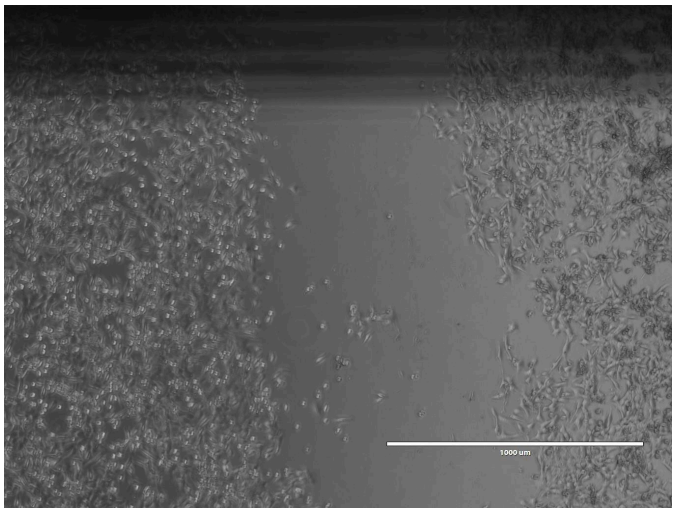


Image 12-KO 10% Left Well 48 hours

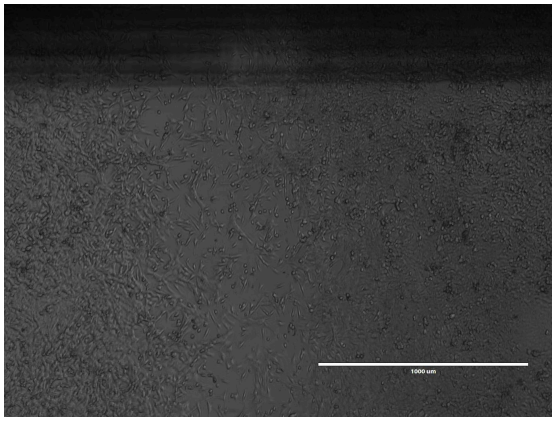


Table 1: Wild-type 5% FBS Serum Percentage Area Change Over 48hrs

WILD-TYPE 5% FBS SERUM AREA PERCENTAGE CHANGE		
	0-19hrs	19hrs-48hrs
RIGHT WELL(%)	37.157	39.372
MIDDLE WELL(%)	45.192	31.290
LEFT WELL(%)	41.432	55.764
AVERAGE CHANGE(%)	41.260	42.142
AVERAGE HOURLY RATE(%/hr)	2.172	1.453

Table 2: Knock-out 5% FBS Serum Percentage Area Change Over 48hrs

KNOCK-OUT 5% FBS SERUM AREA PERCENTAGE CHANGE		
	0-19hrs	19hrs-48hrs
RIGHT WELL(%)	42.734	66.252
MIDDLE WELL(%)	17.706	73.574
LEFT WELL(%)	21.086	86.019
AVERAGE CHANGE(%)	27.175	75.282
AVERAGE HOURLY RATE(%/hr)	1.430	2.596

Figure 1: Distinctive Difference in Appearance: Absence of Dark Knobs on Knock-out Cells

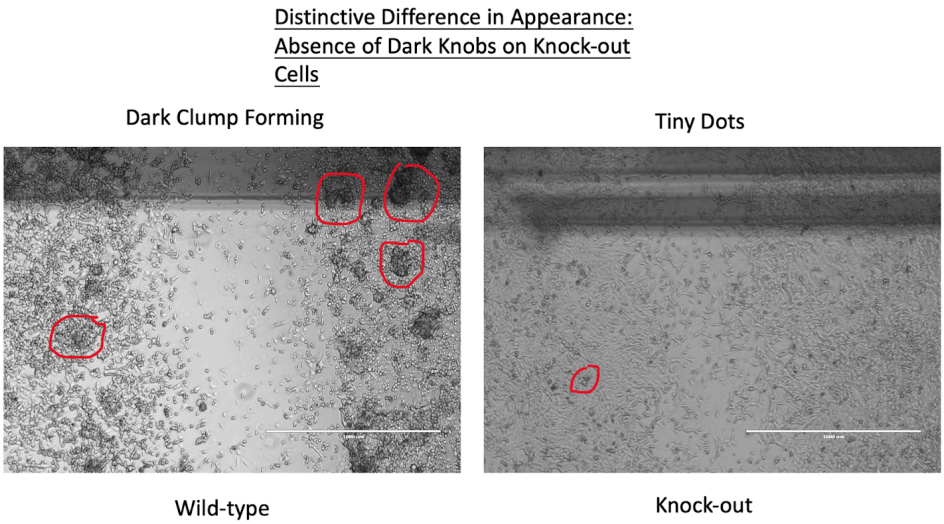


Figure 2: Average Wound Area 5% FBS Over 48 hours

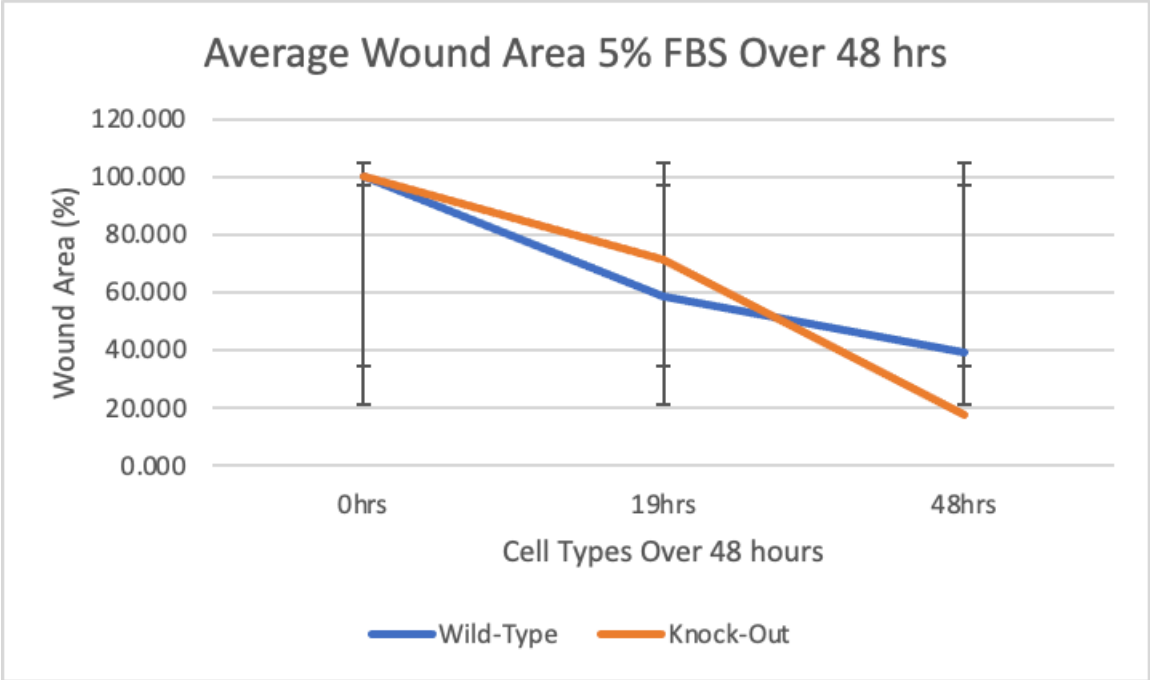
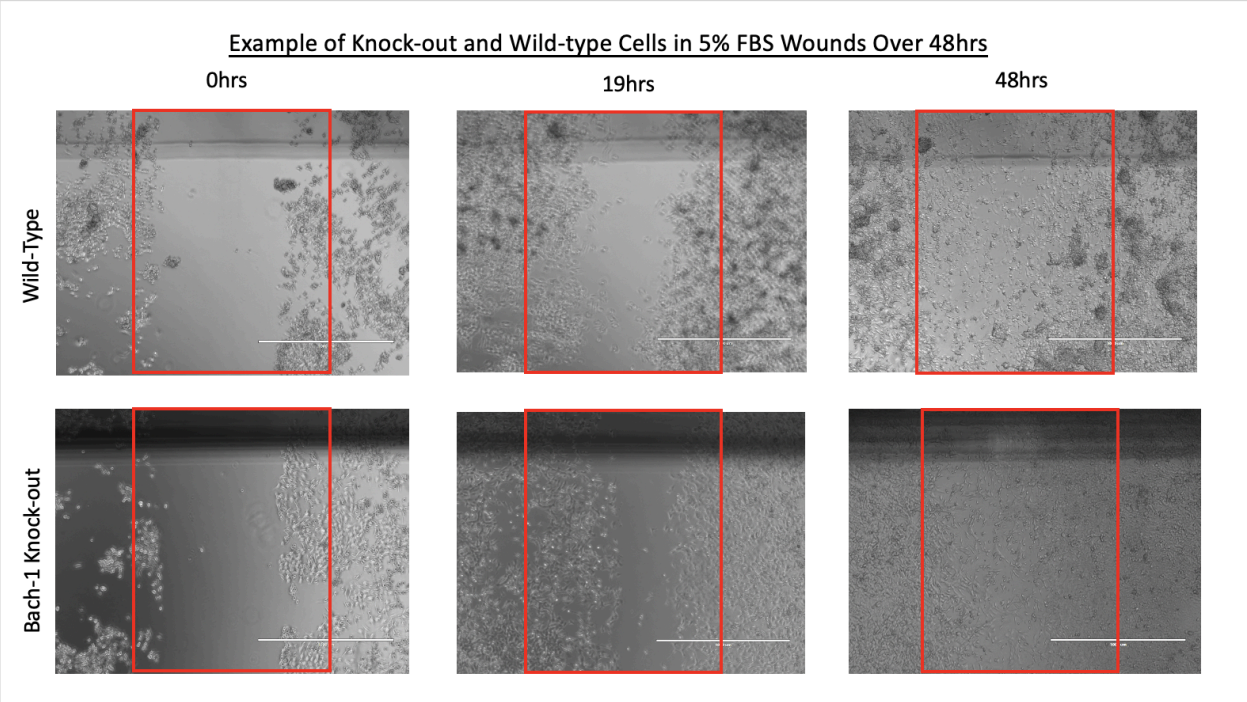


Figure 3: Example of Knock-out and Wild-type Cell Wounds in 5% FBS Over 48hours



Results of Experiment

Suppression of Bach-1 Reduces General Initial Rate of Migration

Compared to Wild-type control, Bach-1 knock-out cells 5% FBS in general had a lower initial rate of migration of two thirds the hourly rate of control cells (Table 1,2). This is in line with the hypothesis that the Bach-1 gene is involved in metastasis by showing that without Bach-1 it takes longer for cells to migrate. The trend however only continues for the first 24 hours. During the time frame of 19-24 hours, Bach-1 knock-out cells had migrated at a significant rate (Figure 2). Though inconsistent with our hypothesis, this does not necessarily undermine the role of Bach-1 in promoting metastasis. As the later (19-24 hours) hourly rate of Knock-out cells is similar to the initial rate (0-19 hours) hourly rate of Wild-type cells and vice versa, it is possible that FBS had been depleted by the Wild-type cells early on, limiting the resulting area coverage. In the meantime, Knock-out cells had slowly caught up with the area coverage. More data is needed support such as migration in the interval between 19hrs and 48hrs (e.g. 36hrs).

Suppression of Bach-1 Down-regulates Phenotype of Cell Knotting

Although the Bach-1 knock-out 5% FBS cells had not shown less migration than wild-type cells throughout the entire duration of the experiment, Bach-1 knock-out cells had exhibited less cell clumping than wild-type cells. Cell knotting under EVOS appears as a large black knob (Image 13). Unlike wild-type cells, Bach-1 knock-out cells did not have black knobs forming, even at the highest confluence and concentration (Figure 1). Possibly, cells metastasize by knotting, splitting, and expanding to migrate to empty space. This would mean that the

appearance of black knobs is only a phase in their migration, which is supported by our observation of black knobs dispersing from their original spot after a period and reappearing on other parts (Image 2, 3).

Suppression of Bach-1 has Relatively Little Effect on Cell Proliferation

To control and isolate measures of cell proliferation and migration, the same cell lines were also scratched under 10% serum which presumably would not limit proliferation. If the Bach-1 gene is only involved in metastasis, not proliferation, it could be hypothesized that both cell lines should have similar growth under 10% serum, any difference accounted for the difference in migration ability. This is supported by the area coverage rate of each cell type, which did not show a very significant difference. However, it must be noted that this hypothesis is only weakly supported as there was still an observable difference between the growth of these cell types under 10% serum. Other measures such as maintaining a cell count must be used to confirm this.

Cases of Bach-1 Knock-out Migrating at a higher rate than Wild-type

In our study, although wild-type cells initially exhibited higher migration rates, instances were observed where Bach-1 knock-out cells migrated more rapidly, particularly in Experiment Part II (data not shown). This discrepancy was likely attributable to limitations in our experimental technique and design. A significant factor was the insufficient number of stock cells available, leading to the wild-type cells in Experiment Part II being plated at a much lower density (1.29x10^5 cells/mL) compared to the knock-out cells (1x10^6 cells/mL). This difference in plating density may have facilitated more rapid expansion of the knock-out cells. Despite the variation in cell concentrations, we proceeded with the assay under the assumption that differential cell densities would not serve as a confounding variable, provided that sufficient time was allowed for both cell types to achieve similar levels of confluence.

Observation

The main objective of the experiment was to find the correlations and mechanisms between Bach-1 and metastasis. To test the hypothesis, we conducted a preliminary experiment as a first trial, as well as a second failed experiment and a third revised experiment. Throughout the preliminary and revised experiments that were performed, both the wild-type and knockout cell lines were grown in both 5% and 10% growth serums. The wild-type Bach-1 cell line acted as a control group for the experimental knockout cell line, which allowed us to compare the differences in rates of metastasis with the knockout cell line. The different concentrations of growth serums, 5% and 10% media, can also be compared to determine the extent of the serum while measuring migration and proliferation. The 5% growth serum is the standard media concentration for measuring migration because it minimizes the proliferation of the cells. On the other hand, the 10% growth media serum is ideal for cell culturing and is optimal for the adhesive mouse cell lines being grown.

Conclusion Growth Rate

Our findings have shown that overall, the wild-type cells had slightly faster growth rates as expected. Using Fiji, we measured the percent change in area across the three wells on each of the four plates (Table 1 and Table 2) and took the average percent change in scratch wound area across two different time intervals as well as the average percent change in wound area per hour. Table 1 illustrates the percent change in the area of the scratch wound in the wild type 5% serum, and wound area has decreased by 41.26% on average in the first 19 hours post scratch, while the scratch wound area decreased by 27.175% on average in the first 19 hours post scratch on the knockout 5% serum plate (Table 1 and Table 2). In Figures 1 and 2, we can observe that the wild-type cells in the 5% serum had more change in area by percentage than the knockout 5% cells in the first 19 hours. However, from 19-48 hours post scratch, the knockout cells were able to close the wound at a faster rate than the wild-type plates. The wild type and knockout cell plates differed in growth rate in the 10% growth medium as well. This time, the growth rates were not consistent across the 48-hour time period. In the first 19 hours post-scratch, it can be concluded that the wild-type plates had faster proliferation rates than the knockout type. In Images 7 and 8, we can see that the wild type cells filled the patches of cells missing on both sides of the wound in the first 19 hours, while there was not a drastic change in cell quantity and density of the knockout cells in that time period (Image 10, 11). From 19-48 hours, however, the knockout growth rate surpassed the wild-type rate, and by the end of the 48 hours, the wound was almost completely covered (Image 11, 12). This is not what we had hypothesized, as we had predicted that the wild-type cells in the 10% would have a faster growth rate than the wild-type overall. The reasoning behind this behavior could be because the wild-type cells grew at such a fast rate in the first 19 hours that the nutrients in the 10% media were depleted, slowing down the rate of growth for the cells 19-48 hours post scratch. On the other hand, the knockout cells have shown a more steady and constant growth rate in the 10% media. Since the growth rate of the wild-type cells dropped after the 19-hour mark, this made the knockout cell growth rate look like it was faster than the wild-type. The sudden bloom of growth of the wild-type cells in the first 19 hours further contributes to supporting the aggressive nature of Bach-1 in the wild-type cells. The rapid growth of the wild-type cells in these model TNBC cells may help to illustrate TNBC cells in humans, where the cells containing Bach-1 will spread and grow very fast in the early stages.

Growth Patterns

The wild-type and knockout cell plates also differ in growth patterns. Before the experiment, we hypothesized that the cell growth pattern would happen linearly, where one cell would extend from another in a single line across the wound. However, we observed that instead of growing in a line, the cells grow in small chunks. The cells tend to fill the “gaps”, or the spaces on the two sides of the wound first before migrating across the wound (Images 1, 2). Then, as the cells migrate, the cells move individually into the wound, and slowly, as the cells

move from the two sides of the wound towards each other (Image 2), the cells change shape and begin elongating and forming webs. As more cells migrate over time, the wound will be covered (Image 3). We have also noticed densely packed cell clumps have formed only on the wild type plates (Image 1-3), and not on the knockout cell plates. As part of the mechanism for proliferation in the wild type cell plates, the cells tend to bunch up into a densely packed clump of cells, and over time, they slowly begin to "unravel" the clump and disperse into new areas, resulting in cell migration. Because the cell clumps are only present in the wild-type cell plates rather than the knockout cell plates, we speculate that cell clumping is directly correlated to the Bach-1 gene, since the only difference between the two plates is the presence of the Bach-1 gene. However, more experiments would be required to confirm this speculation.

Cell Shape

Across both the wild-type and knockout plates, we noticed that the cells were not all uniformly shaped. Some appeared circular, and the others were more elongated and "spiky". When we compared cell growth in both wild-type and knockout plates, we noticed that the more rounded cells were often isolated and separated from other cells. When we took pictures of the cells right after we scratched them, the cells all appeared to be circular and looked like many dots (Images 1, 2, 4). However, as time passed, the cells began to elongate in shape and began "fusing" and "branching" with other cells (Image 3, 5, 6). When the cells became confluent after 48 hours (Image 3, 6), the cells under the microscope appeared to be all connected and looked like a web or a network, rather than individual cells that were adjacent to one another. Therefore, we concluded that a rounder and circular cell shape means developing and "newer", while a "spiky" and "webbed" shape means developed and more mature cells. The results from this preliminary experiment concurred with our hypothesis that the wild-type cells with Bach-1 will be able to migrate and spread out at a faster rate than the knockout cell type.

Discussion

As many studies suggest, the Bach-1 gene promotes cell migration and metastasis in breast cancer tumors and increases cell proliferation (6, 9). Our findings have shown that overall, the wild-type cells had slightly faster growth rates as expected. The wild type and knockout cell plates differed in growth rate in the 10% growth medium as well. This time, the growth rates were not consistent across the 48-hour time period. The sudden bloom of growth of the wild type cells in the first 19 hours further contributes to supporting the aggressive nature of tumor cells that harbor Bach-1 in the wild type cells. The rapid growth of the wild type cells in these model TNBC cells may help to elucidate the mechanisms of TNBC cell metastasis in humans, where the tumor cells containing Bach-1 will grow very fast in early stages. As a result, patients with TNBC tumors should expect rapid growth and spread of their cancer.

The wild type and knockout cell plates also differ in growth patterns. Before the experiment, we hypothesized that the cell growth pattern would happen linearly, where one cell would extend from another in a single line across the wound. However, we observed that instead

of growing in a line, the cells grow in small chunks. As part of the mechanism for proliferation in the wild-type cell plates, the cells tend to bunch up into a densely packed clump of cells, and over time, they slowly begin to "unravel" the clump and disperse into new areas, resulting in cell migration. Because the cell clumps are only present in the wild-type cell plates rather than the knockout cell plates, we speculate that cell clumping is directly correlated to the Bach-1 gene, since the only difference between the two plates is the presence of the Bach-1 gene. Therefore, tumors in patients with TNBC spread in a sort of "contract" and "release" pattern. As the cancer cells accumulate, the cells "contract" and clump into a ball, and later, in order to spread, the cells "release" and flatten out and move to new areas. Learning about the properties and mechanisms of cancer cells with Bach-1 can pave the way for novel ideas for treating TNBC. Since the Bach-1 gene is a transcription factor that targets many different genes, future studies on TNBC can focus on targeting just one or two genes which can possibly inhibit or express specific characteristics of TNBC, such as metastasis or excess proliferation.

In future experiments, instead of testing the function of the Bach-1 gene, we can instead work on ways to prevent metastasis and cancer cell proliferation through Bach-1 inhibition, so that the transcription factor is unable to activate or express metabolic pathways in cancer cells. Another way we can further our studies of Bach-1 can be utilizing downstream inhibition. By silencing or inhibiting specific downstream pathways, proteins, and genes that Bach-1 targets/expresses, such as CXCR4 and MMP-1, viable new drug treatments can be made. Moreover, downstream inhibition will lower the side effects of drugs as knocking out Bach-1 as a whole will disrupt many cellular functions as Bach-1 controls many other bodily processes and the gene found in most cells. Introducing these new drugs opens the door to new options for treatments for many breast cancer patients and shapes how breast cancer treatments are approached.

Error Analysis

One of the first stages of troubleshooting that we experienced was the scratch initially being too wide. We had used the end, instead of the tip, of a p1000 pipette tip. However, under examination under the EVOS FL microscope, we could not capture both sides of the wound even under the lowest objective, 4x lens. We thought that we could observe the migration and proliferation patterns of only one side of the well, but then, we would not know if the injury was healed or not because we could be looking at different areas of the FOV each time. As a solution to this problem, we attempted to scratch at a different portion of the well with a smaller object. We used the tip of the p1000 pipette instead, and the entire scratch could be seen under the EVOS FL microscope. Despite this attempted fix, we noticed that the growth rates seemed slow as some of the cells tended to migrate to the previous, larger injury. This would inhibit our desired results and the cells could not be assessed for growing into the accurate wound.

Another issue that we ran into was the concentration of cells that we first plated, $1x10^5$/mL. After culturing this concentration of cells for two days in the incubator at 37 degrees Celsius, we observed that the confluence level was around 70% instead of the required 80%

density. Regardless of this, we proceeded to perform the scratch assay and photograph the plates. Our results from the photos suggest that the confluence level was not enough as the cells tended to migrate and proliferate in empty areas other than the supposed wound area. This would lower the accuracy of our results and growth rates may have been impacted.

In turn, we decided to plate at a ten-fold increased concentration, $1x10^6$/mL, for our second experiment. We initially believed that this would reach confluence very quickly, and so we scratched the cells after only 19 hours of culturing. However, when any PBS or media was being transferred in and out from the wells, the cells appeared to "peel off" the bottom of the wells in large patches. We hypothesize that this may be due to the fact that the cells ended up growing "too confluent", leading to the cells only adhering to one another instead of being planted firmly to the bottom of the plate. The patches of missing cells were unfortunately connected to our injury, so we had to abandon this experiment and continue to let these plates incubate.

In our third and final experiment, we attempted to repeat the second experiment but with longer culturing times to allow the cells to increase their adherence to the bottom of the wells. However, when we conducted a cell count with the stock flasks that we were given, the wild type cells did not have enough cells to be plated at a concentration of $1x10^6$/mL. According to the Countess Cell Counter, 70% of the cells were dead and only 30% were viable. However, when we performed our cell count with the Bach-1 knockout cells, they had roughly $5x10^6$/mL live cells. This would indicate that the error occurred during cell suspension. We infer that the cells had been trypsinized for too long, or that more than 0.5mL of trypsin had been left in the stock flask when incubating. All of these mistakes could explain why we received such low cell numbers in our cell count. We were told to plate both wild type ($1.29x10^5$/mL) and knock out ($1x10^6$/mL) cells despite them being different concentrations as it was thought that the original plated concentration would not matter if the plates were all confluent before scratching. However, the results for this experiment were skewed as the knockout cells unexpectedly covered the wound faster than the wild type cells, which was different from our first experiment. We deemed these results to be invalid and focused on the results from the first experiment that supported our initial hypothesis.

Conclusion

Based on our experiments, we have found that the Bach-1 gene has an effect on TNBC cell migration. It is known that cancer cells will migrate, regardless of the presence of Bach-1. However, Bach-1 is responsible for promoting migration so that the cells spread at a faster rate. In the scratch assay that we performed, the cells demonstrated more migration in the wild type than the knockout cell type, supporting our hypothesis.

However, throughout this project, we were also able to make many new observations on the properties of Bach-1. In the wild-type cell plates, we saw several clumps of cells, which are a sign of cell migration. The absence of these cell clumps in the knockout plates led us to conclude that Bach-1 causes cell clumping as part of the promotion of migration. Our findings have made

it possible for us to conduct future studies on Bach-1. Silencing or inhibiting specific downstream pathways of Bach-1 can lead to new drugs, and possibly a better treatment for breast cancer patients.

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The Positive Impacts of Music Therapy on Alzheimer's Disease Patients By Glen Finnie

Abstract

Patients with Alzheimer's Disease suffer from numerous symptoms such as loss of coordination, memory, and communication ability. All of this is due to the effect that beta-amyloid and tau proteins have on the brain. Unfortunately, traditional treatment is expensive and doesn't consistently manage the disease. To help with affordable care for patients, music is an option that costs little to nothing and fights Alzheimer's Disease in many ways. The proteins that affect neurons around the brain are partially cleared, helping to slow the progression of the disease and stop symptoms, as well as decreasing levels of depression, anxiety, and stress, and helping with common sleep problems.

Introduction

Alzheimer's Disease affects millions of American patients, caretakers, friends, and family every year. Patients lose memory, coordination, and the ability to perform everyday tasks independently, which puts stress on caretakers, who are frequently unpaid friends or family ("Caregivers"). More people become affected by Alzheimer's Disease each year, yet, most medicines aren't easily accessible, or affordable, and only help fractionally. However, there is another treatment option that is all of these things: music. Music therapy has numerous benefits for patients and is affordable, accessible, and easy to use at the same time.

Overview of Alzheimer's Disease

The National Institute of Aging (NIA) defines Alzheimer's Disease as, "a brain disorder that slowly destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks." It can be characterized by progressively worsening symptoms such as challenges with memory, language, problem-solving, and cognitive skills. Alzheimer's patients don't lose their memories or minds though, they simply lose access to them. This brain disorder affects over 6 million Americans and is projected to affect 13.8 million by 2050. Alzheimer's is the most common cause of dementia and was the sixth leading cause of death in America in 2019 (Alzheimer's Association). Despite this, there are currently no known cures for Alzheimer's Disease, and most treatments today don't prevent the progression of the disease. Also, new treatment methods typically take 7 to 12 years to be approved due to the risk of harmful side effects and lengthy regulatory approval processes. Treatments that work effectively against the disease are unaffordable for many patients.

How Does This Disorder Affect the Brain?

Alzheimer's Disease affects the brain through many means and in many different regions. Its main impact is the destruction of neurons and their connections, especially in parts of the brain involved in memory, such as the Hippocampus and Entorhinal Cortex. There are a few ways these neurons are affected. The first is plaque build-up of proteins in the fluid between neurons. This buildup disrupts normal cell functions and is caused by beta-amyloid ("What Happens to the Brain in Alzheimer's Disease?"). Amyloid typically is stored in the cell walls of

our neurons and is used to help repair the neurons when necessary. The problem begins when the proteins are supposed to be recycled by the body. Typically, alpha-secretase breaks the amyloid protein into two pieces, to be properly recycled. However in some instances, for reasons unknown, beta-secretases and gamma-secretases break the same protein twice. This results in three pieces of protein. The body can properly recycle two pieces, but the third part, beta-amyloid, cannot be recycled (Hornberger).

Our neurons then push the excess proteins out of the cell, for the glymphatic system to dispose of. As we age, however, our glymphatic system becomes less efficient in clearing out beta-amyloid, which results in an increased build-up of proteins. When the beta-amyloid molecules are not disposed of, excess proteins begin to stick together forming strings of protein, and eventually plaques (clumps of 1000s of proteins randomly attached). These plaques are extremely difficult for a declining glymphatic system to dispose of, and lead to blockages between neurons in the brain ("What Happens to the Brain in Alzheimer's Disease?"). This is where the Amyloid Cascade Hypothesis comes in. The hypothesis states that beta-amyloid accumulation is what leads to Alzheimer's Disease, rather than Alzheimer's leading to the accumulation. That would mean that eliminating these blockages can help alleviate symptoms for patients (Hornberger).

Alzheimer's Disease also chemically alters tau proteins so that they disrupt normal neuron processes. Tau proteins are typically used to stabilize microtubules in neurons. Without these proteins, neurons would be unable to transport molecules and lose the structural stability microtubules usually provide. This is detrimental for the cells as they will lose stability, and will be deprived of the nutrients they need. In Alzheimer's patients, when these proteins are chemically altered and stop working, not only do they stop performing their function, but the tau proteins form oligomers, or chains, with each other and become tangled within the neuron (Hornberger). Scientists at the University of Warwick found that introducing tau protein oligomers into healthy neurons led to altered waveforms within just 30 minutes. This leads to slower and shorter signals being transmitted from neuron to neuron. So, faulty tau proteins deprive neurons of the necessary nutrients and form tangles that interfere with normal cell function. Additionally, the Microglia cells that are part of the glymphatic system, and responsible for clearing waste in the brain, fail to dispose of certain waste such as plaques or tau oligomers, due to inflammation of the cells throughout the Alzheimer's process (Hill).

Alzheimer's Disease also disrupts the body's natural circadian system and sleep cycle. In our bodies, the hypothalamus tracks the amount of sunlight being detected by our retinas. When it is exposed to sunlight, the suprachiasmatic nucleus in the hypothalamus is stimulated. This releases serotonin and some other hormones, allowing the body to naturally synchronize cellular activities with daytime. We also have a natural homeostatic sleep drive. This sleep drive builds our desire for sleep the longer we are awake, which helps our bodies fall asleep initially. Once we are asleep, the sleep drive is diminished, and the circadian system decreases alertness throughout the night, which helps us stay asleep for longer. The Circadian System regulates body temperature, melatonin levels, appetite, and cortisol (Guo). However, in Alzheimer's patients,

the hypothalamus often has difficulty recognizing when it is day and when it is night. This hurts the body's natural schedule for sleep, cellular activity, and metabolism, among other things.

Traditional Medicinal Treatment

Medicine can still be beneficial for Alzheimer's Disease patients. The difference between the effects of these medicines and Music therapy is how they treat Alzheimer's. The medicinal treatments focus on the levels of certain neurotransmitters in the brain, as opposed to Music Therapy, which helps prevent blockages and altered proteins from disrupting brain function. The two main types of treatment for patients are cholinesterase inhibitors and memantine.

Cholinesterase inhibitors help manage levels of acetylcholine, which is naturally depleted in Alzheimer's patients. Acetylcholine is a neurotransmitter that passes signals from neuron to neuron, while also contributing to memory, thought, judgment, and alertness. It moves into the synaptic cleft, the space between neurons, and binds to a nicotinic receptor or muscarinic receptor. This process repeats, transferring the chemical message through the brain. Low levels of acetylcholine are associated with muscle and memory problems. Cholinesterase inhibitors' job is to stop cholinesterase, an enzyme that breaks down acetylcholine at increased rates during Alzheimer's Disease. By preventing cholinesterase from functioning properly, cholinesterase inhibitors can regulate levels of acetylcholine in Alzheimer's patients. Though there are many benefits to taking this medicine, there can be side effects of nausea, vomiting, and diarrhea, and it loses its effectiveness as the disease progresses (Cleveland Clinic).

The second approved medicine for Alzheimer's Disease is Memantine, which is currently the only FDA-approved NMDA receptor antagonist. Memantine is approved for moderate to severe stages of Alzheimer's Disease, and it works to stop excess calcium from entering neurons. Typically, glutamate interacts with an NMDA receptor, which allows a certain amount of calcium to enter the brain cell. This is an essential step in the signaling of neurons and in learning and memory. However, increased levels of glutamate are common in Alzheimer's patients and this allows too much calcium into each neuron. This can lead to overexcited neurons, which eventually results in the death of the cells. Higher levels of glutamate have also been associated with higher pain levels, and it has been associated with stress, anxiety, and seizures. Memantine prevents these from happening by blocking any excess glutamate from accessing the cells, therefore helping to ensure proper cell function (Cleveland Clinic).

Music as an Alternative Therapy

With all of these drug-related financial burdens, time commitments, and negative effects on patients and caregivers, there is still little effective and affordable treatment available. However, music therapy has shown numerous benefits for people with Alzheimer's Disease, which are reflected in the patients' caregivers. First, music therapy has been found to calm agitated patients of Alzheimer's Disease, improve mood, enhance long-term memory, and reduce chronic pain, depression, agitation, wandering, and feelings of isolation. One study helped 5 patients participate in one weekly music therapy session. Each patient was given a personalized selection of instrumental music and measured periodically on their Depression Score (Cornell

Scale) and Anxiety Score (Hamilton Scale), and the Caretaker was measured on the burden they felt (Zarit Scale). After four weeks, the patients' average depression score dropped from 10.8 to 2.2, the average anxiety score went from 9.4 to 3.4, and the burden felt by the caregiver dropped from 30.2 to 15.6 ("Impact of Music Therapy on Anxiety and Depression for Patients with Alzheimer's Disease and on the Burden Felt by the Main Caregiver [Feasibility Study]").

There are also many functions and ways to practice music therapy. The effects differ based on whether we are listening, playing, or composing the music. Music can also be used to help memory, or simply to calm patients and relieve stress. When aiming to improve memory, the effect is greater when the music is self-selected by the patient, which allows them to have deeper and more meaningful emotions and memories. Music therapy has this impact because of all the parts of the brain that relate to music.

Decades of research have revealed that processing music impacts six main areas. These include the Auditory Pathway, Musical-syntactic network, Attention and Working memory network, Motor network, Reward/Emotion Network, and Episodic Memory network. These areas of the brain help us recognize and perceive music, which triggers pleasure and rewarding emotions. Though some of these regions aren't majorly affected by Alzheimer's Disease, they can be activated through music, which helps keep them alive and healthy, and prevents any potential damage. The Episodic Memory network, however, is the most affected. This area of the brain is impaired by Alzheimer's Disease and Dementia, as its main purpose is to recognize music and recall any memories that may be associated with the music. Though it is impaired by Alzheimer's Disease and Dementia, music can help reactivate the Episodic Memory Network, which can help Alzheimer's patients recall memories associated with the music they listen to (Sima).

The second benefit of music therapy is that it helps increase levels of melatonin and norepinephrine significantly in Alzheimer's patients. A study at Miami Veterans Administration Medical Center, in Miami, Florida, followed 20 Alzheimer's patients who had blood samples taken before the experiment. For the next 4 weeks, the patients had 30 to 40-minute music-listening sessions in the morning for 5 days a week. Immediately after the study, the patients were tested again and showed significantly increased levels of melatonin, norepinephrine, and epinephrine. Then, 6 weeks later, even without listening to music between tests, the patients' melatonin levels continued to rise. Norepinephrine and epinephrine levels returned to pre-study levels, however ("Music Therapy Increases Serum Melatonin Levels in Patients with Alzheimer's Disease"). Now, why does this matter? Norepinephrine is a neurotransmitter that is important for processes like digestion and the regulation of the heartbeat. There can be reductions of norepinephrine of up to 50% during the late stages of Alzheimer's Disease, but it is thought that depleted norepinephrine can contribute to the behavioral complications seen in Alzheimer's patients, and norepinephrine imbalance has been linked to the obstruction of memory (Rogers).

Melatonin is a hormone that helps our bodies fall asleep, and is controlled by the hypothalamus. When nighttime is detected, the suprachiasmatic nucleus sends a signal to the

pineal gland to begin the release of melatonin. The problem is that Alzheimer's patients' bodies have difficulty detecting when nighttime is, as the hypothalamus doesn't function properly in brains affected by Alzheimer's Disease. This leads to improper sleep schedules for Alzheimer's patients. Researchers in Malaysia have found that melatonin helps with sleep disturbances for Alzheimer's patients, among other benefits. While melatonin can be delivered to patients in supplements, some participants in a study showed signs of social isolation and complained of depression when given supplements. Research has also shown that melatonin helps Alzheimer's patients stabilize their circadian rhythm, which helps with the sleep cycle and other bodily processes. This has a deeper effect though. Studies show that sleep deprivation is linked to further build-up of beta-amyloid. This is because the glymphatic system, the brain's dedicated waste system, works mostly during sleep ("Sleep Deprivation Increases Alzheimer's Protein."). When the glymphatic system doesn't have time to clear out beta-amyloid, more plaques accumulate, which leads to worsening symptoms of Alzheimer's, including bad sleep, which leaves the glymphatic system less time yet again. This vicious cycle continues until something can try to stop it ("How Sleep Clears the Brain").

Music vs. Medicine

Music therapy and Medicine can be used together to benefit Alzheimer's patients in different ways. While medicine helps manage levels of neurotransmitters in the brain, music therapy focuses mostly on the circadian system and sleep cycle. The medicine helps manage levels of neurotransmitters in Alzheimer's patients, which helps to block or delay some symptoms, but it doesn't prevent the advancement of Alzheimer's Disease. While music therapy is extremely affordable, accessible, and easy to use, it also only improves certain aspects of an Alzheimer's-infected brain. Since medicine and music benefit separate parts of the brain, and work in different ways, music therapy should not be used as a replacement for medicine. With that being said, whether or not a patient is receiving treatment in the form of medicine, music therapy will help manage other aspects of the disease and will help the patient decrease levels of anxiety, stress, and depression.

Conclusion

Alzheimer's Disease is a brain disorder that affects millions of people in the US alone. This disease takes over the lives of the patients and the lives of care-giving friends and family. It is a leading cause of death and dementia and causes stress for all parties involved. Not only this, but treatments today are either ineffective, unaffordable, or have harmful side effects. Music therapy offers a counter-balancing solution to all of this. It is proven to improve patients' moods and decrease levels of depression, stress, and anxiety for both caregivers and people with Alzheimer's Disease. All while being very accessible, easy to use, affordable, and with no side effects. As professor of neurology, Oliver Sacks said, "Music can lift us out of depression or move us to tears – it is a remedy, a tonic, orange juice for the ear. But for many of my neurological patients, music is even more – it can provide access, even when no medication can, to movement, to speech, to life. For them, music is not a luxury, but a necessity."

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Promoting A Culture of Working Amongst Youth in India By Adhya Boby

Abstract

This policy paper explores the potential benefits of altering the work culture and attitudes towards employing the younger generation in India. Various factors, including cultural norms, beliefs, the economy, and the prevailing work culture, contribute to the hesitancy in employing young individuals for part-time or full-time jobs. However, by implementing a policy that promotes youth employment, we can create a more comprehensive experience for the younger generation in India, enabling them to learn valuable skills and gain practical experience in the economic realm. This paper highlights the societal issue of youth disengagement from the workforce and emphasizes the need for urgent intervention at a policy level. Encouraging young people to work from an early age not only equips them with essential experiences and lessons applicable throughout their lives but also fosters personal growth, independence, and a realistic understanding of professional demands.

Keywords: Work culture, youth employment, policy, skill development

Introduction

This policy paper aims to bring to light the possibilities of altering the work culture amongst the younger generation in our country and changing people's attitudes towards the employment of the present youngsters of India, aged between 14 to 18 years. Various reasons such as cultural norms, beliefs, economic condition and the work culture contribute to the differing mindset and decisions made by Indian citizens that prevents normalizing youth employment for any part-time or full-time jobs. However, by promoting the culture of employment among youth, India can strive towards creating a more holistic experience for the younger generation where they learn how to deal with work and gain experience on an "economic scale".

The Importance For Teen Labour Force Participation

The lack of engagement of youth in the workforce from a young age, is an important societal issue that needs to be brought to light and requires an urgent intervention by government authorities at an overall policy level. Young people should be encouraged to work from a young age as they gain valuable experiences and learn lessons that can be implemented and used later on in their lives. It makes them stronger and more independent individuals. Further, having a professional experience at this age gives them exposure to real life experiences and aids in moulding their character and work ethic. Some of the benefits of working at a young age are as follows:

1. By working from a young age individuals can develop a sense of responsibility and work ethic. They learn the value of hard work, discipline, and perseverance, which can benefit them throughout their entire lives.
2. Early work experiences can provide youngsters with valuable lessons in financial literacy. They learn to manage money, make budgets, and make informed financial decisions. Moreover, working from a young age can give them a sense of independence and teach them the importance of self-reliance.
3. Employment at a young age can help individuals develop transferable skills that can be utilized in different aspects of their lives. They can acquire communication skills, teamwork abilities, time management, problem-solving, and customer service skills, which can enhance their personal and professional growth.
4. Working at a young age can expose young people to different industries and working environments. This exposure can help them explore various possible career paths, gain insights into their interests and strengths, and make more informed decisions about their future education and career choices.

Challenges Towards Employment Of Young Individuals

Some of the challenges which have led to the current status of lack of established opportunities for young individuals are as follows:

1. India, along with many other countries worldwide has established regulations and labour laws that restrict the employment of young people below a certain age or impose limitations on the type of work they can engage in. These laws aim to protect the rights and well-being of minors, but they also limit the availability of suitable job opportunities for young students.
2. In many societies including India, there is a strong emphasis on academic performance and achievement. As a result, students are encouraged to prioritize their education and focus on achieving high grades rather than seeking practical exposure through experiential learning. This focus on academic excellence often leaves little room or time for young people to explore work opportunities.
3. Employers often seek candidates with relevant skills and prior work experience, even for entry-level positions. This creates a catch-22 situation for young students who are looking for a work opportunity.
4. Some industries or types of work may involve safety risks or liability concerns when it comes to employing young people. Employers may be hesitant to hire young students due to the potential legal and safety implications involved. This cautious approach further limits the available job opportunities for young individuals.
5. Societal attitudes and cultural norms have changed over time, and there is now a greater emphasis on protecting and nurturing childhood. The shift toward prioritizing education,

personal development, and a longer period of dependency on parents or guardians has led to a decreased emphasis on early workforce participation.

Economic Impact Of Lack Of Professional Opportunities For Young Individuals

There could be a series of economic impacts and other consequential problems that arise from the lack of opportunities for young people. Some such impacts are as follows:

1. The lack of working opportunities for young people can lead to a decrease in the labor force participation rates which can have adverse implications for overall economic productivity and growth. A decline in the number of young people entering the workforce can strain the labor market and potentially lead to labor shortages in certain sectors.
2. The lack of early work experiences can result in a skills gap, where young individuals lack the necessary skills demanded by the labor market. This skills mismatch can lead to reduced productivity and inefficiencies in the economy as employers struggle to find qualified workers.
3. Without access to working opportunities, young people may struggle to achieve financial independence. They may rely on their families for financial support for longer periods, which can strain household budgets and limit economic mobility. Delayed financial independence can also lead to postponed investments, such as purchasing homes or starting businesses, which can have broader implications for economic growth.

Policy Framework

Some the laws governing the employment and internship opportunities for young people in India are as follows:

1. The Factories Act, 1948: As per this Act, children under the age of 14 are not allowed to work in a factory. This law also stipulates who, when, where and for how long children between the ages of 15 to 18 can work.
2. The Child Labour (Prohibition and Regulation) Act, 1986: This Act, prohibits and regulates child labour by providing that children younger than the age of 14 years are prohibited to work in occupations and be a part of certain production processes as described in the Act which includes work related to the construction of railways, production of firecrackers, employment as domestic help etc. (Paycheck. in, n.d.) Further, as per this Act, employment of children are prohibited in certain specified hazardous occupations and processes and this Act also regulates the working conditions in others. The list of hazardous occupations and processes is progressively being expanded on the recommendation of the Child Labour Technical Advisory Committee constituted under this Act. Subsequently, the Act was amended in 2016 with the enactment of the Child Labour (Prohibition & Regulation) Amendment Act 2016 prohibiting the employment of Children below 14 years in all forms of employment, along with containing the provisions for the prohibition on employment of adolescents

(14-18 years) in the scheduled hazardous occupations and processes. (Ministry of Labour and Employment, n.d.)

3. The Right of Children to Free and Compulsory Education Act, 2009: As per this Act, it is mandatory for children aged between 6 to 14 to get free and compulsory education. This legislation also required that in any private school, at least 25% of seats be reserved for physically challenged or vulnerable groups of children.

Some of the primary schemes/ initiatives taken up by the Indian government for promoting work opportunities amongst young individuals are as follows:

1. **National Apprenticeship Promotion Scheme ("NAPS")**: NAPS aims to promote apprenticeship training for young individuals to enhance their employability. It provides financial incentives to employers who engage apprentices and offers apprenticeship training in a wide range of industries. The scheme also includes provisions for apprentices' welfare and social security.

Strengths of NAPS -

- ➢ This scheme helps create an industry-ready workforce
- ➢ It relieves financial strain/pressure on the beneficiary
- ➢ This scheme is cost-effective for business, as the companies do not have to bear the cost of recruitment, training and other costs associated with hiring staff, while also providing financial benefits to businesses that take on apprentices.
- ➢ Staffing through NAPS allows businesses to tap into a pool of untouched and raw talent that is yet to be used.
- ➢ Helps the young generation gain real-time work experience
  (Ministry of Skill Development and Entrepreneurship, n.d.)

2. **Pradhan Mantri Kaushal Vikas Yojana ("PMKVY")**: PMKVY is a skill development initiative that aims to provide industry-relevant skills training to young people. It offers training programs aligned with the National Skill Qualification Framework (**"NSQF"**) in various sectors and provides financial support to candidates for their training expenses. The scheme focuses on skill development to enhance employability and entrepreneurship, particularly for unemployed youth or school and college dropouts. (Vikaspedia, n.d.)

Strengths of PMKY -

- ➢ Plans to link the aptitude, aspiration, knowledge of the skilled workforce it creates with employment opportunities and demand in the market.
- ➢ Aim is to empower the country's youth and to make India the skill capital of the world
- ➢ It strives to upskill and reskill the youth of India
- ➢ The beneficiary of this policy would be an unemployed youth or school/college dropout.

- ➢ This scheme provides a good opportunity for students to get trained, assessed and certified.
- ➢ It also facilitates the provision of better employment opportunities to people. (Vikaspedia, n.d.)

3. **Deen Dayal Upadhyaya Grameen Kaushalya Yojana ("DDU-GKY"):** DDU-GKY focuses on rural youth and aims to provide skill training and employment opportunities to them. It offers market-driven training programs, job placement assistance, and support for self-employment. The scheme targets poverty alleviation by enabling rural youth to gain sustainable livelihoods.

Strengths of DDU-GKY -

- ➢ This scheme assists in reducing poverty
- ➢ Awareness building within the community on the opportunities
- ➢ Identifying underprivileged rural youth
- ➢ Mobilizing rural youth who are interested
- ➢ Imparting knowledge, industry-linked skills and attitude that enhance employability
- ➢ Providing jobs that can be verified through methods that can stand up to independent scrutiny, and which pays above minimum wages
- ➢ Supporting the person so employed for sustainability after placement
- ➢ Learn new skills and new technology in modern fully-equipped training centers
- ➢ Earn a government recognized skills certificate upon successful completion
- ➢ Get placement opportunities and interact with potential employers
- ➢ Get support to shift to a new city and job
- ➢ Progress steadily in one's career (CreditMantri, n.d.)

Employment of Youth: A cultural comparison between India and the United States of America

In Western countries such as the U.S.A. the concept of money in the family is radically different from what we have in India. In the U.S., kids staying with their parents after 18 and living on their money are looked down upon. Many even pay rent to their own parents and pay bills. Hence they go to work or seek active employment to be able to afford the same. While in India such things are completely alien to cultural norms and hence there is no pressure to earn money. (Reddit, n.d.) Hence, here is a comparison between the difference in work culture in the United States of America and India.

	India	**USA**
Legal Frameworks and Regulations	The employment of young people in India is regulated	The U.S. has the Fair Labor Standards Act (FLSA, 1938)

	by the Child Labor (Prohibition and Regulation) Act, 1986 which sets restrictions on the types of work and working conditions for children and adolescents. There are specific provisions for internships, including limitations on working hours and ensuring the educational progress of interns.	that governs youth employment. It establishes rules regarding minimum age requirements, working hours, and types of work for young individuals. The FLSA also includes provisions for internships, distinguishing between paid internships and unpaid internships that must meet specific criteria.
Internships	While internships are becoming more prevalent in India, there is still a lower emphasis on formal internships compared to the United States. Many internships in India are informal, and the culture of internships varies across industries and organizations.	Internships play a significant role in the American employment landscape, and there is a strong emphasis on formal internships as a means to gain practical experience and bridge the gap between education and work. There are well-established internship programs in various sectors, and they are often considered valuable for career development.
Work culture and early employment	In India, there is less emphasis on young people engaging in formal employment at an early age. The focus tends to be more on education, with many young individuals pursuing higher studies before entering the workforce.	The United States has a culture that promotes early employment and encourages young people to work part-time jobs during their high school and college years . This culture of early employment is seen as an opportunity for young individuals to gain work experience, develop skills, and become financially independent.

Policy Recommendations

1) The government may consider implementing such policies which allow young individuals to gain work-life experience. These regulations should provide a secure environment, ensuring ethical working conditions and a fixed salary that will motivate and drive youngsters to perform their assigned tasks to their best potential. The

Government may also consider issuing guidelines which encourage the youth of the country to participate in the workforce albeit in a regulated manner and under strict supervision.
These guidelines may include the following aspects:

1. Ensuring ethical working conditions for the youth;
2. The model and appropriate treatment and behavioural guidelines to be followed by entities employing young individuals as interns or in any other form; Providing health insurance coverage to mitigate the effects of any potential health or accidental risks for the young individuals;
3. Ensuring that sufficient remuneration is provided;
4. Prescribing and imposing a cap on the maximum number of hours for which youth of different age groups can work;
5. Duration of the engagement.

2) Government may promote organisations which can help these young individuals secure work opportunities. Among other things, these companies will track the progress of these individuals and also seek to ensure their security and safety. This will assist the parents in sending their children without any worries, as they would be assured of the safety and well-being of their children.
3) The government may consider modifying the PMKVY, DDU-GKY, and NAPS schemes to allow teenagers aged between 14 to 18 years to have the opportunity to experience work at an early stage in their lives. For example, the government may consider modifying the applicability of DDU-GKY to extend its benefits to teenagers, apart from the current beneficiaries comprising young adults in their early to late twenties.
4) The Government may consider focusing on research to understand the various dimensions associated with work opportunities for young individuals aged between 14 to 18 years. This will help bridge the gap existing in the current literature on this subject and enable policymakers to make informed decisions and policies.
5) Policies such as the PMKVY (can be implemented for any youth that is unemployed whether it be a school or college dropout, and the applicability of DDU-GKY can be extended to teenagers, apart from the current beneficiaries comprising of young adults in their early to late twenties. These policies have only been implemented on young adults, where they are provided with industrial-level skill training, market-driven training programs, job placement assistance, financial support and even self-employment. Nonetheless, if we could provide the same sort of assistance to a much younger

Conclusion

Despite the potential obstacles and challenges, promoting a culture of work amongst teenagers in India is of paramount importance and warrants implementation. By addressing these obstacles and adopting effective policies, we can unlock the tremendous potential of our young

population and pave the way for a brighter future. While concerns such as limited access to quality education, lack of skill development opportunities, and social stigmas may pose hurdles, it is crucial to overcome them through a comprehensive approach.

By promoting a culture of work, we empower teenagers to develop crucial life skills, foster a strong work ethic, and gain early exposure to professional environments. This not only enhances their personal growth but also prepares them for future career success and contribution to the nation's workforce. Moreover, a culture of work can instill financial literacy and responsibility among teenagers, teaching them the value of money, savings, and wise financial decision-making. It also provides them with a sense of purpose, self-confidence, and an understanding of the importance of contributing to society.

In conclusion, implementing this cultural shift requires collaboration among policymakers, educators, parents, and society as a whole. It demands investment in infrastructure, mentorship programs, and inclusive policies that protect teenagers' rights and well-being while providing them with suitable work opportunities. By embracing this mindset and working collectively to address the concerns, we can empower our youth, prepare them for a competitive global economy, and build a prosperous and resilient nation. We should aim to create an environment that nurtures the aspirations and potential of our teenage population, ensuring a brighter and more promising future for all.

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Impediment of Chinese Scholars: The Rise of Proclamation 10043 and its Social Impacts
By Yun Feng Benson Xie

Donald Trump's Presidential Proclamation 10043 on May 29th, 2020, aimed to restrict the entry of certain graduate students and researchers from the People's Republic of China. Starting in 2018, continuous political tension arose between the US and China. The US had been accusing China of a series of crimes including intellectual theft, forced technology transfer, currency manipulation, and state subsidies. In 2020, the US further accused China of engaging in a wide range of heavily resourced campaigns to acquire sensitive US technologies and information. By acquiring intellectual property and technology, the White House says China poses a threat to America's long-term economic vitality and safety. (Federal Register, 2020)

Within the Proclamation, former US President Donald Trump stated that the Chinese government uses Chinese students, mostly post-graduate students, and postdoctoral researchers, to acquire intellectual properties through non-traditional means. Thus, any students beyond undergraduate levels who have an association or any means of contact with the PLA (People's Liberation Army), or any individual who is connected to an entity that supports/funds/employed/studied at the "military-civil fusion strategy" would be susceptible to engaging in espionage. As a result, issuing F or J visas to these certain individuals to pursue studies or research in the US is viewed as detrimental to the interests of the United States. (Federal Register, 2020)

However, this proclamation brought a vast surge of discontent from the Chinese international student body. Many Chinese students called for an end to this proclamation and some even filed a class action lawsuit against the US government. But after all endeavors, the proclamation still stands today (Reuters, 2023). As a result of the visa ban, many students who received an acceptance letter from top universities in the US have not been able to attend school or complete their studies abroad. Some students have been forced to decline the offer or complete their research studies virtually. The U.S. State Department estimated around 1,000 visas were rejected, but after an estimation from the Center for Security and Emerging Technology, an estimated 3,000 - 5,000 students are affected per year, a number consistent with estimations from *The New York Times* and *Reuters* (CEST, 2021). Furthermore, this proclamation has led to an increase in the rejection of student visas overall, even in students who clearly had no Chinese military connections. In 2022, the *Wall Street Journal* reported that in the first half of 2022, the number of US visas issued to China dropped by more than 50%. Additionally, there were only 47,000 F-1 visas issued to Chinese students in 2022, 40,000 fewer than were issued from May to August 2021, comprising a 45% decrease (Sha Hua, 2022). Such actions further exacerbated the notion that Chinese students are not welcome in the US. Indeed, it has substantiated discriminatory actions towards Asians, such as Asian Hate. The policy further widens the gap between US and China and encourages the public to become hostile toward the Chinese. This has caused a vast decrease in Chinese students, who have previously made up the single largest foreign student population in the United States. (Edward Wong, 2020)

As the two largest economies in the world, such a proclamation poses detrimental effects to both countries, and it hinders global cooperation, technological innovation, and global economic development. This visa ban puts numerous schools and industries in a predicament, where economic incomes are dropping and technological advancements are stumbling. It also limits opportunities for both countries to thrive. Imposing such a proclamation during a particularly delicate political moment between China and the US undoubtedly aggravates the relationship. Hence, this proclamation needs amendment to prevent further deterioration of the US-China relationship, and to ensure the two nations come to a consensus to compete on equal terms.

Context and Importance–Problem Statement

Proclamation 10043 aimed to promote the idea of protectionism, with the idea that China poses a threat to national security and intellectual property. However, many university professors and experts in the realm of leading technologies disagreed with the policy, because it would reduce the talent pool available for US universities and hinder US technological innovations, especially since many Chinese students are a part of the leading areas of technological developments.

Another concern is that the proclamation negatively influences the US economy. As the largest foreign student population, Chinese students contribute substantially to the US economy. Contributions in large areas such as local economies and university tuition fees, Chinese students contributed around $14 billion to US sectors in 2020, representing nearly 37% of all sectors' economic values according to ApplyBoard (Apply Board, 2022). Many Universities also rely on full tuition payments from Chinese students. Thus, the visa ban will cause tremendous economic loss to society writ large and many universities.

Moreover, this proclamation further impairs US-China relations by exacerbating the notion that Chinese students are not welcome in the US. This has also led to discriminatory actions against Chinese students and magnified certain social phenomena such as xenophobia and Asian Hate. Additionally, many younger Chinese students will likely choose alternative educational options such as studying in Europe or studying domestically considering the unfriendly atmosphere and large scope of visa denials. According to data found by International Consultants for Education and Fairs, in 2022 70-80% of families are looking for multiple options when applying to colleges, a significant increase from only 20% (ICEF, 2023). Lastly, this would create a new problem of competitive talent pools in other countries that will compete against the US.

Historical Background

The US-China relationship is a long and complicated one starting from the late nineteenth century. The countries have both close economic ties and unresolved disputes such as the political status of Taiwan and territorial disputes in the South China Sea. China and the US are respectively the world's second and first-largest economies by nominal GDP. According to Investopia, together they comprise 44.2% of the world's GDP (Investopia, 2023). Since 1949

after the Chinese Civil War when the CCP (Chinese Communist Party) established the PRC (People's Republic of China), the US-China relationship turned hostile. In 1972, President Richard Nixon's visit to China marked an alleviation of tension in which Nixon aimed to resume harmonious relations between the US and China. The US then recognized the PRC as the sole and legitimate government of China and together they established full diplomatic relations. A few decades later, relations quickly escalated into tensions after the administration of CCP's General Secretary Xi Jinping and the 2016 election of President Donald Trump. In 2017, Trump labeled China as a "strategic competitor," and in 2018, Trump launched a trade war against China. Since then, tensions have escalated, triggering a series of bilateral allegations. During the four years of Trump and Xi's administration, US-China relations stepped into a new epoch of tension.

In 2020, one of the main allegations the US leveled against China was Military-Civil Fusion (MCF). According to *Baidu*, the MCF is a national strategy that integrates national defense and military modernization into the economic and social system. To comprehensively promote integration in various fields such as the economy, education, talent pools, and technological advancements. Working with and combining military modernization with economic and social development to provide abundant resources available for the potential realization of military modernization. Where the term military modernization meant the requirements that the military must meet to prepare for future wars and modern warfare by increasing scientific and technological content in the military (Baidu, 2023)**.** Hence, the US then accused China's military-fusion strategy, in which the US states are building links between civilian universities and training students to be sent abroad for espionage.

Thousands of Chinese postgraduate students continue to pursue education in prominent US colleges, and many are a part of sensitive research in biotech, chip development, and technological developments. Concerns regarding national safety and intellectual property have alarmed US officials. The US has accused China of acquiring key technologies through illicit means. According to the US Department of State, the CCP exploits the openness and transparency of global research enterprises to bolster China's military strength through overseas researchers and PRC diplomats. President Trump then issued Proclamation 10043 to promote national security and protect intellectual property from espionage. In order to achieve these goals, the proclamation denies new and revokes previously issued visas to students who studied or conducted research at Chinese universities that support the PRC military initiatives or the military-civil fusion strategy.

The proclamation caused a surge of discontent from the entire Chinese student body because many students' visas were still declined even though they were clearly not affiliated with the PRC. Many students were then blocked from the country, which decreased the economic income of universities and local businesses. Furthermore, this visa ban also led to a decrease in talent pools in crucial areas of research and development, hindering the US's progress in innovating, and losing these talents to other possible rival countries. This resulted directly from Proclamation 10043, which needs amendments.

Policy Implications

Such a proclamation dismisses concerns over national security, which promotes the safety of US citizens. The US accuses the Chinese government of building links between the country's civilian universities and military agencies. It has instituted a policy known as the "military-civil fusion," to leverage civilian universities and sectors to maximize national military strength over the past decade. According to the China Defence Universities Tracker, a great number of Chinese universities are engaged in training defense scientists, collaborating with the military, and conducting classified research. By working closely with universities, the PLA could leverage universities and students to engage in overseas surveillance and espionage for military purposes. Thus, establishing visa bans specifically for Chinese students who are or were related to the PLA significantly reduces the risk of intellectual property being exposed to espionage.

Currently, the Biden Administration has continued the denial of visas under the proclamation issued by Donald Trump. But unfortunately, this proclamation is costly to the US both from a micro and macroeconomic perspective. Many colleges rely on full tuition payments from Chinese students, and the decrease in Chinese students would result in a significant loss of income. According to *Forbes*, It was estimated that 1,000 PhDs blocked per year would cost an estimated $210 billion in the expected value of patents produced by universities over 10 years and around $1 billion loss of tuition over a decade. In compliance with *Insider*, Chinese students pay up to three times more than normal in-state students at public universities (Insider, 2022). Chinese students also are huge contributors to local economies through living expenses such as transportation, housing, and daily expenditures. According to *Boundless*, in 2019 alone, Chinese students contributed $15.9 billion in economic value (Boundless, 2022). The reduction of students would impact sectors such as housing, retail, and services targeted specifically to student populations. Lastly, Chinese students are actively involved in scientific research projects and technological developments. Many professors and Eric Schmidt, former CEO and chairman of Google, have acknowledged the significant contributions of Chinese students to cutting-edge technological developments. At a recent congressional hearing on emerging technologies and their impact on national security, Schmidt said, "If you were to get rid of all of them . . . you will, in fact, hurt America's AI leadership" (Schmidt, 2023) According to *CSET*, China is experiencing the brain-drain problem, where many of its top talents were lost to other countries, most predominantly the US (Remco, 2021). The *Washington Post* says that most talented Chinese students do not immediately return home, whereas 85% of the Chinese STEM Ph.D. program students choose to study at least 5 years after graduating (Washington Post). A decline in Chinese students would lead to a loss of contributions to different research areas, posing detrimental effects to US technological advancements and America's leading position in several technological areas.

On a macroeconomic aspect, it is clear that Proclamation 10043 has severely negative impacts on the whole country. Primarily, the proclamation has intensified US-China relations. It has heightened the notion that Chinese students are not welcomed in the US and substantiated discriminatory actions such as Asian Hate. Considering many Americans believed that the

Chinese were the reasons Covid erupted, anti-Chinese issues would become more prominent. Crime rates against Asians, specifically Chinese, have drastically increased. According to NPR, from March 2020 to June 2021, there were more than 9,081 cases of anti-Asian incidents reported (NPR). Considering safety issues and hostility from the US, Chinese students pursuing school in the US for high school or college have begun to reconsider their choice of studying abroad. Chinese students might decide to study domestically or turn their interest toward other countries. On top of the 3,000 to 5,000 students being banned entry by Proclamation 10043, more potential talents will turn their attention to other countries as families are worried about the political tensions between the two countries. According to Insider, 51% of Chinese students surveyed wanted to study in the US in 2015, while the number slumped to 30% in 2022 (Insider, 2022). On top of that, Jingdong Xiao found in the University World News said, "Before the pandemic, only 10%-20% of Chinese students would consider applying to colleges in multiple countries, but now roughly 70%-80% will" (ICEF, 2023). It is evident that the US is no longer the only destination for Chinese students. Furthermore, according to *Factly*, of the top 25 countries of international students in the US, 15 of the countries have fully or nearly rebounded to pre-pandemic numbers in 2021-22, but the number of Chinese students dropped by 22% compared to 2019-20. As the whole world recovers from the pandemic, Chinese students in the US continue to drop from 372,000 in the 2019-20 school year to 290,000 students in the 2021-22 school year. It is clear that together with the political tensions, anti-Asian racism, and the visa bans imposed by the US government, Chinese students have been steadily decreasing in the past two years despite almost the rest of the world's resuscitating from Covid (Factly). As the largest US international student population, this will lead to a drastic decrease in talent, present an impediment to economic growth, and severely hinder technological development in the US. It is critically important for the government to invest in and amend this proclamation.

Critique of Policy Options and Alternatives

Overview of Proclamation 10043:

Presidential Proclamation 10043 has posed harm to US developments and disrupted international relations with other countries. Below is a policy matrix providing all the advantages and disadvantages of various amendments to the proclamation. The proclamation aimed to promote the safety of the nation and intellectual property by imposing visa bans on a certain number of Chinese students and researchers.

The purpose of this proclamation is to promote the safety of intellectual property. It resulted in the restriction of visas for many Chinese postgraduate students and researchers. The advantage of this proclamation is that it protects many US universities and firms being utilized to acquire sensitive US technologies and reduces the threat of intellectual property being leaked to other countries. The disadvantage is that it will cause a significant reduction of talent in the US, posing a threat to local US economies and technological advancement. Furthermore, it will aggravate US-China relations, leading to a further potential reduction of talent, economic loss, and talent lost to other countries, threatening the US's dominance in technological advancements.

Alternative 1

The first alternative would be to amend Section 1 to lower the scope of visa restrictions on students by limiting restrictions only to the Seven Sons of National Defense universities. Moreover, there would need to be a new section where the other students who are not a part of the Seven Sons but are suspected of espionage activities would need to agree to surveillance by the Department of State on all communications in order to continue studying in the US. Doing so could increase the number of Chinese students, and resuscitate lost economic activities and technological developments. More importantly, it would lead to a decrease in people accusing the proclamation of being discriminatory as it would target only universities that have direct ties to the military. According to the Australian Strategic Policy Institute, each year over 10,000 graduates from the Seven Sons join the defense research sector, around 30% of all employed graduate students (Alex Joske, 2019). While Statista says there will be a total of 290,086 Chinese graduate students studying in the US in 2020, this is greatly different from the 10,000+ students from the Seven Son universities (Statista 2023). Furthermore, according to the estimation from the Center for Security and Emerging Technology, there is an average of 3,000 - 5,000 students being denied visas by Proclamation 10043 (CSET, 2021). If the proclamation is amended, this whole lower the scope of Chinese students being affected and greatly reduce the number of students being banned from issuing visas. However, this might lead to criticism of human rights abuses and also a potential decrease in students. Letting students agree to surveillance would cause huge discontent from the Chinese student body as a violation of human rights. Thus, China might potentially accuse the US of abusing human rights, leading to reconsideration of certain Chinese parents.

Alternative 2

The second alternative would be to amend Section 3 Part A, where the Proclamation should make public the list of entities being banned from issuing visas by this proclamation, and also make public the decisions of the Secretary of State in Section 2 Part A numbers v, vi, and vii. Making public the decision of the Secretary of State would mean they would be more carefully made and scrutinized. This could provide a satisfactory explanation to the public of which the proclamation accused students. According to the Association of American Universities (AAU), the AAU, the American Council of Education, and 39 other associations sent a letter to the Department of State to explain the scope of Proclamation 10043 (AAU, 2021). Explaining the scope of this proclamation could also appease certain public rage that was ignited. Furthermore, this could lead to a higher quality of classification of students between who falls under the criteria and who doesn't. This alternative would allow all students who previously were denied visas and had clear evidence of not being affiliated with the PRC or other military-civil fusion programs to regain a chance to study in the US. However, the disadvantage of this alternative is that it would add substantial work time to the State Department by requiring explanation and transparency. Much more time and effort will be required to maintain this proclamation.

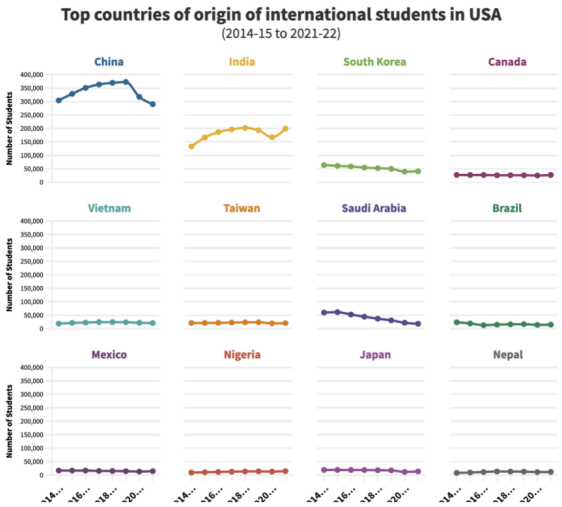
Alternative 3

The third alternative would be to amend Section 1 by reestablishing the target of this proclamation. CSET has shown that almost 90% of all US research and development takes place outside of academia, such as in the private sector, nonprofit organizations, and government labs (CSET, 2021). Even within academia, most professors and postdoctoral students are the ones who work on cutting-edge technologies and developments. Instead of targeting mass numbers of Chinese-born students, the US could target international researchers in different research sectors and firms, where most are a part of 90% of all research and developments. The advantage of this alternative is that more students would have opportunities to study in the US. Furthermore, the student population could further increase US development by contributing to its economy and increasing the possibilities for future talented researchers. On top of that, by not targeting specifically the Chinese population, this would then not be viewed as a discriminatory proclamation. However, this proclamation would influence talented individuals in the private sector and research organizations which might pose great harm to the development of the US. When the government starts to ban individuals who are part of government labs or private sectors, it would pose detrimental effects on US developments considering that this population is responsible for nearly 90% of all research and development.

Alternative 4

The last alternative would be to repeal the whole proclamation, as it brought extreme harm domestically such as technological developments and economic income, but moreover, it brought harm to US china relations, harming future opportunities for the US. Repealing the whole proclamation would expose US research and development to a certain risk of espionage from Chinese students. Nevertheless, from data shown from the CSET, almost 90% of all research and developments are conducted in other realms than academia, and only professors and postdoctoral students are a part of this research. Hence, not many students would be a part of technological research and development. The benefit of repealing the whole proclamation completely outweighs the negatives where more Chinese students can enter the US, creating more economic values and fostering new employment opportunities. Furthermore, this act would soothe the current US-China tension, and Chinese families would then reconsider the choice of studying abroad. Consequently, this would increase the opportunities for future talent/economic inflow.

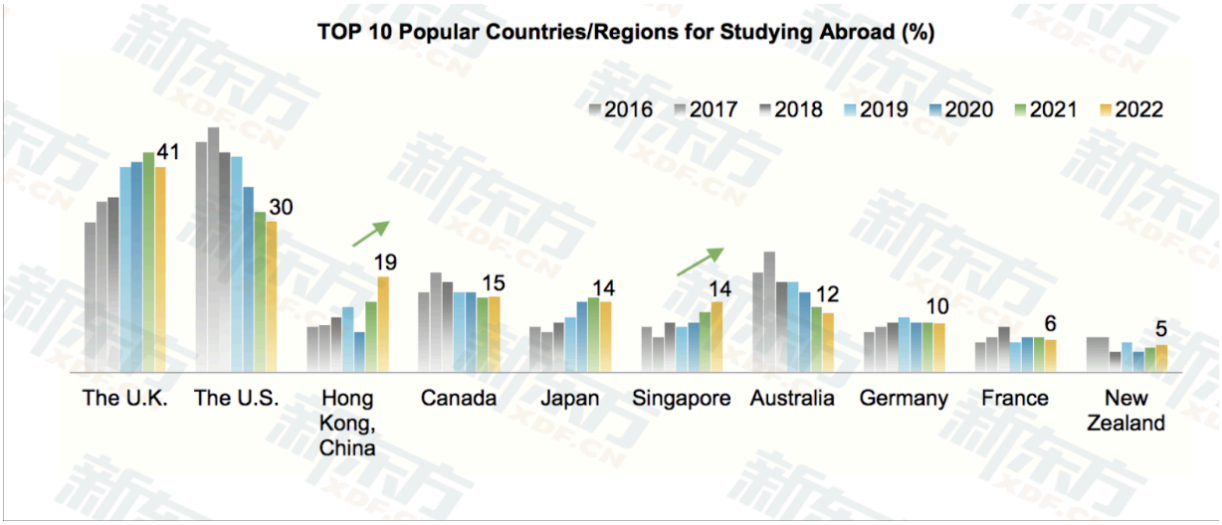
Figure 1



(Pavithra KM, 2022)

Figure 1 presents the number of international students studying in the US from the top 12 countries that originate the most international students in the US. It is seen that from 2014-15 to the 2019-20 school year, China has been the country that sends students to the US the most. In 2020-21, most of the countries experienced a covid shock, but either resuscitated in numbers such as India, or stayed at a steady number such as Canada. Instead, the only country that experienced a double dip in numbers is China. As the whole world is slowly resuscitating from the pandemic era, China's numbers are continuously decreasing which could be proven by tense geopolitical relations such as the Presidential Proclamation 10043.

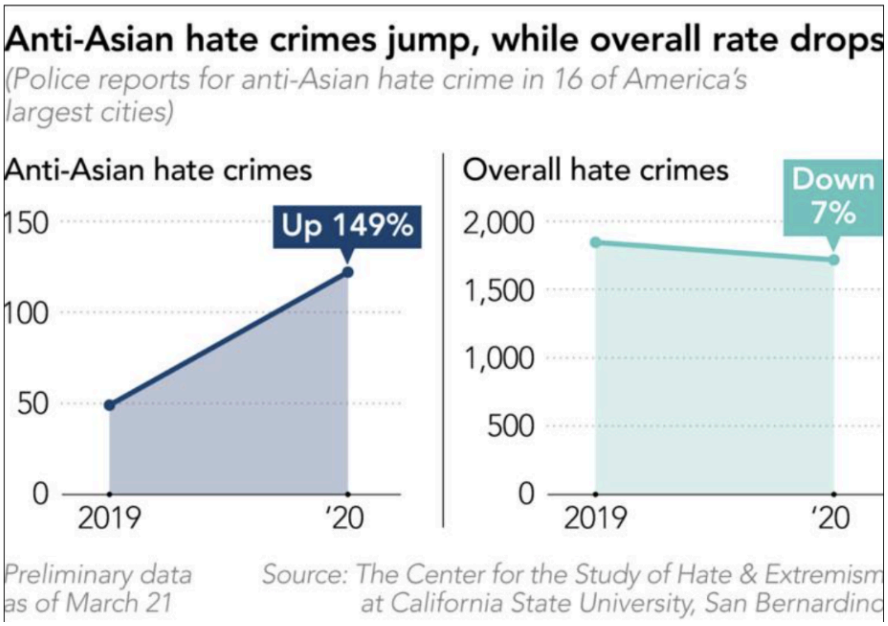
Figure 2



(Abigail Lindblade, 2022)

The second figure presents the percentage of Chinese students attending schools in the top 10 most popular countries for studying abroad. The graph presents the numbers from the year 2016 to 2022. It is clear from the graph that countries such as the UK, Hong Kong China, Japan, and Singapore have been on a steady rise, while countries such as Australia and the US are declining. Whereas other countries have been staying at relatively steady numbers. Looking specifically into the US's case, in the years 2016 and 2017 there is a steady trend rising, but starting at the year 2018 until year 2022 the numbers have continued to downslope, especially when it reaches the year 2020. This is the year when Proclamation 10043 was introduced, subsequently with the rise of political tension between China and the US. Since then, while other countries are steadily increasing in numbers, the US has continually been decreasing. This is a clear signal of talent loss and the Chinese families' changing decisions on their children's education destinations. According to the graph, in the year 2018, the UK has around 33% and the US has around 45%, whereas in the year 2022 UK has around 41% and the US has only 30%. This notable drop in numbers testifies to these social phenomenons and bears witness to the change in the US's attraction to Chinese talents.

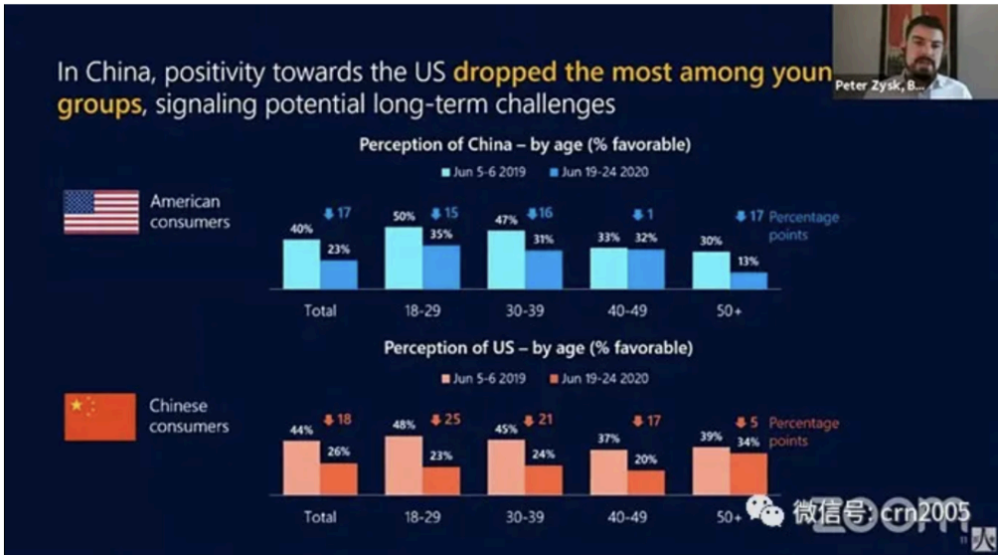
Figures 3:



(Marrian Zhou, 2021)

Figure 3 demonstrates the increase in Asian hate crimes compared to overall hate crimes. Looking into the graph on the left shows a steep climb of rising Asian hate crimes in 2019-2920 with a stunning 149%, while the overall hate crimes have been steadily dropping. This number is a clear indication of the rising hostility that the US has shown towards China, which is also a huge contributing reason to the decrease in Chinese students wanting to study in the US.

Figure 4



(Dong Ri, 2020)

Figure 4 presents the drop in the percentage of favorableness in both China and the US towards each other regarding different age groups. It is evident from the graph that both US and China had a similar total decrease in the percentage of favorableness from 2019 to 2020, but the 18-49 age group of Chinese tends to have a lesser favorability than the 18-49 age group in the US. This has resulted from some of the policies and unwelcomeness demonstrated by the US, such as Proclamation 10043, which ignited public rage from the Chinese body. The younger Chinese age group, especially the ones who frequently travel and go to school in the US, could easily sense the hostility from the US. From the data, it is clear that both countries have been drastically decreasing the percentage of favorableness towards each other, proving evidence of the tense political relations and continuous decrease of Chinese students in the US.

Policy Matrix

Current Policy: Restrict the entry of certain Chinese graduate students from enter the US by posing visa bans (Proclamation 10043)	**Advantage:** Promote national security and protect intellectual properties from being theft by other countries.	**Disadvantage:** Disrupts economic incomes, hinders technological developments, aggravates US-China relations, and contributes to future potential talents/economic loss	**Cost:** Estimation of 3,000 - 5,000 students lost per year. A 22% decrease in Chinese students from 2019-20 to 2021-22 school year, and an estimation around $1.9 billion lost from 2019 to 2020.

Alternative 1: Lower the scope of the Proclamation from all Chinese graduate students to specifically graduate students from the Seven Sons. For students who arouse suspicion from the Secretary of State that is not a part of the Seven Sons shall be agreed to surveillance on all communications	**Advantage:** Decrease in the amount of Chinese students being denied visas, more students allowed to enter the US, and resuscitating lost economic activities. Also, targeting military schools would decrease the amount of people labeling the proclamation as discriminatory.	**Disadvantage:** China might accuse the US of human rights abuses, and thus there might be potential loss of students. Furthermore, this would increase possibility of other students not from the Seven Sons university that the Department of State might omit.	**Cost:** According to Statista, the 290,086 Chinese graduate students in the US greatly differs from the 10,000+ students shown by the Australian Strategic Policy Institute. Around 280,086 would regain their rights and not be examined by the Proclamation 10043, increasing the amount of Chinese Students in the US.
Alternative 2: Make public the list of entities that arouse the suspicion of the Secretary of State, and making public of all the decision made by the Secretary of State	**Advantage:** Provide a satisfactory explanation of banning certain individuals' visas, appeasing public's discontent. Also lead to a higher quality of classification of the students. Less students would be banned by this proclamation due to errors.	**Disadvantage:** Much time, efforts, and resources will be required from the officials. Officials would need to go through every single student and provide an explanation for each.	**Cost:** Extra manpower and time would be devoted to maintain this proclamation.
Alternative 3: Reestablishing the targets of Proclamation 10043 on suspicious workers from private sectors, governmental labs, and nonprofit organizations rather	**Advantage:** Chinese students previously mistreated by the proclamation could study freely in the US. Chinese student population will increase, advancing	**Disadvantage:** Pose a threat to the number of talents in private sectors, non-profit organizations, and even governmental institutes.	**Cost:** According to CSET, nearly 90% of all research and developments occurs outside of the academia in private sectors, governmental labs, and other organizations. By

than the Chinese Student body.	technological developments, economic growth, and increasing possibility in the future inflow of talents.		targeting this group would greatly hinder the development of US's development.
Alternative 4: Repeal Proclamation 10043	**Advantage:** Chinese students are again available to freely access education in the US without risk of being banned visas. This will boost technological developments, resuscitate economic activities, repair US-China relations, and increase the chance of future talent flow.	**Disadvantage:** The US then might be exposed to the possibility of intellectual and technological theft.	**Cost:** According to CSIS, there are 224 reported incidents of Chinese espionage directed to US since 2000, where 54% sought to acquire commercial technologies, 29% sought to acquire military information, and 17% sought to acquire information on US civilian agencies or politicians. The cost will be a continuous or increased amount of Chinese espionage activities in the US.

ANALYSIS OF EVALUATIVE CRITERIA

Table 1
Evaluative Criterion Matrix

Criteria/Alternative	**Alternative 1: Amend the scope of affected groups and increase surveillance**	**Alternative 2: Make public the list of entities and the decisions by the Secretary of State**	**Alternative 3: Amend the targeted individuals as firms rather than academia**	**Alternative 4: Repeal entire Proclamation**	**Status Quo: Revoking and banning visas on certain Chinese students**

Effectiveness	Lower the scope of targeted students - 3	Lowers public discontent and increase accuracy of classifications - 3	All students can pursue studies in US without restrictions - 4	All students can pursue studies in US without restrictions - 4	Aggravate economic activities, US-China relations, and technological development - 1
Efficiency	Extra surveillance on individuals - 2	Increased usage of resources, time and labor - 1	The proclamation remains only targeted groups change - 3	Proclamation ends immediately - 4	The State of Department needs to look into every single student - 2
Cost-benefit	Possible increase or decrease in GDP but decrease in future talents - 2	Possible increase in GDP and future talents - 4	Decrease in GDP and increase in competition, but increase in potential future talents - 2	Potential increase in GDP and amend relations with China, but is susceptible to espionage - 2	Decrease in GDP and future potential talents, but protects US R&Ds - 2
Political feasibility	No support from human rights representative and denouncements from China - 1	Potential disagreements from Secretary of State - 2	Potential disagreements from certain firms and research sectors - 3	Many governments, senators, and the public will appose to this decision - 1	Resentment from the public and many prominent universities - 1
Equity	Inequitable towards the individuals surveilled, but equitable for US R&Ds - 2	Equitable towards US R&Ds but extra work created for the Department of State - 3	R&Ds are protected but firms and sectors are impacted - 2	Equitable towards the Chinese students but inequitable to towards the R&Ds - 2	Inequitable towards the Chinese students being banned - 1
Total	**10**	**13**	**14**	**13**	**7**

Results of Criterion Matrix

Looking at the results of the matrix, it is clear that alternative 3 stood out among the others as the best overall proclamation with a total rating of 14. Alternative 2 and 4, equal in their approach, tied at 13 being the second highest total, with alternative 1 to follow up at the fourth, and the status quo at the bottom with only a total of 7. The status quo is at the lowest rating of 7 because of its ineffectiveness and several negative impacts it has brought to the US. By hindering economic activities, aggravating US-China relations, and disrupting technological developments, this has disrupted its political feasibility and favor of the public. This is why it is rated at the bottom being the last on the list. Alternative 3 stood out being the best alternative because it retargets the audience from Chinese students to all researchers at different firms or research sectors. This solves all the emerging problems regarding the decrease in Chinese students such as the decrease in economic activities and hindering technological developments. Furthermore, the world will not label this proclamation as discriminatory, and it could ameliorate US-China relations because the proclamation now applies to all countries instead of China alone. This is why this proclamation stood out as being the best choice.

Opinion of Both Sides of Debate:

There are opinions on both sides of this proclamation, the ones in favor of Proclamation 10043 and the ones against it. The US government and the Department of State argue that the PLA is utilizing the military-civil fusion strategy to send Chinese students, mostly graduate and postgraduate students, abroad to acquire technological properties through nontraditional means. To prevent this, they stated that they should ban issuing visas to certain Chinese graduate students to prevent this issue. However, the opposing side was many prominent universities and professors. They say it hinders economic activities, disrupts technological developments, and aggravates US-China relations. This proclamation would cause turmoil in many areas of the US economy, but most importantly the relations with China. Trump finally signed the bill which caused a negative shock to both the US economy and their relations with China.

Conclusion and Policy Recommendation

Policy Conclusion

The Proclamation 10043 aimed to promote national security and the safety of US intellectual properties from espionage. During Trump's four years of administration, Trump accused China of intellectual property theft and labeled China as a "strategic competitor", and the tension between US and China has quickly escalated over the four years. In 2020 the last year of Donald Trump's presidency, the rising competition for technological advancement made Trump declare Presidential Proclamation 10043, which prohibits Chinese students that are associated with the PLA from obtaining a J or F visa. Immediately, discrepancies arose domestically, where some people supported this proclamation while others believed it brought harm to the US. Meanwhile, the Chinese government strongly opposed the limitations, and many students filed a lawsuit against the proclamation. Although Trump received much criticism and opposition, he focused on the safety of the US and intellectual properties instead. But in the end,

this proclamation has proved that it has brought devastating effects on the US economically, socially, and internationally.

Proclamation 10043 hoped to protect US technologies and safety, instead, it created a controversy where most people repelled it. To some extent, the proclamation may have brought benefits for the safety of the US and US technologies. However on the flip side, it has disrupted economic activities, hindered technological developments, reduced the possibility of future talent, and exacerbated US and China relations.

As the largest international student body, Chinese students have contributed to the US economy in many ways. They have contributed to the local economy through services such as housing, transportation, dining services, and daily expenditures. Furthermore, they have also contributed to the income of universities where many colleges rely on full tuition payment from international students. In addition to contributing to the economy, many Chinese students are a part of some of the leading technological developments, where many of their fields require their crucial contributions. With their expertise and talents, many US industries and research sectors would gain tremendously from their contributions. When the proclamation was implemented, many of the contributing talents were restricted from entry. All the economic activities and technological advancement promoted by these individuals have either regressed or are in a state of stagnation. Economic loss and talent loss have cost a heavy price on the US.

According to the information provided by Figures 1, 2, 3, and 4, it is clear that Proclamation 10043 did more harm than good. There is a continuous decrease in Chinese students, an increase in Chinese families' inclination to study in countries a part of the US, an increase in Asian hate crimes, and an increase in hostility between the two nations' citizens. These are all clear indications of intensifying US-China relations and talent loss, which contributes to economic loss and technological loss. To conclude, it is evident that Proclamation 10043 was a mistake. The loss of Chinese students has been proven to impact the US negatively both from a political, social, and economic standpoint.

Recommendations:

To ensure that Proclamation 10043 does not harm the economic development and talent inflow of the US, they would need to reestablish the targeted scope of this proclamation. Proclamation 10043 has restricted many students from receiving a visa and their entry into the US. Considering that education is one of the top motives to attract Chinese students to study in the US and educational sectors are one of the main economic contributors by Chinese students, the reduction of Chinese students would cause a huge talent and economic loss. Retargeting the audiences would ideally avoid restricting the entry of Chinese students and possibly positively enhance the effect of Proclamation 10043.

The final recommendation would be to amend Section 1 by retargeting the scope of individuals from academia to businesses, firms, and research centers. By retargeting the intended individuals, no Chinese students would fall under the criteria of Proclamation 10043. Hence every Chinese student, including graduate and postgraduate, can receive a visa without any restrictions. Furthermore, according to data shown by CSET, nearly 90% of all research and

developments occurs in governmental lab, research sectors, and other research organizations instead of academia. By amending Section 1 of the proclamation, it would perfectly avoid the restriction of any Chinese student's entry and enhance the accuracy of this proclamation, resuscitating the lost economy and talents.

The changes in this policy would be monitored by the Department of Homeland Security, the Department of State, and the National Institute of Standards and Technologies within the US Department of Commerce.

Even with a country as powerful as the United States, it is important to ensure a peaceful relationship with foreign countries to promote its own economic vitality and technological innovations. Proclamation 10043 and its effects are a perfect exemplification of a disturbance in the relations between two countries. For the purpose of promoting one country's development, it is crucial to establish a stable relationship with other countries and eliminate any opinions or policies that are xenophobic or discriminatory. Thus, it is paramount that the US government would need to amend Proclamation 10043.

It's time to challenge and disrupt the status quo and implement the alternatives that are the most feasible. Amending the targeted scope of Proclamation 10043 eliminates the risk of losing competitive talents in the US and secures a large group's economic and technological contributions. Even though some might argue that targeting the firms and research sectors would cause a more severe decrease in research development of technologies, considering that 90% of all research and developments are in sectors and businesses. Still, it would be a lower opportunity cost for the US to retarget because then it would secure all talents, economy, and sustainable relations with China. Furthermore, the US government could shift more of the R&D to governmental-owned research centers to lower the negative effect brought by the proclamation. For this to happen, it would require the President of the United States and many of the governmental departments to coordinate and collaborate in amending and adhering to the newly devised proclamation.

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Eco-Art: Catalyst for Environmental Action Against Global Warming By Sain Kim

Abstract

Amid the urgent call to tackle global warming, the Eco-Art Movement is a light of hope, combining art, activism, and environmental awareness. This study looks into the transforming power of eco-art therapy in promoting action against climate change. It investigates how eco-art promotes community strength, empathy, and positive transformation through case studies, theoretical frameworks, and empirical analysis.

Using an interdisciplinary approach that combines environmental psychology, art theory, and activist studies, this study investigates the role of eco-art therapy in group counseling sessions with four participants from SMA Negeri 2 Bandung. Through triangulation analysis, it investigates how eco-art therapy fosters autonomy and emotional expression.

The findings emphasize the importance of group supervision in developing empathy and resilience, providing insights for counseling educators. Integrating eco-art therapy into counseling sessions is a promising way to empower people to handle psychological issues while furthering environmental sustainability in the face of global warming complications.

1. Introduction

The need to combat global warming and its extensive effects on the globe is more crucial than ever in the modern world. It is impossible to dispute the importance of ecologically conscious art in environmental education (Ross, 2009). The Eco-Art Movement arises as a ray of hope and a driver of constructive change as we struggle with the unavoidable truth of climate change. The eco-art movement offers innovative solutions to environmental problems and works to restore ecosystems; and art activists are essential for this movement because they use their cultural power to bring attention to environmental issues (Brown, 2014). This movement offers creative ideas and game-changing viewpoints to lessen the effects of climate change. It celebrates the union of art, activism, and environmental conscience. In light of this, this study investigates the revolutionary possibilities of eco-art as a weapon against global warming.

Art is a powerful tool for raising awareness and igniting critical dialogue about environmental issues and paradoxes, regardless of whether it addresses or distances from environmental concerns (Miles, 2010). The Eco-Art Movement addresses environmental challenges worldwide, but its influence is not limited to conventional domains. This study examines how eco-art therapy can be used in group counseling sessions as a creative method, focusing on four counseling clients from SMA Negeri 2 Bandung. We investigate how eco-art therapy promotes participant autonomy and emotional expression using a triangulation analysis of observation and interview data and a comparative descriptive research technique.

The results highlight group guidance's contribution to developing empathy and resilience, providing advice, and counseling educators with crucial new information. Crucially, integrating eco-art therapy into counseling sessions offers a potentially fruitful way to enable people to handle personal struggles independently. In addition to addressing individual well-being, creative

therapies such as eco-art therapy support larger efforts in environmental sustainability as we traverse the intricacies of global warming.

1.1 Background and setting:

This section explores eco-art's historical and sociocultural setting concerning environmental action and climate change rhetoric. It recounts the evolution of eco-art, highlighting significant events, societal developments, and influences that impacted its rise to prominence as a powerful change agent. This section offers the groundwork for a more in-depth study of eco-art's role and significance in modern society by situating it within historical and sociological contexts.

1.2 Reasons for Using Eco-Art as a Climate Action Tool:

This section discusses why art is included in climate change mitigation and adaptation activities. It delves into art's distinctive communicative and persuasive abilities, focusing on its capacity to elicit emotion, provoke thought, and inspire action. Furthermore, it investigates the psychological and cognitive mechanisms eco-art encourages sustainable behavior and environmental stewardship. This section makes a strong case for exploring eco-art as part of the research by discussing the arguments for using the creative process to solve climate change.

1.3 Research Objectives:

This section outlines the research's fundamental goals and intents for eco-art to promote environmental action against global warming. These goals include comprehending the notion and evolution of eco-art, explaining its qualities and manifestations, and investigating its connections to activism, ecology, and the arts. In addition, broader objectives such as assessing the impact and effectiveness of eco-art initiatives, identifying obstacles and opportunities, and recommending future paths for the area are highlighted. By outlining these goals, this section provides a road map for methodically investigating eco-art's role to solving climate change, one of our time's most serious concerns.

This section explains the essence of eco-art, which is based on ecological concepts and environmental concerns. It investigates the numerous aspects of eco-art, such as its definition, history, characteristics, forms, and connection to activism, ecology, and the arts. This exploration provides readers with a better grasp of the complex character of eco-art and its potential as a transformative force in solving environmental issues.

2. Eco-Art

2.1 Eco-Art's Definition and Development:

The section under "Definition and Evolution of Eco-Art" explains eco-art's conceptual structure and chronological progression as a unique artistic form. Eco-art, also known as environmental art or ecological art, is a broad term for various creative practices that deal with environmental issues, topics, and procedures. Eco-art has evolved significantly due to shifting social, cultural, and ecological contexts. It began with early forms of land art and earthworks in

the 1960s and 1970s and continues with modern interventions that use recycled materials, renewable energy, and digital technology. This section delves into the various interpretations and definitions of eco-art, charting its inception as a reaction to contemporary ecological concerns and its development into an international movement that surpasses traditional disciplinary lines.

2.2 Features and Types of Eco-Art:

The section on the characteristics and forms of eco-art looks at the distinctive qualities and modes of expression that set eco-art apart from other forms of artistic expression. "eco-art" refers to a broad spectrum of media, methods, and approaches, such as interactive art, installation, performance, photography, video, and sculpture. A shared dedication to social participation, ecological awareness, and environmental sustainability unites these manifestations. By fusing natural materials, found artifacts, and recycled parts into their creations, eco-artists invite spectators to reevaluate their relationship with the environment and blur the lines between art and nature. This section examines eco-art's aesthetic, philosophical, and ethical aspects, emphasizing how it may spark thought, refute preconceptions, and motivate revolutionary change.

2.3 The Confluence of Activism, Ecology, and Art:

The section under "Intersection of Art, Ecology, and Activism" clarifies how eco-art and more significant ecological and social movements work in tandem. An effective medium for promoting empathy, increasing awareness, and spurring group action in response to environmental issues is eco-art. Eco-artists incorporate scientific research, ecological stewardship, and grassroots activism with artistic expression to address urgent environmental challenges such as pollution, resource depletion, climate change, and biodiversity loss. This section explores the connections between eco-art and political ecology, ecofeminism, environmental ethics, and other theoretical frameworks, highlighting the art form's capacity to cross disciplinary barriers and bring about significant local, regional, and global changes.

3. Case Studies of Eco-Art Initiatives

3.1 "Ice Watch" by Olafur Eliasson

Renowned artist Olafur Eliasson's "Ice Watch" is an engaging piece of eco-art that uses a tactile and immersive experience to face the harsh realities of climate change. Large blocks of ice were taken from Arctic seas and placed in public areas, where they slowly melted over time to represent the alarming rate of glacial retreat and the effects of global warming. The show "Ice Watch" challenges viewers to consider the vulnerability of our planet's ice caps and the pressing need for coordinated action to prevent climate change by bringing the palpable effects into urban surroundings. This case study demonstrates the ability of art to arouse strong feelings, increase public awareness, and motivate support for threatened ecosystems. (Eliasson, n.d.)

3.2 Art & Ecology Now

The ground-breaking study "Art & Ecology Now" examines how modern artists interact with the natural world, the environment, and ecological concerns. The book, which includes the work of 95 international artists and art collectives, presents a variety of strategies for using art to address environmental activism and climate change. It is a provocative look at how art may inspire transformation and alter perceptions regarding the natural world with more than 300 drawings. (Brown, 2014)

3.3 Random International's "The Rain Room":

The interactive eco-art installation "The Rain Room" by Random International is designed to replicate a rain shower without getting people wet. Using motion sensors and digital programming, this immersive experience challenges conceptions of control, nature, and sensory perception by creating the illusion of raindrops splitting around people as they move through the area. "The Rain Room" challenges spectators to reevaluate their relationship with the natural world and the effects of human involvement on weather patterns and ecosystems by muddying the lines between reality and simulation. This case study is an excellent example of how eco-art can encourage sensory engagement, hands-on learning, and environmental awareness. (Random International [VernissageTv], 2012)

4. The Impact and Effectiveness of Eco-Art

Eco-art effectively increases awareness, builds emotional connections, organizes communities, and inspires action in response to pressing environmental issues. Eco-art therapy can be applied in guidance and counseling (Kulsum & Siregar, 2022). This section looks at its complex impact and efficacy.

4.1 Changing Perceptions and Raising Awareness:

Eco-art challenges cultural attitudes toward environmental issues and raises awareness. Eco-artists use installations and multimedia displays to effectively express the gravity of environmental concerns, encouraging spectators to reconsider cultural norms and personal behavior in light of ecological imperatives.

4.2 Fostering Empathy and Emotional Connection:

Eco-art elicits strong emotional responses, which promote empathy and a sense of oneness with nature. Immersive experiences and compelling storytelling force viewers to confront their emotions about ecological challenges, creating togetherness and inspiring collective action for environmental justice.

4.3 Promoting Community Engagement and Action:

Eco-art brings communities together by empowering people and groups to advocate for environmental stewardship. Eco-art projects encourage varied stakeholders to join in conservation efforts by promoting grassroots involvement and collaboration while also fostering a culture of shared environmental responsibility through public engagement and educational initiatives.

5. Problems and Rebuttals:

Eco-art faces numerous challenges:

5.1 Money and Resources: The impact of eco-art projects is hampered by a lack of money, which limits their scope and duration.

5.2 Activism and Artistic Expression: It can be challenging to strike a balance between the two because too didactic techniques run the risk of offending viewers.

5.3 Cultural and Socioeconomic Diversity: Eco-art frequently ignores other viewpoints and reinforces Western-centric narratives, so it is essential to make an effort to be inclusive and culturally aware. Greenwashing and Tokenism: There are worries that specific 6.4 eco-art initiatives would put symbolism ahead of true sustainability, which could lead to charges of tokenism or greenwashing.

6. Future Directions and Recommendations

Prospective Routes and Suggestions:

6.1 Strengthening Artists and Scientists' Collaboration: By combining science's scientific rigor with artists' creative insights, fostering interdisciplinary collaboration between artists and scientists can lead to innovative approaches to addressing complex environmental challenges.

6.2 Expanding the Scope and Reach of Eco-Art Interventions for Greater Impact: Using digital platforms, strategic collaborations, and financing sources, eco-art interventions can reach a wider audience and inspire them to take up environmental causes and take action.

6.3 Integrating Eco-Art into Education and Public Outreach: Learners of all ages can be empowered to become positive change agents in their communities by fostering environmental literacy, creativity, and civic engagement through the use of eco-art in both formal and informal education settings as well as public outreach programs.

6.4 Encouraging Equity and Inclusion in Eco-Art Practices: Giving equity, diversity, and inclusion a top priority in eco-art practices entails elevating marginalized voices, honoring indigenous knowledge, and cultivating relationships with marginalized communities. This way, eco-art projects will be sure to represent and respond to a wide range of societal needs and viewpoints.

7. Conclusion

The transformative power of eco-art in motivating action against global warming is thoroughly examined in this research article. Examining case studies, theoretical frameworks, and problems provides an understanding of how art might support more comprehensive initiatives to promote environmental sustainability. Furthermore, it emphasizes how crucial interdisciplinary cooperation and creative thinking are when tackling the intricate reality of climate change.

The investigation's transformative potential in igniting environmental action against global warming is highlighted in the conclusion (8.1 Key Findings). Eco-art is a potent instrument that encourages empathy, increases consciousness, and motivates people to take significant actions toward sustainability.

8. Consequences for Research, Practice, and Policy:

To maximize eco-art's influence on social mobilization and community empowerment, it is advised to incorporate it into environmental education, public campaigns, and urban planning. Practitioners should prioritize diverse stakeholder involvement, interdisciplinary collaboration, and inclusive approaches. Furthermore, researchers should investigate novel methods for assessing these interventions to improve our comprehension of how eco-art interventions influence viewpoints and promote ecological sustainability.

8.1 Call to Action:

As stewards of the planet's future, we must fully realize the promise of eco-art. Let us embrace the creative ability of art to promote empathy, stimulate thought, and motivate action in the face of ecological concerns like climate change. Using eco-art as a catalyst for a sustainable future, let's work together to foster environmental stewardship, resilience, and collaboration. It's time to rethink how we interact with the natural world, take back the mantle of protecting it, and clear the path for peaceful cohabitation with all living things.

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From a Railway Explosion to War and Beyond: The Japanese Invasion of Manchuria By Edie Park

Introduction

In the late 1920s and early 1930s, Japan experienced both industrialization and the harsh realities of poverty and unemployment, being directly impacted by the Great Depression in the United States. Facing economic challenges such as protective tariffs imposed by the U.S., its main silk importer, Japan took the straightforward approach of engaging in wars across Asia to secure vital resources. The U.S. concurrently sought China's natural resources to pull itself out of the Great Depression. The competition for wealth between Japan and the U.S. set the stage for a complex dynamic. Amidst this political turmoil in East Asia, the explosion of a Japanese-owned railway in Manchuria, allegedly by Chinese nationalists, gave the Japanese military the opportunity to assert control. The invasion was Japan's first significant step towards expanding its power. As Japan's imperial ambitions collided with those of the United States, tensions culminated in the attack on Pearl Harbor, ultimately pulling the U.S. into WWII.

The First Sino-Japanese War

The transition to manufacturing and technological advancements is a hallmark of industrialization. As population and production increase, so does the need to obtain natural resources. Following in the steps of industrialized societies throughout the world who exhibited a need for territorial expansion, Japan looked toward resource-rich Asia to support its growing market. Its first prominent war after industrialization was the First Sino-Japanese War, where Japan fought China to demonstrate its military superiority on Korean territory. China had long been trading with Korea for its benefit, but Korea was also a strategic target for Japan because of their adjacent location and shared sea.

With tension brewing months before the war started, the Li-Itō convention was placed to enforce the withdrawal of both Chinese and Japanese troops from Korea. However, their truce was broken when, on March 28, 1894, Chinese officials assassinated pro-Japanese Korean activist Kim Ok-Kyun in Shanghai and displayed his body in Korea as a warning to others rebelling against Chinese rule. Portraying his death as the "tragic fall of an honorable activist," the Japanese media seized this opportunity to attack the moral character of the Chinese government. The situation was aggravated by the Tonghak rebellion, where the Chinese government sent troops to Korea to suppress a social revolt. When Japan sent troops to disperse the insurgency, the two clashed, and Japan sank Chinese reinforcements at sea.

Japan declared war on China on August 1, 1894. Despite its comparatively small military and fewer resources, Japan's modernized military defeated China in a mere seven months. The Treaty of Shimonoseki, issued in April 1895, proclaimed the independence of previously Chinese-ruled provinces, including Korea and Taiwan. China agreed to also concede the Liaodong Peninsula in southern Manchuria to Japanese control. This victory solidified Japan's stature and boosted its confidence, posing a threat to the Western world that would later result in a full-blown war.

Railway Explosion

Manchuria, situated in the northeast corner of China, was rich in mineral resources including aluminum, coal, and iron. In Mukden, the biggest city in Manchuria, was the infamous South Manchuria Railway Company, the heart of Japan's administrative affairs over Manchuria. Originally built by Russia in the 1890s, Manchuria's vast and rapidly expanding railway network was monitored by Chinese and Japanese military units. Its bountiful natural resources and proximity made Manchuria a key target for Japan. Following its victory in the First Sino-Japanese War, Japan held Manchuria for four decades, but fought over it once more with Russia in the Second Sino-Japanese War. Again, Japan won Manchuria, and by the early 20th century, Manchuria was a hub of Chinese and Japanese affairs.

Endorsed by the Japanese government, Japan's Kwantung army, which governed the province of Manchuria, devised a way to further secure absolute power over the region. To this end, they planted a bomb on their own railway track. However, they framed it on Chinese nationalists to face minimum resistance while using more aggressive tactics in officially dictating Manchuria. The track exploded on September 18, 1931, and alarmed the Chinese army and residents alike. Approximately 600 Chinese soldiers were killed, and most of the survivors evacuated. Thousands of residents and 9000 troops fled to neighboring regions to avoid the growing instability.

The League of Nations, an international organization established to maintain world peace, sent a delegate to investigate while acting as a neutral third party. It concluded that China and the Japanese military held equal blame. Following the investigation, the Lytton Commission, representing the League, assembled a report stating that the Japanese government "[had] no territorial designs in Manchuria" and noted a Chinese representative's statement that his government would "assume responsibility of the safety of lives and property of Japanese nationals… as the withdrawal of the Japanese troops [continued] and the Chinese local authorities and police forces [were] re-established." When the report was ratified two years later, Japan left the League to continue pursuing its political expansion plan. In May 1933, the Tanggu truce with the Nationalist government in Beijing permitted Japan to move in and control all activity in Manchuria.

The establishment of Japanese forces in Manchuria in March 1932 marked the beginning of a new chapter in Japan's imperial reign. Despite officials broadcasting a goal of unity and harmony, the Kwantung army ruled Manchuria as it pleased, using their power and resources for military objectives. To do this, they first needed to "Japanize" Manchuria. So on February 25, it was given the Japanese name Manchukuo, and a couple adjacent provinces were brought under the rule of Manchukuo state. The last Manchurian emperor, Puyi, was proclaimed the regent and later the emperor. Behind the scenes, the Declaration of Statehood, formed by a committee of high officials on March 1, rejected all ties to the Chinese government and maintained Japanese control. Puyi was used as a puppet to disguise the Kwantung army's full sovereignty over Manchukuo to minimize resistance.

It is important to note the growing discrepancy between the ambitions of the Japanese government and the Japanese military. Whereas the government wished to maintain the status quo, it was the military who pushed forward for political expansion. The different priorities between the two were responsible for the social tensions surrounding the Manchurian incident and general military campaigns. Media outlets across Japan strongly influenced public opinion during this time, telling not-so-far-off tales of the riches they would acquire if Japan became more powerful. Japanese workers and soldiers were portrayed as "heroic men with nothing but good intentions." Such sentiments and propaganda were used to gain the support of the majority of the population, and resulted in strengthened Japanese nationalism.

America in War

In several ways, conflict between the U.S. and Japan seemed inevitable. First, Japan's withdrawal from the League of Nations freed it from the diplomatic pressures of "allies" within the international organization. In pursuit of independence and to evade punishments following the Manchurian incident, Japan's Minister of Foreign Affairs, Yōsuke Matsuoka, opted to leave the League of Nations on March 25, 1933. Free from international ties and the obligations of numerous treaties it had entered since 1930, Japan could expand its military ambitions. Second, the successful invasion of Manchuria had given Japan confidence and momentum to attempt such an invasion again. Japan targeted America partly because of the economic sanctions America imposed on Japan in support of the Chinese military. With the goal of replacing the U.S. as the dominant power in the world, Japan officially joined WWII by signing the Tripartite Pact with Germany and Italy on September 27, 1940. To eliminate competition and obtain valuable American oil, Japan bombed Pearl Harbor.

WWII had raged on for two years before President Franklin Delano Roosevelt declared war on Japan. Roosevelt aimed to keep the U.S. out of the war to avoid losing countless more lives, only supporting the Allies through initiatives like the Lend-Lease program. However, American citizens were much divided on the issue of American isolationism, debating whether or not to remain neutral and to what extent the U.S. should be involved. Isolationists argued that their geographical distance from Europe made it possible to stay out of the conflict. One prominent isolationist, Charles A. Lindbergh, delivered a famous speech to the America First Committee in New York City in April 1941 titled "America First." He urged Americans to turn their eyes and faith "back to [their] own country before it [was] too late."

As Germany continued to occupy more European countries, public opinion in the U.S. gradually shifted, with an increasing percentage of citizens favoring intervention. At the outbreak of the war with Germany invading Poland, 42% of survey respondents believed the U.S. should send troops abroad, while 48% preferred to avert the war. The most extreme shift occurred in May 1940, after Germany invaded western Europe, with 93% opposing U.S. involvement. However, after the bombing of Pearl Harbor, 91% supported declaring war on Japan and Germany. The attack shattered the illusion of geographic immunity for many isolationists, marking the end of isolationism and the onset of unprecedented national unity.

Following the Pearl Harbor attack, the America First Committee immediately ceased its meetings as the nation could not evade the war anymore. As is customary in wartime, essential goods like sugar, meat, gasoline, and shoes were rationed, leading to a surge in demand for specific materials. Millions of men and women enlisted in the military, and those on the home front contributed to the war effort in various ways. The isolationist movement was replaced with a fierce, prevalent determination to get revenge on Japan and, in doing so, defend the core American values of liberty and democracy.

A Successful Ending for Some

For the next four bloody years, over thirty nations engaged in a relentless battle in the name of upholding social justice and international order. Tens of millions of soldiers and civilians had already perished, when the U.S. began developing an atomic bomb that would boost the Allies' chances of bringing an end to the war. These scientific efforts culminated in the bombing of the Japanese cities Hiroshima and Nagasaki on August 6 and August 9, 1945, respectively. The immediate aftermath saw an estimated 150,000 lives lost, with many more succumbing to illnesses induced by the bomb's lethal radiation. Within a month, Japan surrendered unconditionally and vowed to withdraw all of its troops from foreign nations.

Italy and Germany had surrendered months earlier, so Japan's capitulation marked the end of WWII. It also signified a dramatic shift in global power; Japan's formerly formidable reputation as annexer of Asia and international leader went to the U.S. This shift was concretized economically; as shown in Appendix A, Japan's Gross Domestic Product (GDP) in 1940 was $192 billion. In 1945, the GDP dropped to $144 billion. The GDP of the U.S., on the other hand, skyrocketed from $943 billion in 1940 to $1.47 trillion. This was an extraordinary victory for the U.S., which had grappled with the depths of the Great Depression merely five years ago. The military, geopolitical, and social transformations also indicate Japan's loss of power; however, just looking at Japan's and America's economy before and after WWII clearly reveals the impact this war had on global dynamics.

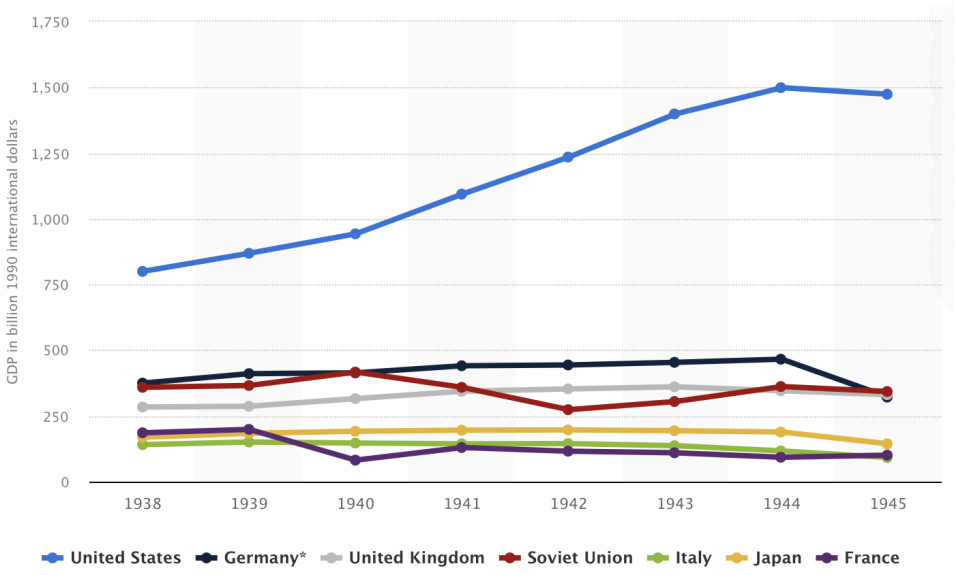


Fig 1: Estimated annual GDP of WWII's greatest powers, 1938-1945

In addition to the relation between the two countries, another noteworthy consequence of WWII occurred within the U.S. itself: a radical shift in attitude. In contrast to the uncertain isolationism prevalent among most Americans prior to the war, the victory ushered in a resolute desire among American political and economic leaders to safeguard the nation's newfound power and to firmly establish the U.S. as a global leader. That is, the U.S. witnessed a profound turning point when it emerged from the war with a heightened sense of responsibility and commitment to global affairs for its own welfare.

As for Manchuria, the Soviet Union reasserted control over the region. Premier Joseph Stalin, leader of one of the three major Allied Powers, stipulated control over Manchuria as a condition for their wartime contributions towards the end of WWII. With the agreement of other Allied leaders, Soviet troops commenced their conquest in May 1945. Despite the war nearing its conclusion, the Soviet Union declared war on Japan and invaded Manchuria on August 9, 1945. This late-stage intervention resulted in the capture of the emperor of Manchukuo, Puyi, as the Soviet Union claimed the spoils of their newly acquired territory.

In the ensuing years, the victorious Allies implemented a slew of economic, political, and social reforms, intended as punitive measures for Japan's military expansion leading up to and during WWII. However, the economic crisis Japan grappled with from 1947 prompted a reconsideration of some of these policies. The Allies then shifted their focus towards revitalizing Japan's economy to maintain economic stability. The eruption of the Korean War in 1950 alleviated the crisis, with Japan benefiting economically from the conflict. Concerns about Japan's re-emergence as a dominant power were mitigated by its confinement with American defense perimeters established in Asia to support the Korean War. In this new era, Japan's secure political and economic future prompted other nations to organize peace treaties with Japan, marking the end of its tumultuous journey for political power.

Japan's retreat from trying to occupy foreign territories, America's economic prosperity, the development and eventual settlement of international relations, the beginning of a new era of Western-ruled peace–none of this likely would have happened if Japan hadn't first invaded Manchuria, prompting them to subsequently attack Pearl Harbor, a central American naval base.

Conclusion

In his 1929 work "A Plan for the Solution of the Manchurian and Mongolian Problems as a Basic Policy to Change Our Country's Destiny," Lt. Colonel Ishiwara Kanji best summarized the Japanese perspective of why the invasion of Manchuria was the turning point that drew international attention, eventually leading to American involvement in World War II: "Japan's survival depends on a favorable resolution of the problem of Manchuria… Japan must be willing to fight America to achieve national objectives," which is what they did. The Manchurian Incident occurred two years after this was written, and the bombing of Pearl Harbor that prompted the U.S. to wage war on Japan was exactly ten years after that.

Nearly a century has elapsed since Japan invaded Manchuria, a conquest that created tensions between Japan and China that persists to this day. Japan's Ministry of Foreign Affairs acknowledges the existing concerns between the two nations, compounded by their geographic proximity. Despite their rocky past, their connection is appreciated as "one of Japan's most important bilateral relationships," embodied in close economic ties and enduring cultural exchanges. Japan's relationship with the United States is even more robust, underlined by a close defense treaty that establishes security. The U.S. maintains military bases in Japan and has actively supported Japan's membership in various organizations. Aside from "intermittent bouts of trade friction" noted by the Weatherhead East Asian Institute, trade between Japan and America has generally remained active.

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A Black Box Paradox: Would International Aid Lead to Economic Growth?
By Audrey Hengrui Zhang

Abstract

In the past decades, foreign aid has been identified as an important measure to pursue the goals of equitable global development, achieving the UN Millennium development goal. More and more multilateral and bilateral organizations have been formed on the mission of eliminating extreme poverty via international aid. However, whether foreign aid would lead to economic growth and social development has become a long paradox for decades. This essay examines the effectiveness and efficiency of foreign aid on developing nations through a hybrid methodology, combining data analytical approaches and case studies, with a focus on its impact on economic and social development. Rather than relying on the well-established database focusing on one single territory, this essay built our own database through web scraping, and first time collecting macro and micro level economic indicators as well as social and political factors. With this database, the quantitative analysis reveals nuanced relationships. Contrary to the initial hypothesis, there is no significant correlation between foreign aid provided and a country's development level. However, results show that they are more effective in countries with an established governmental and economic system, and may cause negative impacts on countries that do not have a well-built system. A case study on four African countries, Eritrea, Ethiopia, Uganda, and Somalia, further explores and verifies the conclusion. As the global community continues its pursuit of sustainable development, this research contributes insights to policy decisions of foreign aid to better improve its effectiveness and efficiency for poverty elimination.

Introduction

For a long time, eliminating extreme poverty has become the end goal for the international society. Signed in September 2000, the United Nations Millennium Declaration included the goal to free the entire human race from want, sparing "no effort to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty, to which more than a billion of them are currently subjected" (General Assembly Resolution 55/2). Entering the new era, UN Sustainable Development Goals (SDGs) also put it as first priority, which SDG Goal 1 is to "End poverty in all its forms everywhere."

However, due to different historical, geographical, social and political backgrounds, some countries become developed while some countries are underdeveloped (Ian*,* 2019*, Why do some countries develop and others not*). According to the World Bank, the GDP per capita among the most developed country (Luxembourg) is $135,000 while it is only $200 for the least developed country (Burundi). Hence, the discrepancy among rich and poor globally is huge and foreign aid is one of the important matters to eliminate extreme poverty globally via the form of financial, either cash-based or non-cash based, technical and manual transfer from developed countries or organizations to underdeveloped countries. Since the Marshall Plan and the establishment of the UN, IMF, World Bank, and other international organizations, foreign aid has become the dominant method by which countries provide aid to recipient countries through capital, goods, or services.

Most recently, more and more bilateral and multilateral organizations have been built for the purpose of international aid, such as AIIB, New Development Bank, etc. As of 2022, foreign aid covered 17,000 activities in 212 countries and regions, reaching a total of $70 billion in obligations (Foreign Assistance Data), which forms one of the most important weapons to eradicate poverty.

For long researchers have debated the effectiveness and impact of foreign aid. Some present analysis that foreign aid has a positive correlation with the economic growth under certain circumstances; Others argue that international aid corrupts the natural development of a country, and the overdependence on world superpowers leads to negative effects. Based on this paradox, this paper intends to explore whether international aid will lead to a country's economic or social growth and the mechanism behind if it leads or forms the barrier of international growth. Thanks to the computational social science, this paper uses web scraping to collect all kinds of information from public database and built a comprehensive integrated panel database, which covers countries' economic development, social well-being, political background etc., to better understand whether it would contribute to the countries' development, and use data modelling to better understand the mechanism behind. Further, this paper also provides a case study to verify the success and failure of international aid via a comparative perspective. This paper would be organized as follows: Section 2, Literature Review; Section 3, Data and methodology; Section 4 Quantitative methodology; Section 5 Case Study; and closes with discussion and conclusion.

Literature Review

Previous research on foreign aid has used diverse methods to evaluate the correlation between aid provided and growth in the recipient country. Some concluded that there is a strong correlation that the international aid would lead to a country's growth while others identify the possible negative influence from foreign aid.

Some studies concluded that foreign aid has a positive effect on the recipient countries, presenting trends of "increases in investment and growth" (Clemens 2011), as well as being "conducive to the improvement of the distribution of income" (Chong 2009), under the circumstances that "donors and recipients must obtain the necessary information to actually target and achieve desired goals" (Williamson 2010). This together leads to the positive side of international aid, which has been regarded as one of the most important factors for international development.

On the other hand, studies that oppose this claim argue that there is "little robust evidence of a positive relationship between aid inflows into a country and its economic growth" (Rajan 2005), and furthermore "aid is ineffective and perpetuates the cycle of poverty and derails sustainable economic growth" (Dambisa 2009). Different from the positive influence of foreign aid, this counter argument focuses on the lack of efficiency and proof that the foreign aid would lead to countries' growth.

These studies utilized empirical data to reach conclusions, but both only focus on discussing the economic benefit. Also, these literatures mainly rely on existing evidence to reach the conclusion, which ignores to focus on a broader question "Whether it would lead to the benefit of the citizens" and have a both macro and micro understanding of international aid. In this paper,

thanks to web scraping and data modelling, we obtained more recent and relevant holistic data from the World Bank and other official organizations to perform analysis through data science models in a more macro perspective, decoding this long-lasting paradox. Further, we also dig into the micro perspective, and verified the quantitative conclusions through individual case studies in Africa to consolidate our conclusions.

Data and Methodology

To better holistically understand whether international aid would lead to countries' development, we built a new panel database from multiple different perspectives and resources via web scraping for data collection and data cleansing afterwards, which included economic, social, and political factors. With this panel data, we can better analyze the correlation between the amount of foreign aid received for a certain country and its development level.

For the independent variable, international aid, we used Python to crawl the foreign aid amount by countries from the World Bank and built them into a panel database. In order to account for the difference in GDP volume, we performed EDA to add another variable that divides foreign aid amount by the country's total GDP. Hence, we acquire both an absolute international aid amount as well as the respective international aid amount.

For economic factors, we looked at macro-level statistics including national debt, Gross Domestic Product (GDP), and GDP growth; as well as individual statistics including GDP per capita and Gross National Income (GNI). Apart from national statistics, we further observed the interaction between nations using trade volume data. These statistics were acquired from the World Bank database. Because the raw GDP value for each country is too big compared to other values, we scaled it by taking its log value, which standardized the data and made it more proportionate to other data.

For social factors, we looked at the Happiness Index evaluated by the Sustainable Development Solutions Network, which uses global survey data to report how people evaluate their own lives.

For political factors, we looked at the corruption level of a nation's government, the Corruption Perceptions Index evaluated by Transparency International, which calculates holistic economic and political data to give a score between 0 and 100.

After web scraping assessing the data, we conducted data cleansing and merged all these data together into a panel data. In total, we have data for 107 developing countries who have received foreign aid between Year 2012 to 2020, with a total of 962 data points. The descriptive results of the data can be seen in *Table 1*. The complete dataset can be found at: Foreign Aid Global Data 2012-2020.

Table 1: Key variables in the international aid database.

	Number # of observation	Max # number	Min # number	Avg.
International aid (in billion USD)	962	116	0.00005	1.046
Aid/GDP	962	3.114	0.0000001	0.021
GDP Growth (%)	959	43.480	-36.392	3.089
Corruption	944	68	8	33.388
Happiness Index	642	7.646	2.567	4.911
Debt	962	2350000	76	59300
GNI	960	14600000	246	237000
Trade	878	347.997	0.785	72.645

Using these data, we uniquely conducted an analysis by taking the data science approach, modifying the features and selecting data to analyze correlations between different factors in different countries. This allowed us to obtain a holistic conclusion supported by evidence.

Apart from quantitative data, we also performed a case study on 4 African countries near the Horn of Africa: Eritrea, Ethiopia, Uganda, and Somalia. These countries are similar in geography and history, yet their different governing styles and attitudes towards foreign aid led to different results of economic growth and development. By keeping constant variables the same, we were able to gain a conclusion regarding whether and when foreign aid is effective.

Quantitative Analysis

After retrieving the dataset, we used Logistic Regression analysis to project whether the amount of foreign aid a country receives can contribute to its GDP growth. Also, in this model, given the hypothesis of other social and political influence, we built in the happiness index and corruption as key variables in the model.

First, the whole dataset was studied, looking at correlations within all countries. The results are as in *Table 2* Influence of foreign aid on GDP growth.

Table 2: Influence of Foreign Aid on GDP Growth

GDP Growth	Co-efficiency	SD	t	p> |t|
Log Aid	0.02	0.1	0.21	0.835
Happiness Index	-0.15	0.2	-0.73	0.464
Corruption	0.01	0.02	0.74	0.462
Constant	2.3	2.36	0.97	0.331

With a small coefficient of 0.022 and very strong p-value, this shows that within all countries, no strong correlation between foreign aid and GDP growth can be visible. This proves some theory that on all countries' level, international aid would not necessarily lead to a country's development. This might be because the span of the countries and time is too big, causing both positive and negative impacts to even out. As a result, the coefficient for total aid is not significant.

Thus, another approach was taken: to look at the data by area. For example, due to geographical and historical differences, the impact of foreign aid on countries in Asia and countries in Africa might be very different. Thus, the dataset was separated by geographical area, and grouped by continent.

```
. regress GDPGrowth logAid HappinessIndex Corruption Trade
```

Source	SS	df	MS		
Model	120.335936	4	30.0839841	Number of obs	= 243
Residual	4228.04526	238	17.7648961	F(4, 238)	= 1.69
				Prob > F	= 0.1522
Total	4348.3812	242	17.9685173	R-squared	= 0.0277
				Adj R-squared	= 0.0113
				Root MSE	= 4.2148

GDPGrowth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logAid	.1751508	.1876686	0.93	0.352	-.1945528	.5448545
HappinessIndex	.6448861	.3270724	1.97	0.050	.0005596	1.289213
Corruption	.0267365	.0266799	1.00	0.317	-.0258224	.0792955
Trade	-.0055371	.007217	-0.77	0.444	-.0197545	.0086804
_cons	-3.65272	3.611129	-1.01	0.313	-10.76658	3.461138

Figure 1 GDP and Foreign Aid: African Countries

Figure 1 presents the correlations between GDP growth and international aid in Africa. Here, a positive correlation between GDP growth and aid is presented. This also proves that international aid does have influence on a country, and its trend is more apparent when focused on more specific geographical areas, differing on a country-by-country basis. Following the trend of

GDP growth with increased foreign aid, a more positive correlation is presented between GDP growth and the Happiness Index. In other words, as the GDP increases, the Happiness Index significantly improves as well.

Apart from the geographical difference, to further study the correlation between foreign aid and GDP growth, we also zoomed into each country's different political background, i.e. the corruption index in this scenario. The most apparent difference appeared when comparing the corruption within countries.

In countries with low corruption, foreign aid does not bring significant economic improvement, yet the Happiness Index largely increases. Contrastingly, in countries with high corruption levels, not only does foreign aid not bring economic development, and furthermore, there is little change in happiness levels as well.

Thus, the effectiveness of foreign aid in terms of providing a better life for citizens of a developing country is largely correlated with its level of corruption. This can be a two-sided cause-and-effect relationship. Countries with high corruption levels are less likely to receive foreign aid from aid providers, as the communication and execution of the plans are significantly more complex. Even when they receive foreign aid, the amount that is injected into the wider society is questionable, as reflected by the trend that happiness levels do not increase, indicating low economic development. Therefore, for countries with high corruption levels, it is an urgent need to quickly reduce corruption.

Case Study

After studying the effects of international aid on African countries through quantitative analysis with holistic data, some countries will be examined closer to answer the questions: how has foreign aid impacted the development and attitude of developing countries in Africa? What's the role of foreign aid in a country's development?

To ensure that the countries are comparable, four countries with similar historical backgrounds and geographical locations were chosen: Eritrea, Ethiopia, Uganda, and Somalia. The map on the right denotes their location in red. These countries are concentrated in the Horn of Africa, most sharing characteristics like access to open water, climate, population, and more. This can help us exclude some key geo-political influence on the effectiveness of international aid.



Following the defeat of Italy in the Horn of Africa during World War II, Eritrea became a federated province of Ethiopia. After 30 years of civil war, Eritrea broke off from Ethiopia in 1991, granting the independence and power of two new governments. As of today, border conflicts still arise between these two countries. They share a similar population makeup and social structure, as well as the same geographical location and history. Yet, they have different approaches and attitudes to international aid, causing a difference in their development.

Eritrea's government is one of the most oppressive and corrupt regimes in modern history, and they accuse that foreign aid is inherently corrupt and intended to subjugate its recipients (Schrag). Some aid has been slotted to go towards the development of the energy sector, improving agriculture infrastructure. The E.U. has also attempted to follow recommendations of the U.N. to reduce the occurrence of government-perpetrated human rights abuses (Burnett). But apart from that, Eritrea has received little foreign aid. As a result, the state has experienced an "overall rise in poverty and an intense degradation of trust between civil society and government" (Schrag).

On the other hand, Ethiopia is highly dependent on foreign aid. It has received $3.5 billion from countries like Germany and the UK. Recently, the US has also launched a 5-year, $40 million program, the Health Financing Improvement Program (Kahrmann). These programs have helped Ethiopia's poverty rate fall from 44% to 30% in just 10 years (Rodriguez).

Ethiopia and Eritrea's different approaches toward foreign aid have caused a great difference in the general living qualities of their citizens. Furthermore, the difference in government styles reveals the importance of anti-corruption.

Multiple other examples support how corrupt governments have led to the ineffectiveness of foreign aid, for example, Uganda and Somalia.

Somalia neighbours Ethiopia. In 2011, the Public Management Unit announced that $30 million in government funds and $70 million from Arab donors had gone unaccounted from Somalia's treasury (Anoba). These constant changes in government have led to various economic policies that do not align with donors' priorities and there exists a lack of competence and strategic initiatives to carry out the said economic policies by successive governments.

Uganda has enjoyed benefits from foreign aid, yet its corrupt government has challenged the stability of aiding plans. Since the mid-1990s, Uganda has enjoyed an influx of foreign aid amounting to 80 percent of its development expenditures and has been the beneficiary of a number of generous donor initiatives (UNU-Wider). There is convincing evidence (Barkan, 2011) that in all sectors in general, and in the educational sector in particular only a small fraction of foreign aid reaches its intended destination, the major part being unlawfully consumed by corrupt officials, This exemplifies how corruption reduces the effectiveness of foreign aid by taking away the financial support provided. The high level of ineffectiveness of the strategy involving debt relief for Uganda is best illustrated by the fact that on one occasion "immediately after Uganda's debts were forgiven, the government bought a private jet for the president at a cost of USD 35 million" (Mwenda, 2006). This is an example of how approaches that relieve debt from a country might only result in more corruption. A substantial amount of cash entering Uganda as aid is increasing the level of demand for products and services, at the same time when the level of output of

products and services is not increasing, and this situation is blamed for a very high level of inflation in Uganda (Bilur et al., 2011). This shows how foreign aid regarding exports of goods and services might disturb the domestic market, preventing the growth of local economies.

These results from the case study are also consistent with the previous quantitative learning that international aid works more among low-corrupted countries while less function among the heavily-corrupted regime. The case of Ethiopia and Eritrea provides us with a more vivid explanation that when the government is more corrupted, as the foreign aid is a more top to bottom supporting system, it would never to the bottom. Rather, some more bottom to the top system (such as NGO, corporate based international aid etc.) might function well under these regimes, and having a stable, transparent and working political and social background has become the prerequisite for a country's development.

Discussion and Conclusion

Our analysis presents a clear correlation between lower levels of corruption and the positive impact of foreign aid on both economic development and happiness values. Also, this analysis depicts why in some countries, international aid works, while in others it does not. Therefore, to enhance the effectiveness of foreign aid, there is an imperative need to address corruption in recipient countries. Donor countries should implement mechanisms that ensure the transparent use of aid, while recipient countries should invest in strengthening government structures and combating corruption. The need for realistic and accomplishable plans that fully utilize economic resources is also crucial in the design of foreign aid projects. Another problem faced is the faster growth of population compared to economic growth, stepping into the "Malthusian Trap" and diminishing the perceived effects of foreign aid. Thus, there is also a need to increase women's education and lower fertility rates. Combined together, not only do these possible approaches maximize the effectiveness of aid, they also further contribute to fostering sustainable development.

The strength of our study lies in its holistic approach that combines quantitative and qualitative analysis to offer a comprehensive understanding of the effectiveness of foreign aid. The integration of economic as well as social-political indicators allows for a more robust analysis of complex relationships between aid, development, and well-being. However, we do admit that there might be some limitations: Lack of some data for certain years or for certain countries, only counting for data from official or governmental international aid etc., while these limitations would be addressed in the future study to provide a more holistic picture to the readers.

While our research provides valuable insights, the effectiveness of foreign aid may vary depending on regional, cultural, and historical contexts, as well as the specific type of foreign aid that is being provided. Further research can explore deeper into the specific mechanisms through which corruption affects the effectiveness of foreign aid, providing a more complete understanding of the challenges that recipient countries face. This could contribute to building more sustainable development efforts. The role of cultural and historical factors can also be researched to enhance the applicability of our findings across more diverse regions and provide targeted policy recommendations.

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World Bank, GDP.

World Bank, GDP Growth.

World Bank, GNI.

World Bank, International Debt Statistics.

World Bank, Net Official Development Assistance and Official Aid Received.

The Battle Against Smallpox: Expanding the Narrative beyond Edward Jenner

By Jiyu Hong

Abstract

This article sheds light on the networks of women and colonial administrators that contributed to the ultimate eradication of smallpox, a lethal disease dating back to 1350 BCE Egypt. Working with the premise that the wide-scale vaccination of the people is as important as the discovery of the vaccine itself, this paper proposes to push beyond the familiar narrative that takes us back to Edward Jenner, the physician credited to have invented the first smallpox vaccination. This paper argues that the fight against smallpox cannot be solely attributed to the single individual that discovered the vaccine. Many individuals and institutions were involved in realizing a wide-scale campaign to build herd immunity, and we must examine the forces that enabled its wide adoption. In making this case, I closely examine the role played by women in Britain and the local administrators of the Spanish Empire, and their use of local knowledge and networks to ensure the wide vaccination of the people. These are just two examples of the countless individuals that contributed to the historical battle against smallpox. Besides all the lives it saved, the discovery and enactment of small-pox vaccination is significant in that it imparts a key lesson: no great deed in history is accomplished by a single hero alone.

Introduction

Smallpox is a deadly old scourge with a long history. Strains of smallpox have been traced back to as early as 1350 BCE in Egyptian mummies (“History of Smallpox Vaccination”). The earliest recorded cases date back to 4th Century China and 7th Century India (“History of Smallpox”). Over the many thousand years of its existence, smallpox is said to have indiscriminately ravaged populations all around the world, leaving hundreds of millions dead or disabled in its wake. Absolutely no one was safe; the rich, the poor, children—everyone was a victim regardless of age, gender, race, and class. In fact the blight was so devastating that it is recorded to have killed one in every three people infected (Jerry 2023). Symptoms of the disease were extremely gruesome. Infections led to high fever, vomiting, and mouth sores. This, however, was only the beginning. Soon, multiple pus-filled lesions would spring up all over the patient's body—even their lungs!—and a painful process of death followed. Those lucky enough to survive found it impossible to return to their previous life, as they were often left with permanent disabilities like blindness (Riedel 2005).

The World Health Organization’s 1980 declaration of smallpox’s “complete” eradication announced the end to this long historic battle and marked a watershed in the history of public health. In fact, smallpox is “the only infectious disease to achieve this distinction” (“History of Smallpox”). How did we get here? This paper examines the history of humanity’s struggle against a deadly epidemic, and the work of countless individuals and institutions that carried the battle to victory. As we shall see below, part of the story involves a physician named Edward Jenner. Many authoritative sources—from the Centers for Disease Control to the Encyclopedia

Britannica—all point to Jenner, who is invariably credited for having "invented" the method of vaccinating a small dose of cowpox to help build immunity against smallpox in May 1797.

However, the eradication of smallpox cannot be credited back to a single man alone. Vaccines were experimented by Jenner but also by his contemporaries—and perhaps more importantly, there were endless networks of people involved in spreading the knowledge and ensuring acceptance and promotion. This paper points to two such endeavors: the role of women and women's networks in motivating other mothers in Britain to have their children vaccinated, and local emissaries of the Spanish Empire like Joseph Flores who built on the local knowledge of indigenous communities to refashion vaccinations as part of a popular religious ceremony. While it would be great to identify a clear, singular turning point in the fight against the scourge of smallpox, the truth is that its eradication was achieved through the sustained contribution of countless individuals throughout history.

I. The Traditional Narrative: Jenner's Discovery

Early forms of treatment were ineffective to say the least. Treatments ranged from placing people in hot or cold rooms, a strict anti-melon diet, tightly wrapping patients in red cloth, and most bizarrely, intoxicating the patient with twelve small bottles of beer every twelve hours (Hollingham 2022). One of the more successful early attempts to treat smallpox involved a procedure known as variolation, which involved injecting smallpox cells from infected individuals into healthy ones; it was found that variolation cut death rates from 30% to 1-2% ("Smallpox: Variolation"). However, variolation came with risks. When it failed, variolation caused wide epidemics throughout society. Many were victims of variolation, including King George III, who lost his son through this procedure (Ibid.). The world was in desperate need of a better solution.

A critical date was 1796, the year the world's first vaccine was "officially" discovered. The success can be credited to a doctor in the small town of Berkeley in Gloucestershire named Edward Jenner. Jenner's experiments first began when he started to notice that almost all milkmaids seemed to be unaffected by smallpox (Jerry 2023). Jenner hypothesized that the cowpox, which milkmaids would have been exposed to almost daily while milking the dairy cattle, was somehow "protecting" these maids from ever getting smallpox. This hypothesis was not so far-fetched, as for many years Jenner had heard countless stories about milkmaids who had survived cowpox (Riedel 2005). So Jenner developed a theory: if cowpox did indeed make one immune from smallpox, then perhaps deliberately infecting healthy people with a small dose of cowpox could help build "shared immunity" (Hollingham 2022). In 1796, after gathering some circumstantial evidence from farmers and milkmaids, Jenner decided to try an experiment.

In order to test this theory, Jenner inoculated an eight year old boy with the cowpox sore from milkmaid Sarah Nelmes ("History of Smallpox"). The boy began showing mild symptoms of smallpox including high fevers, occasional vomiting, and the loss of his appetite. However, after a little more than a week, the boy was found to be back in full health. Jenner then injected the boy with smallpox. As the hypothesis suggested, the boy showed no smallpox symptoms.

Later Jenner tried again, this time injecting the boy with smallpox twice. Yet again, Jenner wrote in his treatise, "no disease followed" (Jenner 1798). The cowpox cure had shielded the boy from smallpox, and later Jenner would coin the term "vaccination" to describe this process. The name finds its roots in the Latin word for cowpox, or "vaccinia" (Jerry 2023).

Jenner enthusiastically presented this momentous solution to the British Royal Society in 1797, only to be politely rejected (Riedel 2005). Feeling that society would never know of his findings if he didn't take matters into his own hands, Jenner gathered more evidence and published a small book that detailed his discoveries and titled it *An Inquiry into the Causes and Effects of the Variolae Vaccinae* (Jenner 1798). The treatise is one of the most important publications in the history of mankind, for it was directly responsible for the promulgation of the idea of vaccination. Despite errors and controversies, the idea and practice of vaccination spread rapidly, first to London, and shortly thereafter, to the rest of the world (Riedel 2005).

II. The Jenner Narrative

The narrative of humanity's fight against smallpox invariably features Edward Jenner. As writer Jonathan Jerry points out in a McGill University publication, this is the story exposed and related by many prominent institutions. "This tale is so good," Jerry writes, "it can be found on authoritative websites, like the Centers for Disease Control's and Encyclopedia Britannica's. St. George's University of London and the London School of Hygiene and Tropical Medicine both put forward the yarn as canon in the history of vaccines (as does Pfizer!), and we find it repeated in Forbes and the Guardian" (Jerry 2023). Jerry writes in a tone of outright denunciation in calling this narrative a "boldfaced lie." He points to others like Benjamin Jesty, who used material from cow utters to vaccinate his wife and children way before Jenner discovered it.

Many scholars are in agreement with Jerry, and there is growing recognition of Jesty as the first historical figure to attempt the method of vaccination. In fact, there is data that takes us to others before Jesty. Professor of Pathology Stefan Riedel, for instance, observes that "the use of smallpox and cowpox was widely known among the country physicians in the dairy counties of 18th-century England" (Riedel 2005). However, even while inviting us to look beyond Jenner and Jesty, Riedel still argues that we must give Jenner due credit. "The recognition of these facts should not diminish our view of Jenner's accomplishments," Riedel writes. Jenner may not have been the first to "discover" vaccination, he was the first to "confer scientific status on the procedure and to pursue its scientific investigation" (Ibid.). Indeed, Jenner worked relentlessly to confirm his theory about the effectiveness of vaccination; he conducted a nationwide survey, and even included positive control to his research.[259]

Jerry is right in pointing out that we must expand beyond Jenner. However, Jerry is mostly preoccupied with finding the first person to have discovered the vaccine. However, in tracing the vaccine's origins, we risk losing sight of the broader forces that were critical in the

[259] For studies that point out the questionable ethics behind Jenner's choice of subject for his experiments, see Davies, Hugh. "Ethical Reflections on Edward Jenner's Experimental Treatment." Journal of Medical Ethics 33, no. 3 (2007): 174–76.

vaccine's wide adoption. This paper argues that we must expand our horizons to take a closer look at broader social forces and networks that enabled the vaccine's acceptance and promotion.

III. Expanding the Narrative beyond Jenner

The biggest hurdle in the wide adoption of vaccination after its discovery was the attitude of society. How to reach, convince, and motivate the population worldwide to accept vaccination? The idea of compulsory vaccination that injects material from a cow was quite controversial, and people began hiding from vaccination teams (Parker 1996). Many religious zealots even proclaimed smallpox to be punishment by god, and feared that trying to fight against it would bring about his wrath. Others even began circulating rumors that "people would turn into cows," a not so shameless pun ("History of Smallpox"). Even medical practitioners like Benjamin Moseley expressed strong concerns about infecting children with animal matters, and launched a tirade against what he considered to be the "cow mania" of his contemporaries (Moseley 1800, 184). Even after having discovered the virus, medical researchers and government officials could not enact a wide-sprad vaccination campaign on their own. They needed help.

Role of Women and Women's Networks in Britain

Smallpox was of critical interest to women, as it was by and large mothers who took up the role of actively informing themselves of new treatment methods and caring for children through the disease. However, when it comes to variolation, women do not often feature in the historical accounts. Granted, there is continued reference to Lady Mary Wortley Montagu and her role in promoting variolation in the 1720s. The wife of the British ambassador in Constantinople, Lady Mary Worteley Montagu is widely credited to have imported Turkish variolation methods into English Culture. She made the decision to inoculate her son in 1718 and her daughter in 1721 while her husband was away, and took up the role of spreading the practice in aristocratic circles.[260] However, besides Lady Mary Wortley Montagu, there is little discussion of female activism in the literature, a neglect that can partly be explained by the scattered and anecdotal nature of the source materials involving women.[261]

The vaccination movement in early 19th Century Britain is different. As historian Michael Bennett points out, Jenner's endless dedication and continued promotion of vaccination has left a great body of textual evidence—especially letters—that sheds light on the attitudes and involvement of women towards the newly proposed method. To borrow Bennett's eloquent

[260] There is continuous reference to Lady Mary Wortley Montagu's contributions since the 1950s. See for example, Genevieve Miller, The Adoption of Inoculation for Smallpox in England and France (Philadelphia, 1957); Robert Halsband, "New Light on Lady Mary Wortley Montagu's Contribution to Inoculation." *Journal of the History of Medicine and Allied Sciences* 8, no. 4, 1953; Diana Barnes. "The Public Life of a Woman of Wit and Quality: Lady Mary Wortley Montagu and the Vogue for Smallpox Inoculation." *Feminist Studies* 38, no. 2, 2012.

[261] To cite one example, the role of women in experimenting with variolation is not mentioned in comprehensive study by Sarah Knott and Barbara Taylor ed., *Women, Gender, and Enlightenment.* Basingstoke, 2005.

encapsulation, a close survey of these correspondences demonstrate that "women were crucial to the rapid establishment of the new practice: as mothers with experience of smallpox and cowpox; as discerning customers and disseminators of medical knowledge; and as activists, in terms of both patronate and practice" (Bennett 2008, 497).

Jenner was part of a circle of powerful and influential women, and messages about the new smallpox cure spread through networks of family and friendship. Jenner's marriage to Catherine Kingscote was critical in establishing these connections, and Jenner's role as physician at the Berkeley Castle and his practice in the spa-town of Cheltenham in 1795 gave him an additional foothold in society that proved favorable to the vaccination movement (Saunders 1982). King George III made a five week visit in 1788 'set the seal' on the spa-towns' popularity of the town, bringing together a wide array of visitors from all across the country. Jenner practiced in this world of polite sociability, and this setting enhanced the wide circulation of information.

Members of the aristocracy, with women often in the lead, accepted the practice into their families and shared it within their spheres of influence. Records show that the first woman of rank who made the decision to arrange a vaccination was Lady Frances Morton (Baron 1827). Other women shared information with their daughters and played a role in lending credibility to the practice. For instance, Frances Lady Jerningham wrote to her daughter Charlotte Lady Bedingfield on March 26th, 1802:

> The Cow Pox appears to be in universal Practice, and I believe that Doctor Jenner is going to have a premium from Parliament for having discovered so useful a muzzle for the Dreadful Disorder all men are sentenced to have in the smallpox. Doctor Nikol advises it, and so does Pritchard, so that I give up my first prejudice against it and hope that it is a Blessing almighty God has permitted shall be now discovered ("The Jerningham Letters" 1896).

In spreading news of the new cure, Lady Jerningham does not fail to cite authority figures like the Parliament and prominent physicians in support of the method.

If certain female activists worked to influence their family members, others like Jane Marcet built on the fame she achieved through her book *Conversations on Chemistry, intended more especially for the Female Sex* (1806) to play a more public role in the support for vaccination (Fisher 1991, 189). Marcet was not unique in this endeavor. Pamphlets, written by both women and Jenner flourished during the early 1800s. In a letter to her sister, Jane Austen describes how two women at her latest social gatherings read aloud Jenner's pamphlets to others over tea (Le Faye 1995). Within a few decades, discussions of vaccination and its effectiveness were widely discussed in books like *Companion to a Frugal Housewife* (1837) by Mydia Maria Frances Child. Through their social networks of patronage, women of nineteenth century Britain informed themselves of the procedure, made proactive decisions whether to vaccinate their children, and publicly promoted the practice to other households.

Some women even took up the procedure in their own hands. Jenner's first biographer Lord Baron observes that a woman named Mrs. Gooch vaccinated others in the parish of

Hadleigh in Suffolk using the cowpox vaccine supplied from her sister Lady Peyton (Baron 1827, 381-382). Jane Austin's mentor, Mrs. Lefroy is also said to have vaccinated over 800 individuals "with her own hand," and a young woman from Monmouth vaccinated over 1,600 children "without a single failure" (Baron 1827, 362). These women actively exchanged letters with Jenner, asking for advice and sharing their findings. While indeed Jenner is the protagonist of Baron's biography, endless women feature in the story. The work of disseminating vaccination was by no means limited to the elite. Women like Mrs. Cox of Damsels in Gloucestershire worked to distribute lymph samples and vaccinate the poor in the Painswick parish. So many female activists were involved that a physician named Dr. Lettsom observed that by 1805, "ladies of rank have alone vaccinated 30,000" individuals (Lettsom 1806, 16).

The rapid pace and extensive scope of the vaccination effort unveil a previously overlooked aspect of British women's mobilization in eighteenth to nineteenth century British society. We see that the women wielded significant decision-making power over their children's health, and built on key networks to shape public discourse. The new vaccination movement truly harnessed the energies of those who sought to play a larger role in the family and beyond the domestic sphere (Bennett 2008, 510). The involvement of women crossed the private-public divide, and sheds light on what Irene Brown calls the emergent 'rational domesticity' of early modern Britain (Brown 1982).

Role of Local Knowledge Networks on the other side of the Atlantic

Soon after Jenner made his discovery, news of it would spread all over Europe. King Charles IV of Spain heard about Jenner's achievement, and helped spread the practice around the world. In 1803, a royal vaccination expedition was launched. Dubbed the Real Expedición Marítim, the expedition sailed a ship that carried twenty-two children with the cowpox virus. From 1803 to 1806, the ship traveled through Spanish colonies in Central America, South America, and eventually crossed the Pacific to reach the Philippines (Hollingham 2022). This was the world's first vaccination campaign, and bore many modern features like central planning and the deployment of specialized staff. Each city was divided into smaller regions, and each region was led by a team of licensed medical professionals, governmental officials, and citizen leaders (Mark and Rigau-Pérez 2009). The vaccination began with a census, the establishment of a temporary hospital for vaccine injection, and the care of the ill.

However, the execution of this plan was not always easy. The Spanish expedition faced increasing difficulties in rural areas with large indigenous populations. Just as in Britain noted above, the locals in rural areas questioned the effectiveness of the vaccine as well as the safety of the procedure. The Real Expedición Marítim needed a different approach. Historian Martha Few points out that when on sea, the circulation of smallpox knowledge "built on regional trade and mail networks across oceans." And on land, the vaccination process "relied on religion and religious conversion networks and personnel" (Few 2010, 537). Few's discussion of the latter is particularly fascinating, as she demonstrates with vivid detail that the empire-wide vaccination

expedition would not have been possible without the experience of individuals who had amassed great working knowledge with indigenous communities.

One example is Jose Flores, a medical physician with extensive experience with the natives in Guatemala during the epidemic of the 1780s and 1790s. He understood the central import of religion in the Mayan community, and argued the expedition campaign should be "adapted to the nature [*naturaleza*] and diet of the Indians" (Ibid., 535). Quickly noticing the limits of the Spanish Expedition's "forced" vaccination method, Flores built on his knowledge of the locals and framed vaccination as a highly regarded religious event. To begin with, Flores proposed to link vaccinations to baptisms to ensure that they took place. The 'rite' of vaccination was depicted as important as more traditional rites like baptism and marriage:

> During this act [of vaccination], the acolyte or altar boy should light a candle, and the parish priests should dress in his surplice [sobrepellis] and stole [estola], then bless the child and say a prayer. Then to conclude, the parish's medical physician, or the person named to be the vaccinator, will vaccinate the child, and the priest will say another prayer [deprecación]. Remind the godparents that they need to bring news when the child recovers from the vaccination, so that his name can be placed in the parish vaccination book (Few, 535).

The Vaccination Book, to be maintained by the priest along other parish books of baptisms, marriages and deaths, elevated the status of the vaccination rite. Flores further recommended placing the vaccine fluid in the same chamber as the holy water, further cementing its importance in the minds of the religious locals (Ibid.). These mechanisms gave vaccinations the religious legitimacy to convince the natives, and also served as a method of ensuring that the vaccinations took place.

Cultural and religious values played a key role in the success of the empire-wide vaccination campaign. While such vaccination campaigns did have measurably positive health effects, we must keep in mind that this was indeed a coercive process, one that reinforced the hierarchies of power between the colonizer and colonized. The religious conversion networks and local knowledge emerged from the lived experience of Spanish colonial administrators, and they helped sustain the Spanish empire and its imperial healthcare policy.

III. Conclusion

In 1980, The World Health Organization declared the smallpox as completely eradicated. The smallpox vaccine is one of humankind's greatest inventions, and the critical role played by Edward Jenner is not to be neglected. It is critical, however, that we do not solely attribute this watershed moment in history to Jenner, for the widespread inoculation of the vaccine was as important as the discovery of the vaccine itself. This latter was enabled by Jenner and his contemporaries, who built on local knowledge and personal networks to convince those around them to participate in the nationwide and global-scale vaccination campaign.

Besides having pacified the oldest scourge in history, the smallpox vaccine has a broader significance. It was the world's first attempt at world-wide disease control, and became the

bedrock for modern immunology. The smallpox vaccine also had extensive political import. It occasioned moments of rare solidarity between former enemies that set aside differences to fight against a common woe. In 1811, Jenner was elected as a foreign member of the Institute of France despite being an Englishman during a period of almost continuous war between England and France. As Jenner himself observed in a letter to the National Institute of France, "The sciences are never at war" (Hotez 2001). In the mid-1900s, the smallpox vaccine was again the source of collaboration between the United States and the Soviet Union. An unprecedented instance of global unity emerged during the WHO's Smallpox Eradication Programme, when the rival Cold War nations worked side-by-side to enable key technology transfers ("History of Smallpox Vaccination"). The eradication of smallpox marks a triumphant achievement in both medicine *and* politics.

The history of vaccination illustrates in vivid detail that if we set aside our differences, we can achieve great feats. Perhaps more importantly, it also demonstrates that however small it may seem at first glance, every individual's role is critical in building a future together. The paper seeks to highlight the achievements of men and women who have not been given the full credit that they deserve in the fight against smallpox. It pluralizes the story of the world's first vaccination, and how everyday knowledge and networks were critical in changing the global frontier in medicine, science, and politics. The stories we decide to tell shape how we view the world.

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Link between Personality and Music Genres By Lil Ogano

Abstract

Music is a universal language that has helped shape cultures, generations and identities. It has a great power to influence our behaviours and our relationships with others. From classical symphonies to modern pop, the variety of music genres reflects the complex tapestry of human behaviour and individuality. While everyone's experience with music is subjective and different, recent research has begun to explore the intriguing connection between an individual's musical preferences and their personalities. Learning about the connection between music genres and preferences can be knowledgeable as it can provide us with psychological insights and deeper cultural understandings.

Previous research

There has been a previous study done on the relationships between music genres and personality traits in 2010 by Professor Adrian North of Heriot from Watt University. He asked more than 36,000 people in more than 60 countries to rate more than 104 different musical styles. They were required to fill out the Big 5 (openness, conscientiousness, extroversion, agreeableness and neuroticism), which determined their personality traits for their study. The results showed that there was a correlation between personality and music preference which are shown below.

- Blues: high self-esteem, creative, outgoing, gentle and at ease
- Jazz: high self esteem and creative
- Classical; high self-esteem, introvert and creative
- Rap; high self-esteem and outgoing
- Opera; high self-esteem, creative and gentle
- Country & Western; hardworking and outgoing
- Reggae; high self-esteem, creative, not hardworking, outgoing, gentle and at ease
- Dance; creative and outgoing, but not gentle
- Indie; low self-esteem, creative, not hardworking and not gentle
- Bollywood; creative and outgoing
- Rock/heavy metal; low self-esteem, creative, not hardworking, not outgoing, gentle and at ease
- Pop; high self-esteem and hardworking
- Soul; high self-esteem, creative, outgoing, gentle and at ease

Another study, published in the Psychology of Aesthetics, Creativity and the Arts in 2010 had researchers examine the connection between the Big 5 personality traits to music preferences. They had 100 volunteers who were asked to rate 20 different music tracks, those who identified as extroverts had a natural preference for happy and upbeat music like rap and pop.

Purpose

I carried out my own study on 100 people in my school, from age 13-59 to determine if extroverts are more likely to listen to pop and jazz compared to introverts. I think this will be the outcome as according to the study published in the Psychology of Aesthetics, Creativity and the Arts, extroverts have a preference for happy upbeat music such as pop and jazz.

The variable being investigated is the music genre preferences in extroverts and introverts. The first variable I chose to analyse was music genres preferences, I chose to investigate the genres of pop, rock, country, classical, jazz and indie. The reason I have chosen to investigate those genres is because they are very broad and basic genres that most people have already developed preferences or non-preferences for. The categorization I have chosen is extrovertness, extroverts compared to introverts. I have chosen this categorisation as I want to investigate the correlation between music genres and personality traits. The reason I have chosen extrovertness as my variable is because extrovertness is a big part of personalities and identities and is one of the easier personality traits to measure accurately. The reason investigating this connection between music genres and personality traits is significant is because it provides several important implications such as psychological insight, cultural understanding, therapeutic applications and marketing behaviour. Music preferences can bring valuable insights into an individual's personality traits and emotional states, this can help therapists to encourage positive behaviour through certain music genres. Music is also deeply rooted in culture, reflecting societal norms and beliefs, it can help foster appreciation of culture and discover differences and similarities with other cultures.

Method

1. A google form was set up and sent to students and teachers around the school
2. All participants consented for their responses to be used without their emails being collected
3. Participants take the MBTI quiz which gives a personality description which they enter in the form (eg. extrovert for ESFP, introvert for ISFP)
4. Form surveys participants on age, gender and extrovertness based off the MBTI test
5. 45 seconds clips of 6 songs from different genres are listened to with a blank screen
6. The participants then rate each song out of 5 (1 - least liked, 5 - most liked)
7. Calculate the average rating of each genre for extroverts and introverts and record the results in a table (Table 1) and create a graph
8. P-test data to check for statistically significant differences (Table 2)

The songs I have chosen for this investigation have been controlled so they are not radio-played songs as many people create bias towards songs overplayed by the media. When listening to songs, participants are not given the name of the song or artist name to help prevent bias.

1. Pop - ‘Nonsense’ by Sabrina Carpenter
2. Rock - ‘American Girl’ by Tom Petty
3. Country - ‘Humble and Kind’ by Tim McGraw
4. Classical - ‘Beethoven Symphony:No. 2 Op.36’ by Beethoven

5. Jazz - ‘From The Start’ by Laufey
6. Indie - ‘Blue Hair’ by TV Girl

Results

Table 1: Average Song Genre Ratings changes Between Extroverts and Introverts

Average Song Genre Rating (3sf)	Pop	Rock	Country	Classical	Jazz	Indie
Introvert	2.04	1.73	2.13	2.63	2.95	2.79
Extrovert	2.34	1.75	1.84	2.55	2.93	3.16
Differences	0.30	0.02	0.29	0.08	0.02	0.37

Graph 1: Average Song Genre Ratings Changes Between Extroverts and Introverts

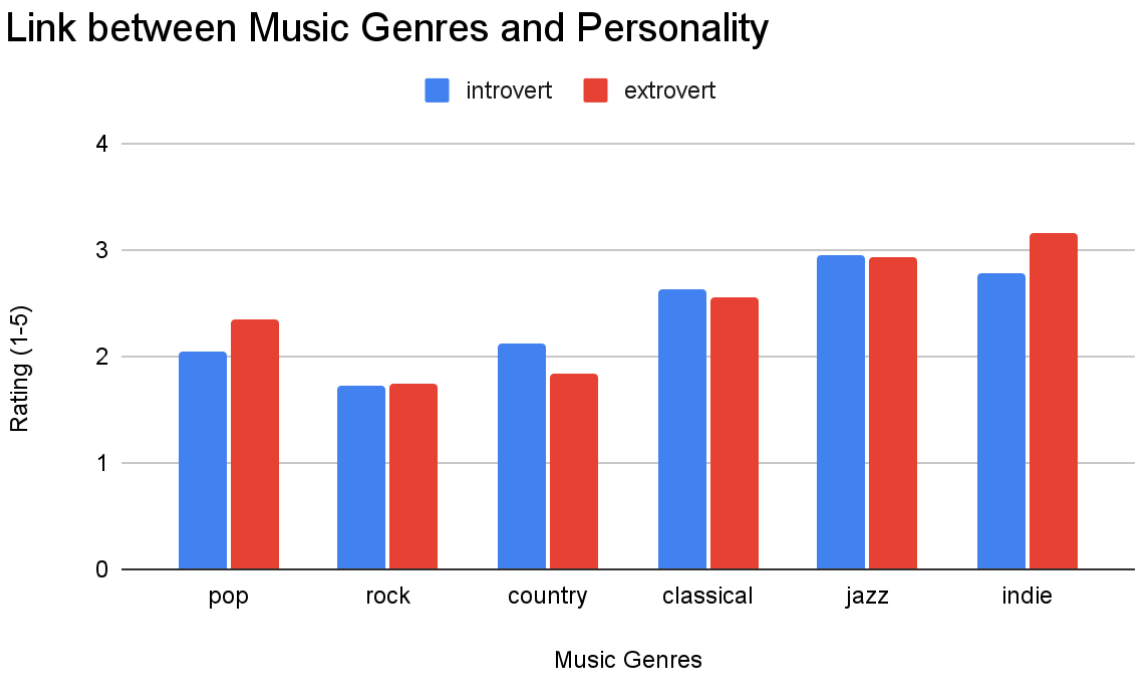


Table 2: P- Values of Average Song Genre Ratings changes Between Extroverts and Introverts

Music Genre	Pop	Rock	Country	Classical	Jazz	Indie
P-test value	0.052734	0.465028	0.086614	0.394746	0.479198	0.083537
Result	Significant as	Insignificant	Insignificant	Insignificant	Insignificant	Significant as

	$p < 0.10$	as $p > 0.10$	as $p < 0.10$	as $p > 0.10$	as $p > 0.10$	$p < 0.10$

Conclusion

The main objective of this experiment was to find a link between music genres and personality by having extroverts and introverts rate 6 different songs from different genres. In my experiment, there were 100 participants, 87% of the participants were aged from 13-14 while the other 13% were aged from 15-59. Most of the participants were females (57%) compared to males (42%) and 44 were extroverts compared to 56 were introverts. The distribution of ratings in each genre were all skewed. In the pop, rock, classical and country genre, more than 50% of the ratings were 1s and 2s. While the jazz genre had more evenly distributed ratings and as well as the indie genre apart from its clear mode of 3. These low ratings especially in pop, rock, classical and country may not be due to the genre and extrovertness but rather the songs themselves.

The results showed very little differences in ratings of songs between extroverts and introverts. All ratings had a difference of less than 0.38, however my P values suggest that some of the differences in ratings are relevantly significant. The rock, classical and jazz genres showed no statistically significant differences as all their P-values were greater than 0.10 which was my significance level. However the pop, country and indie music genres had P-values that suggested their differences were statistically significant.

The smallest P-value we found was for the pop genre at 0.0527 (3sf) where the introverts had an average rating of 2.04 while extroverts had an average rating of 2.34 (0.3 difference). The P-value suggests that the differences of ratings between extroverts and introverts in the pop genre is relevantly significant to suggest that extroverts are more likely to listen to pop than introverts in my sample. However genres like jazz had P-values of 0.479 (3sf) which is greater than 0.10 therefore showing no statistical significant difference between extrovert and introvert ratings for jazz for this sample. This insignificant difference is also shown by introverts rating the jazz genre 2.95 while extroverts rated it a 2.93 which is only a 0.02 difference in ratings.

My aim was to determine if extroverts are more likely to listen to pop and jazz compared to introverts. In conclusion, my results showed that there were no significant differences in the ratings of jazz however there were significant differences in the ratings of pop. My aim was not fully supported as jazz had a P-value of 0.479 (3sf) which is greater than 0.10 making the difference in jazz ratings insignificant. This means extroverts were not more likely to listen to jazz compared to introverts in my sample. However, my aim was still supported by my pop results as in the pop genre the P-value was less than 0.10, my significance level. This suggested that extroverts were more likely to listen to pop compared to introverts in my sample.

Other implications that were made by my results were that the country genre was more preferred by introverts than extroverts in my sample. This is shown by its P-value of 0.0866 (3dp) being less than my significance level of 0.10 as well as a difference of 0.29 in average ratings. Another implication that was made was that the indie genre was more favoured by

extroverts than introverts in my sample. This is shown by its P-value of 0.0835 (3dp) being less than my significance level of 0.10 as well as a difference of 0.37 in average ratings.

Discussion

My hypothesis was both approved and disapproved. My hypothesis was that extroverts are more likely to listen to pop and jazz compared to introverts. My results showed there was not statistically significant difference in ratings between introverts and extroverts for the jazz genre due to its P-value of 0.479 being greater than 0.10, my chosen significance level. However my results did suggest that there was a statistically significant difference in ratings for the pop genre as its P-value of 0.0527 was less than 0.10. This meant my hypothesis was disapproved as extroverts are no more likely than introverts to listen to jazz in this sample. However, it was also approved as extroverts were suggested to be more likely to listen to pop than introverts were in this sample.

My results showed no clear relationship between certain music genres and personalities while other genres did. Rock, jazz and classical music showed no statistically significant differences to demonstrate a relationship between music genres and personalities in this sample. However, other genres like pop, country and indie had statistically significant differences to suggest a relationship in my sample. According to my P-values, extroverts were more likely to listen to pop and indie than introverts were, while introverts were more likely to listen to country music than extroverts.

Our results were similar to the study published in the Psychology of Aesthetics, Creativity and the Arts as their study showed that extroverts had a natural preference for happy and upbeat music like pop. We also found this similar relationship as pop and indie are both upbeat and happy genres. However, the results showed a difference to the study done by Professor Adrian North of Heriot from Watt University. He found that the country music genre was preferred by mostly outgoing people, extroverts, while we found that introverts were more likely to listen to country than extroverts in this sample. This may be due to most of my participants (87%) being aged 13-14 years old, while Professor Adrian's participants were not. My results compared to Professor Adrians may suggest that during teenage years introverts are more likely to listen to country music than extroverts. We also had a difference of having no statistically significant differences in our other genres while Professor Adrian had found personality links to each genre. This may be as our experiments were performed differently as I measured participants' personality by their extrovertness while Professor Adrian included other personality traits like creativeness, self-esteem and hardworkingness.

The experiment was kept valid by controlling variables to eliminate bias. For example we controlled bias by choosing specific songs that were not radio played. By choosing a not well known song it eliminated some bias as most popular songs are overplayed on the radio, giving us a subconscious bias. Over time hearing a song too many times can cause you to dislike the song even if it is good. If we had chosen radio played songs our ratings for each genre would be invalid as the participant would be rating the song on the previous times they had heard not the

actual genre or song. This would give us invalid results and therefore affect the average rating. This would therefore make the relationship found between extrovertness and music genres invalid.

Another way we controlled bias was by compiling all the songs into one file where the participants could not see the name or singer of the song. This controlled bias as people could not base their rating on how much they like the singer but instead the actual genre and song. For example if I had included the names of the singers in the form, participants may have judged their rating on whether they like the singer or not. This would give us invalid values as our ratings are not based on which singer they like best but rather based on what genre they like best. These invalid results would also affect the average and therefore the relationship found between personality and music.

One thing we didn't consider in our experiment was controlling other biases, although we did not choose popular radio-played songs participants may have already formed an opinion on the one song we chose for a specific genre. This means the participant would not be giving their true rating to the genre and song but rather other times they had heard it. We could have changed this by creating a greater variety of songs for each genre. If we had multiple songs per genre it would eliminate the bias and give us a more valid average ratings of the specific music genres. This may be why our experiment did not detect many statistically significant differences between the music genre ratings between extroverts and introverts.

An improvement we could have made to our experiment was increasing the amount of participants. Our experiment only consisted of 100 people where we found no statistically significant differences. However if we increased our experimental pool, we would have more values and could have possibly found statistically significant differences for each music genre.

Another way we could have improved our experiment was having a wider range of ratings. In our experiment we only used a rating scale of 1-5 which did not allow for much differences in ratings. If we used a wider range like 1-10, we would have more different values which could have made the differences in ratings between extroverts and introverts greater therefore the experiment would have found statistically significant differences in more music genres.

If I was to do this experiment again, I would also change the way I measure extrovertness. In this experiment I used the MBTI test to detect whether someone was introverted or extroverted. However the MBTI has been proven to not be the best accurate portrayal of personality characteristics. Therefore if I were to repeat this experiment, I would use the Big 5 test to measure the extrovertness as it is proven more accurate than the MBTI test. This difference in tests could change results as the MBTI may have wrongfully identified people as introverts as extroverts or vice versa. This can give us a more accurate correlation between personality and music genres as extrovertness is a key variable in this investigation. As more people are correctly identified as their personality trait, the more accurate the ratings are. This inaccurate identification may also have been a factor to my many statistically insignificant differences between the music genre ratings between extroverts and introverts.

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Impact of Classical Mythology On The Modern Science By Ziwei Zeng

Abstract

The popularity of Classical mythology has gradually increased in contemporary society. The narrative revolving around classical mythology can be seen as unrealistic fancy flights used by the ancient Greeks, but it has greatly impacted modern science. It is evident that classical myths do not originate from experimental results and thus are not actual realities but have successfully shaped contemporary scientific skills and knowledge. Classical mythology, comprising the captivating stories of heroes and gods, not only entertains but also has left a long-lasting impact on understanding and applying scientific knowledge. The information and knowledge from Classical mythology have subtly influenced modern science. It has shaped most scientific discoveries and even formed the basis of the principles used to define scientific concepts. The research paper examines the impact of classical mythology on modern science by exploring the effect on the universe's origin, weather and natural phenomena, healing and medicine, navigation and astronomy, communication and language, modern hydrology, and analogies and metaphors.

Keywords: Classical mythology, influence, modern science, astronomy and navigation, healing and medicine.

Introduction

Since ancient times, humans have attempted to create a sense of the natural world surrounding them. When looking at strange things that happen or natural disasters occur, individuals naturally search for explanations before contemporary science. Finding the explanation before consulting modern science implies that sometimes, back then, people had to search for the explanation on their own without science. Even though Classical mythology can now seem hard to believe and outlandish, it was the basis and what provided the cause of different natural phenomena just before modern science involved day and night subjects, volcanoes, and whirlpools.

Myths such as classical mythology have been consulted to discuss and describe each aspect of science, from simple concepts such as rain and wind to complex concepts such as the Northern Lights and the solar eclipses. Auroras happen when charged particles established along the Earth's magnetic field connect with the Earth's upper surface gases (Haarmann, 2015). Classical mythology and its captivating stories of heroes and gods surpass its course of mere entertainment. Classical mythology has an incredible mark on the modern world's scientific knowledge fabric. From computer science terminologies to navigation and medical intricacies, the influence and impact of classical mythology can be observed and explained in modern science foundations.

Review of Literature–Computer Science

According to Computer Science, "The Trojan Horse" refers to a computer virus that acts harmless but secretly imposes damages. The appellation of the virus is derived from Classical mythology; the word Trojan Horse is generated from classical mythologies, most notably Homer's Iliad (Chami, 2015) and Vergil's Aeneid. Homer explains how the Illiad army failed to capture Troy city, retreated from the siege, and left a wooden Trojan Horse in front of the gate, ostensibly exhibiting it as a gift to the city gods. Troy city residents accepted the gift by pushing it inside the city's walls, even though the Trojan priest, Laocoon, had already warned the crowds about the imminent danger. In Aeneid Book 2 line 50-53, it says, "Sic fatus validis ingentem viribus hastam in latus inque feri curvam compagibus alvum contorsit. Stetit illa tremens, uteroque recusso insonuere cavae gemitum que dedere cavernae." Having spoken in this way with powerful strength, Laocoon hurled a spear into the side, and the belly of the horse curved by the joints. The spear stood trembling, and with the belly having been concussed the hollow cavities resounded and gave a groan. Yet Laocoon's warning did not raise the Trojans' alarm. The Trojan Horse was then brought by the Trojans to the middle of the city together with people's celebrations as the book depicts, "fatalis machina muros feta armis. Pueri circum innuptaeque puellae sacra canunt funemque manu contingere gaudent. Illa subit mediaeque minans inlabitur urbi". This translates into "fateful machine filled with arms climb the walls. Boys and unmarried girls sing sacred songs around and rejoice to touch the rope of the wooden horse by hands. The Machine comes up and being menacing, glides towards the middle of the city". At night, Greek soldiers emerged from the horse and went ahead to capture Troy city, setting all places on fire. Vergil describes that day as, "nos delubra deum miseri, quibus ultimus esset ille dies, festa velamus fronde per urbem", meaning that day was the last for our men cover the temples of gods with festive foliage through the city, implying how doomed they were and how fatal the Trojan House was.

Trojan Horse computer virus is a demonstration of Classical Mythology in that the Trojan Horse computer program acts as a perfect and legitimate program, such as a file handler or a compiler with access to different users' files. However, once people click on it, the seemingly legitimate-purpose program turns into malicious software, starting to attack the host computers. An example of a Trojan horse virus can be seen in the Appendix.

Also, apart from modern science terminology, it is evident that the universe's system is "heliocentric," meaning that the planets rotate around Helios (Chami, 2015). There is also a theory referred to as Gaia to theory, wor. Thea refers to an appellation based on Greek mythology and implies Mother Earth. Furthermore, in 1795, the famous German chemist Martin Klaproth was very excited about discovering a fresh metallic element, and he named the finding "Titanium" (Chami, 2015). It is directly connected to Classical mythological Titans, Earth goddess sons. Also, the "Promethium" appellation is generated from the Classical mythological Prometheus, who is believed to be the mythical figure who gave humans gods stolen fire.

Additionally, Scorpius refers to a summer constellation on South Ophiuchus. Based on Greek Mythology, the scorpion is the one that stung the hunter Orion to death. However, the accounts collide with the actual situation. In Classical mythology, Ophiuchus is associated with medicine by the Greek god Aesculapius. Capricorn is the 10th zodiac symbol rooted in the Capricornus constellation. According to the Greeks, Capricorn represented the mountain Pan, who acted as a night musician and a shepherd in the daytime. Astrology's fifth zodiac symbol is Leo, which has existed since the Leo constellation. The constellation is also associated with a Classical myth related to the initial task among the twelve tasks given to Hercules, which is slaying the Nemean Lion, also known as the Nemean Leo.

Weather and Natural Phenomena

Classical mythology contains narratives explaining the origins and the foundation of natural phenomena such as lightning and thunder, the varying seasons, tsunamis, and earthquakes. The narratives entertained the early Greeks and ensured they effectively made sense of the surrounding environment. Modern-day scientists and researchers have established their views and opinions and developed an in-depth understanding of the natural world phenomena through experimentation and observation. One example of the influence of Greek mythology on the general knowledge of natural phenomena revolves around the narrative of Zeus, the king of gods, and his powers of control over lightning and thunder. According to Classical mythology, Zeus was known for throwing thunderbolts to punish people who angered him. The narrative enabled the early Greeks to explain and describe the thunder crashes and the lightening's bright flashes they heard and observed during heavy storms. Contemporary science, however, has demonstrated that lightning and thunder are caused by electricity discharge in the atmosphere (Karakis, 2018). The concept and phenomena can be understood and studied through meteorology.

The narrative of Poseidon is another example of who the sea god was and the powers he had to cause earthquakes. In classic literature, Poseidon was said to be responsible for earthquake creation and its shaking process. The myth enables the early Greeks to create sense from the destructive and powerful forces they faced. In the modern world, with the advancement and development of seismology, researchers and scientists have experimented and discovered that the primary cause of earthquakes is the tectonic forces' movement beneath the Earth's surface (Konstantinou, 2021). Understanding this is essential since it has enabled people to forecast, predict, and effectively prepare for the mitigation measures related to natural disasters. Classical mythology has also successfully offered explanations for the varying seasons through the narrative of Persephone and the time she spent in the underworld. Referring to the myth, the descent of Persephone inside the underworld during winter seasons described the Earth's barrenness. Persephone's return during the spring explained the plant's rebirth and return to life. While the early Greeks might have associated these variations with the actions of goddesses and gods, current science has explained that the varying seasons result from the Earth's axial tilt and orbit around the sun.

Healing and Medicine

Classical mythology's influence on current science also extends to medicine and healing, where early beliefs and narratives have the understanding and knowledge concerning the human body and the disease's treatment and prevention remedies. The ancient Greeks believed that sickness was due to the imbalance of the body's humor, the bodily fluids responsible for ensuring good health (Miller, 2020). This belief led to the development of the four senses of humor: black bile, yellow bile, phlegm, and blood. Every humor among the four humors was related to distinct personality traits and physical features. Hippocrates, the Greek physician always regarded as the "Father of Medicine, " was instrumental in shaping treatment and medical practices based on Classical mythology (Greco et al., 2021). Hippocrates emphasized the importance of documenting and observing signs and symptoms and the importance of ethical practice and conduct in medical practice.

Hippocrates stressed the importance of pharmaceutical products since they directly affect a person's health. Hippocrates also created the Hippocratic Oath concept that set future directions and guidelines for medical physicians to follow during their practice (Hu, 2023). The Oath acknowledges the significance of confidentiality, patient care, and the principles and rules of medical practice that are highly utilized and followed in modern medicine. Classical mythology also influenced the creation process of medical terminology. Most terminologies used in medical practice, like pharmacy and hygiene, are believed to have originated from the early Greek words. The ancient Greeks strongly believed in the effectiveness of plants and herbs in curing and healing. Their understanding and knowledge of herbal medical plants are still being applied and used by modern generations. Currently, people still depend on herbal medicine, and some modern antibiotics and drugs are manufactured through plants. Furthermore, the study and research of herbal remedies remain significant in medical research, especially pharmaceutical research studies.

Navigation and Astronomy

Classical mythology also played an essential role in developing and establishing navigation and astronomy, influencing how civilizations interpreted and observed celestial bodies in the universe. Classical mythology influenced the celestial body naming whereby the Greek myths gave names to constellations and stars like Pegasus, Ursa Major, and Orion (González-Vaquerizo, 2019). The initial naming of the Classical constellations mythological concept was cited during the 7th Century before Christ in Homer's achievements. For example, Homer explains how the craftsman god Hephaistos made Achilleus shield in the Iliad. The first god in Greek was Ares; the Romans referred to him as Mars; he was regarded as the battle god; he was eras and Zeus' son and was characterized by his tendency to lead and his ferocity.

Artemis, referred to as Diana by the Romans, was the hunt goddess and identified by the moon (Chami, 2015). She was also considered a twin sister to Apollo. Athena, whom Romans gave the Minerva appellation, was believed to be a skill, wisdom, and warfare goddess. Apollo

was considered to be archery, man's beauty, prophecy, plague, healing, knowledge, arts, and music. The Romans consider Aphrodite Venus and is always regarded as the most beautiful goddess. Romans also refer to Hades as Pluto, the brother of Zeus. All the names referring to the gods and the goddess are currently used in the solar system as the names of various planets.

The names offered a way for the early navigators to navigate by and identify the stars, enabling them to pass information and knowledge about the celestial bodies from one generation to the next. Secondly, it influenced the explanation of celestial phenomena, where the classical myths always included narratives that described natural phenomena involving celestial experiences, such as the planets' changing position, meteor showers, and eclipses. The stories enabled the early astronomers to interpret and understand the happenings, forming the basis of scientific inquiry. Moreover, classical mythology influenced the navigation process in the Mediterranean since explorers and navigators applied the concept and knowledge of constellations and stars mentioned in the myths to guide and direct their routes and journeys during that period.

By effectively observing the sky and night and sticking to the patterns of the sky, the navigators could navigate the Mediterranean and explore the new islands and lands. Also, even though it is not a scientific field, astrology is said to have originated from Classical mythology and played a vital role in early societies. According to ancient individuals, the movements of celestial bodies are the position of the celestial destiny and behavior (Vico, 2020). The belief system affected the decision-making process involving exploration and navigation. Classical mythology affected early navigation and astronomy and provided the groundwork for the scientific understanding and exploration of the universe's stars, which continued until modern-day science.

The influence of classical mythology on science, especially astronomy, is so effective and diverse that the heavenly bodies and the sky have been awarded mythological names. Other celestial bodies and planets, including the stars making up the whole solar system, are, in particular instances, named after the Roman goddesses and gods and also from the classical myth. The different natural seasons and phenomena in the globe have effectively derived their original names from the Greek heroes and gods. Also, Johann Kepler applied the observational data from Tycho and devised the three laws about planetary motion during the 17th century (Falkner, 2020). The three laws explain the planet's elliptical orbits around the sun, the relation between the planet's orbital period, the distance between it and the sun, and the law of equal area. Kepler's laws are still crucial in planetary motion research and even influenced the development of celestial mechanics. Galileo Galilei, using a telescope he created himself, conducted a groundbreaking observation in astronomy during the 17th century (Falkner, 2020). Galilei was able to observe the four largest moons of Jupiter and the phases of Venus and discovered sunspots.

Galileo's groundbreaking observation effectively supported and backed up the heliocentric model and contributed to the Copernican system's acceptance. Astronomy and physics were also transformed in the 17th century by Sir Isaac Newton's theories of motion and

universal gravitational law. Newton's law of motion and universal gravitation provided a comprehensive explanation of celestial and earthly motion. (Falkner, 2020). The laws described the comet's behavior, the moon's motion, and the planetary orbits, creating a universal framework for understanding how gravitational forces work. Ancient astronomers, especially those of the Babylonian and Greek traditions, developed the concept of the ecliptic plane and the celestial sphere. The ecliptic refers to the apparent sun's path across the sky during the year. Contemporary astronomy still applies these concepts as essential reference points for celestial objects' location and identification of their positions.

Moreover, Zodiac names representing a person's star sign start from the date of birth and originate from classical mythology. For example, cancer the crab refers to a Goddess Hera creature sent to destroy Heracles (Giacomo, 2021)). Aries, the ram represents a golden ram's picture placed by Zeus among the stars for heroism honor ship (Wang & Bu, 2020). "Leo," the lion, was linked to Heracles' laborers, and his initial role involved killing the Nemean Lion.

Communication and Language

Among the ways classical mythology has shaped current science is the influence of myth on the growth and development of communication and language. Communication paved the way for the exchange of scientific knowledge and concepts. The early Greeks strongly believed that language and communication were vital to preserving cultural traditions, teaching lessons, and sharing narratives. The belief is clear enough and evident in the ancient myths shared and passed down from generation to generation by word of mouth before they were documented. With its extensive grammar and rich vocabulary, the Greek language has had a long-lasting effect on the growth and development of most Western languages.

Most scientific terminologies, such as biology, originated from the ancient Greek word bios, which refers to life, and logos, which refers to study examples. Most scientific terms used today were applied in ancient Greece during communication (Shavkatovna, 2021). Additionally, classical mythology offered a common framework for understanding and communication among the early Greek societies, creating a sense of cultural unity. The shared myths allowed for efficient and easy knowledge and ideas to be transmitted, thus facilitating ideas and dating scientific advancements and inventions. In the contemporary world, the impact of Classical mythology on communication and language is still evident since most of the scientific ideas and concepts that continue to be found originate from Greek mythology and language.

Modern Hydrology

Although hydrology is a term used in Greek, it was not used in classical literature. However, the term hydrology was used sometime later during the Renaissance. The classical natural philosophers formed robust knowledge in most of the related scientific fields, providing them with names such as hydraulics, climate meteorology, etc. The terms are currently in use globally. The classical natural philosophers formed the basis for the hydrological idea with the hydrology cycle. Knowledge development was achieved through technological solutions to

natural practical challenges and scientific curiosity. While the early descriptions belong to the mythology sphere, the rise and development of philosophy were followed by the need for adequate scientific explanations of the phenomena (Perdomo Marín, 2020). It seems like an initial geophysical challenge formulated according to scientific terms was the explanation of the Nile flood regime.

Nile flooding explanation was then considered as a paradox due to the striking distinctions from the run of the river in ancient Greece that the point where the flooding of the river happens in summer at the time the rainfall volume is low in most parts of the Mediterranean (Koutsoyiannis & Mamassis, 2021). Even though the initial trials were unsuccessful, Aristotle formulated a correct hypothesis. The initial historical, scientific expedition tested the hypothesis of the change to Hellenistic from classical periods. Hellenistic times led to advances and developments in science fields such as hydrology, such as the measurement and the definition of the flow discharge done by the heron of Alexandria. The hydrology explanation is a concrete confirmation of the view that the cycles of hydrology were effectively understood in early Greece. However, it creates a question about why correct descriptions were not considered and why modern and ancient mythological concepts were considered until the 18th century.

Analogies and Metaphors

Analogies and metaphors drawn from Greek mythology are essential and powerful tools researchers and scientists apply while elucidating significant scientific concepts and ideas. The figurative contrasts and comparisons are critical to bridging the gap between the intricate scientific concepts and the broader general audience understanding. The application and usage of mythological references enhance vivid imagery and familiarity with explanations and scientific descriptions, making them accessible. The best example is the "Achilles' heel," which explains how such metaphors are used. The phrase "Achilles' heel" is generated from Classical mythology, particularly the narrative of Achilles, who was an instrumental and heroic figure during the Trojan War (Reniers, F. (2022). The myth explains that Achilles was invulnerable but not for his heel; that was the source of his downfall when it was pierced using an arrow.

According to scientific concepts, the phrase is applied metaphorically to illustrate a critical vulnerability or weakness in a theory, process, or system. When researchers refer to something as the "Achilles' heel" in a specific model or concept, they discuss a fundamental limitation or flaw potentially compromising the system. Through the application of such mythological metaphors, researchers tap into a common cultural reservoir, making them share and communicate intricate principles related to science in a related and experimental way. The metaphors facilitate and contribute to comprehension and add value to the storytelling element of science, increasing the memorability and engagement of a diverse audience.

Conclusion

Classical mythology has directly influenced and has had a profound impact on modern-day science. One of the significant aspects of classical mythology's impact and influence

on contemporary world science is mythology's contribution to the general understanding of the universe's origins. Classical mythology, with its rich narratives and tapestry of creation stories and gods, was the foundation of early civilizations and scientific revolution through discussing and explaining how the natural universe started to exist. Moreover, classical mythology comprises stories describing the origin and the causes of natural phenomena such as earthquakes, tsunamis, and volcanic eruptions. The stories were used to entertain ancient people and also to ensure that they make sense of the environment in which they reside. Modern scientists, through experiments, have been able to explain the cause of natural phenomena, a practice that the ancient Greeks started.

Furthermore, the idea relating to the use of herbal medicines for treating diseases in early Greece has also been extended to the modern field of medicine, where herbal treatment and manufacturing of pharmaceutical drugs are still being practiced. Classical mythology has also influenced the naming of celestial bodies such as planets and constellations. The mythology also influenced language and communication, where scientific terminologies such as biology have been used to describe science. Hydrology is an ancient science; scientists also used hydrosol, a current scientific term applied in the current scientific explanations. The application of ancient metaphors such as the Achilles heel has contributed to a common understanding in the scientific field. Lastly, classical mythology's power to guide and inspire scientific inquiry must be considered. The impact may be connected to a river carving through the human language landscape, forever leading the scientific discovery process.

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Schizophrenia in the Black Community: Issues on Identification, Symptom Management, and Advocacy By Rahi Dhoke

Abstract

In the identification and treatment of schizophrenia, extant work has reported significant disparities between Black and White patients. Specifically, stark differences exist between Black and White communities in the frequency of schizophrenia diagnoses, treatment protocol for schizophrenia, and quality of life post-treatment. Furthermore, the areas in which Black individuals live may themselves contribute to the risk of developing schizophrenia. Little work has focused on closing the gap. This paper reviews how inadequate medical care (e.g., bias, overdiagnosis, lack of medical resources) for patients with schizophrenia can result in a pronounced negative quality of life, such as the attainment and retainment of jobs, quality of social relationships, and risk for suicide in Black individuals living with schizophrenia. Creating space for knowledgeable discussions about the ways in which medical attention is deficient for Black patients can stimulate social reform in the field, which can forge an enhanced healthcare system, and in turn, inform social change in other oppressive systems.

Keywords: schizophrenia in the Black community, healthcare disparities, healthcare reform

Introduction

Schizophrenia is among the most severe psychiatric conditions with a mortality rate of up to 7.4 times that of the general population (Correll et al., 2022). It has a lifetime morbid risk of 7.2% (McGrath et al., 2008)—meaning that 7.2% of the general population are symptomatic or unhealthy due to schizophrenia—and a lower life expectancy of 10 to 20 years less than people without the disorder, driven by increased suicide rates (Sher & Kahn, 2019). Schizophrenia affects all populations, with a prevalence of 1.4 to 4.6 per 1000 people and incidence rates in the range of 0.16-0.42 per 1000 (Jablensky, 2000). Furthermore, schizophrenia is known to co-occur with other psychiatric diagnoses (see Kessler & Lev-Ran, 2019), particularly severe mood symptoms, which can result in the diagnosis of schizoaffective disorder (Escamilla, 2001). While the pathology of schizophrenia remains somewhat elusive, symptoms include hallucinations, delusions, disorganized thinking, speech, and behavior. Common risk factors for schizophrenia include genetics, history of psychological disorders, and substance use (Davis et al., 2016). Specifically within the Black community, manifestations of racism can lead to intergenerational trauma, which can increase the likelihood of the onset of schizophrenia (Lee et al., 2023). As the high overdiagnosis of schizophrenia within the Black community (Barnes, 2004) suggests, it is noteworthy that simply being Black presents a risk for a schizophrenia diagnosis. Importantly, schizophrenia is diagnosed more frequently in Black individuals than in other racial-ethnic groups (Bland, 1992; Cohen & Marino, 2013). Much work has examined the cultural implications of schizophrenia symptomatology and the diagnosis itself; thus, a comprehensive review of this literature is timely.

Living with schizophrenia is known to come with a myriad of other life consequences, from social interactions to physical health (Bjornestad et al., 2019). While these symptoms do contribute to loss of livelihood, the indirect implications of mental illness are additionally conducive to the worsening of one's life. Due to racist historical policies such as redlining, Black populations have largely received less neighborhood funding, resulting in fewer resources in schools, both of which can impact the amount and quality of education that Black individuals receive (An et al., 2019). These inadequate materials can lead Black individuals toward a "school-to-prison" pipeline that may include the use of drugs as a means to cope and gain assets, which is conducive to the development of substance-use disorders. (McCarter, 2016). Coupled with the heavy over-policing of Black communities, all of these oppressive models of racial discrimination result in the disproportionate incarceration of Black individuals (Hinton et al., 2018; Beckmann et al., 2018), which is a stressor for schizophrenia (Ford, 2015). Black neighborhoods are also more likely to include chronic stressors that can add to and exacerbate pre-existing medical conditions (Anglin et al., 2021). This cycle of oppression not only extends itself to mental health disorders, but also adds to etiology (Fig. 1). These systemic disadvantages can generate joblessness, dispossession, and even lower rates of happiness compared to White communities—24% versus 34%, respectively (Iceland & Ludwig-Dhem, 2019). While these circumstances also affect other marginalized communities, this paper will focus on the effects in Black communities.

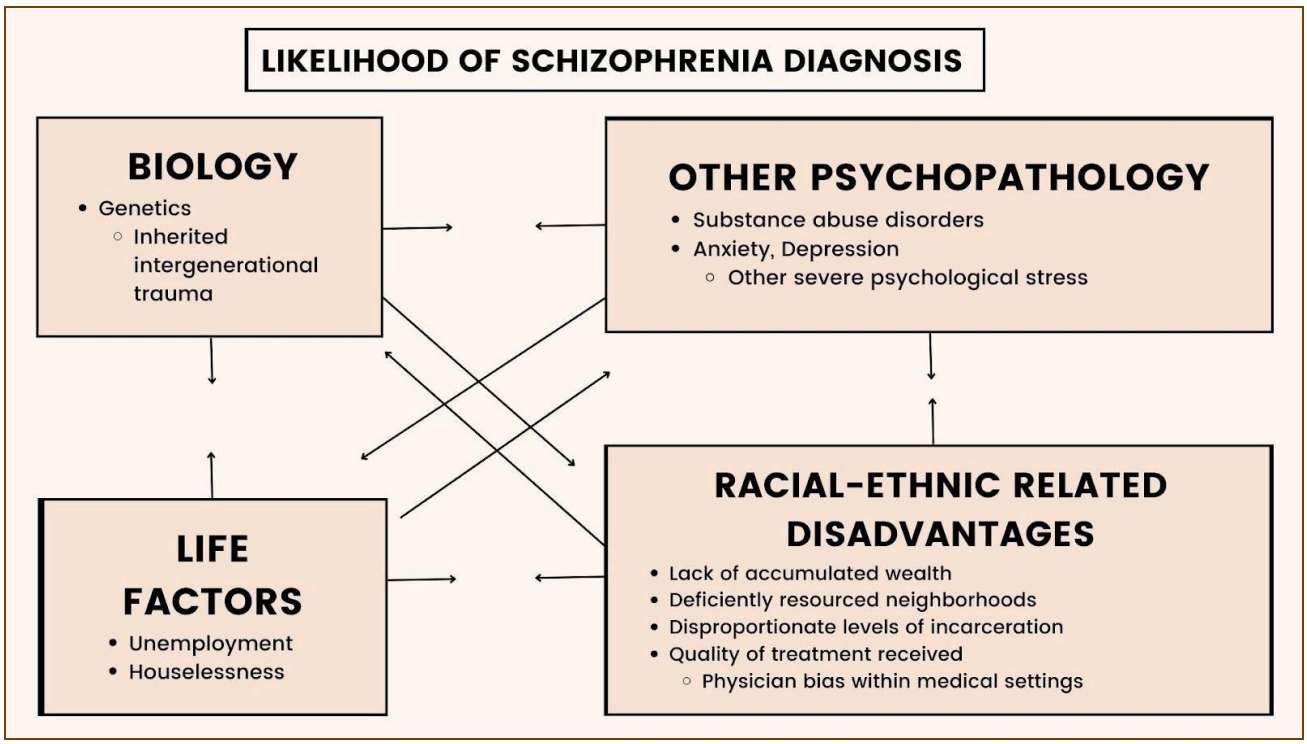


Fig. 1: Systemic disadvantages have a bi-directional correlation, which particularly impact Black people with schizophrenia and underlie a myriad of poor outcomes.

Physician Bias

A large body of evidence suggests that Black individuals are more likely to perceive their racial-ethnic identity as a disadvantage when receiving medical care (see Alang, 2019 for review; Shavers et al., 2012). Further, physicians, including psychiatrists, tend to appraise symptoms differently across racial groups. For instance, Hoffman & colleagues (2016) found that White medical students and residents endorsed inaccurate views about biological differences between Black and White patients, believing that Black patients experienced less pain. Unsubstantiated medical beliefs, such as these and other stereotypes, inform physicians' diagnoses, indicating why, in part, misdiagnoses of schizophrenia within the Black community are common (Chapman et al., 2018; Ninan et al., 1993; Faber et al., 2023) and also why schizophrenia diagnosis rates are higher in Black communities than White, Hispanic, Asian, or other racial-ethnic groups (Gara et al., 2019; Bazargan-Hejazi et al., 2023), despite there being no genetic evidence suggesting that schizophrenia symptoms are more prevalent within the Black community (Eack et al., 2012). In another paper, Mallinger & colleagues (2006) suggest that Black individuals with schizophrenia are less likely to receive gold-standard antipsychotic medication, indicating a clear disparity in treatment. In all, physician bias seems to significantly influence the prevalence and treatment of Black individuals with schizophrenia.

Physician bias may reveal itself in a physician's beliefs about the demographic of patients that they are treating. Stereotypes such as the incorrect idea that Black individuals are inherently more dangerous, aggressive, and untrustworthy than White individuals correlate with the disparities mentioned above in schizophrenia diagnoses within Black communities; that is, routine emotions shown by Black individuals may be wrongfully characterized as symptoms of schizophrenia. Historically, the 1974 printing of the DSM-II focused on the "hostile subtypes of schizophrenia" within Black communities, leading to an association between Black individuals—particularly Black men—and schizophrenia, along with general mania. While this taxonomy issue has been revised to exclude these perceptions within diagnostic criteria, the acumen of Black individuals as dangerous and dishonest has lingered in various forms. Additionally, sanist perceptions of people with schizophrenia as violent and dishonest link the biases together, even where diagnostic criteria do not support the bias (Kennedy, 2022). These faulty associations may be a cause for the overdiagnosis of schizophrenia within Black communities (Barnes, 2004).

Researchers of schizophrenia have largely underrepresented Black communities in clinical studies (Durant et al., 2011), thus disregarding specific risk factors for Black people that may contribute to the presence of schizophrenia in an individual, such as intergenerational trauma (Lee et al., 2023). Furthermore, this lack of inclusion within clinical study samples does not allow for the results of the study to be generalizable to whole populations; extant work has found that many groups who are underrepresented, or altogether excluded, in clinical trials may have specific circumstances regarding their health that will affect how they respond to a new medicine (Beglinger, 2008; Crawley et al., 2003; Garcia et al., 2016; Ramamoorthy et al., 2015).

The efficacy of provided treatment is known to be influenced, in part, by the empathy shown by medical providers (Elliot et al., 2018; Priebe et al., 2019). Derksen & colleagues (2013) found that empathy shown by physicians correlated with significantly better clinical outcomes for patients, while Roberts & associates (2021) observed that an empathy gap may exist for patients of multiple race/ethnic groups, including Black and African American patients compared to White patients. Lack of empathy in clinical spaces may not only result in wrongful diagnoses and substandard treatments, but may also discourage Black communities from following medical advice altogether (Yeary et al., 2015). In relation to the taxonomy issues of previous DSMs, physicians have been taught—through uninformed medical curricula—that Black patients are, for example, in less need of pharmaceutical drugs and have thicker skin (Louie & Wilkes, 2018). Consequently, physicians are, on a large scale, taught the biases that form the empathy gap, leading to disparities in care for Black communities.

Distrust of the Healthcare System

Medicine has a long history of disregarding and manipulating minority groups while justifying their actions for the sake of advancement. Historically, unconsenting Black communities have been used as test subjects for researchers to experiment on (e.g. the Tuskegee Syphilis Study; see Scharff et al., 2010 for review). These exploitations (see Baptiste et al., 2022) have resulted in a deep mistrust of the healthcare system within the Black community. Importantly, this traumatic history demotivates Black individuals from seeking treatment (Schraff et al., 2010). This issue is also related to the underrepresentation of diverse participants in clinical studies. Black individuals make up only 5% of clinical trial participants (Alegria et al., 2021); when scouting for voluntary trial participants, many researchers do not make Black individuals feel comfortable enough to take part in their study, as the healthcare system has committed exploitations in the past. For example, in one cancer study, Black and Hispanic individuals had a lower phase 1 enrollment than Asian individuals (Perni et al., 2021). In addition, a lack of diverse clinicians and researchers—as of 2018, only 5% of doctors in the United States were Black, compared to 56.2% of White physicians (*Diversity in Medicine: Facts and Figures 2019*, 2019; Lloyd Jr & Miller, 1989)—can further discomfort Black individuals and discourage them from participating in medical research (Scharff et al., 2010). Moreover, Goode-Cross & Grim (2014) found that there was a level of connection between Black therapists and Black patients, leading many Black clients to prefer a Black clinician (Cabral & Smith, 2011; Townes et al., 2009).

Barriers to Treatment

According to the 2021 National Survey on Drug Use and Health, only 39% of Black and African Americans individuals received mental health services, compared to 52% of White individuals, despite both groups having similar reported rates of mental illness. Black individuals are also much less likely to seek care (Alegría et al., 2008; Cook et al., 2014; Jimenez et al., 2013; Roll et al., 2013; Wells et al., 2001), and more likely than their White counterparts to be

given antipsychotic medication and higher-potency antipsychotic medications at higher doses, in addition to less evaluation time with clinicians once treatment has been initiated (Segal et al., 1996). Furthermore, Li & colleagues (2011) suggest that Black schizophrenia patients experience significantly less improvement in thought disorder symptoms of schizophrenia (such as thinking, language, and communication abnormalities—see Özbek & Alptekin, 2021), negative and general psychopathology symptoms, as well as functioning, even after adjusting for the baseline differences in clinical and sociodemographic characteristics. The lack of resources shared by treating physicians may contribute to low treatment effectiveness rates. Among physical barriers, such as large locational distances and the inability to obtain transportation due to transportation costs or otherwise, physician bias and a distrust of the healthcare system can beget the ineffectiveness of treatment or caution those in the Black community from seeking treatment itself.

Effects of Schizophrenia Diagnosis in the Black Community

The current state of psychiatric medicine has disadvantaged Black communities in that well-validated treatments for severe diagnoses, like schizophrenia, are few and far between for non-WEIRD populations (referring to those raised in Western, Educated, Industrial, Rich Democracies). A combination of racial-ethnic disparities in clinical research and an abhorrent history of medical research in marginalized communities unsurprisingly deters members of the Black community from seeking care; these disparities in clinical research underlie poorer clinical outcomes for Black individuals with schizophrenia and a myriad of other social, economic, and physical consequences.

Extant work has suggested a bidirectional correlation between unemployment and psychosis (Bouwmans et al., 2015). According to a report by the Bureau of Labor, joblessness in Black communities is particularly high—8.6% compared to 4.7% in White communities (*Labor Force Characteristics by Race and Ethnicity, 2021: BLS Reports: U.S*, 2023). Joblessness is linked to poverty (Rachidi, 2018; *Why Poverty Persists | NBER*, 2005), and as Black communities generally have less wealth than their White counterparts (Harris & Wertz, 2022), impoverished Black communities are more likely to lack the financial resources needed to fund medical treatment (Santillo et al., 2022). On the one hand, Boydell & associates (2012) found unemployment and the development of psychosis to be positively correlated; further, this relationship was found to be stronger in Black Caribbean and Black African individuals than in White individuals. In terms of employment after onset, symptoms may make working more difficult; according to Global Burden of Disease Studies, schizophrenia accounts for a high degree of disability (Charlson et al., 2018; Jablensky, 2000; Velligan & Rao, 2023). Recent work has also shown schizophrenia symptom severity to be negatively related to success in the job market (Martini et al., 2017). In addition, Black individuals already face discrimination when applying for jobs (Schaeffer, 2023). Untreated symptoms make everyday tasks challenging, and as stated above, make it more difficult to work. Importantly, unemployment itself is positively correlated with poor health outcomes, such as high blood pressure, stroke, heart attack, heart

disease, and arthritis (*Employment - Healthy People 2030 | Health.gov*, 2020; Hintikka et al., 2009; Jin et al., 1997) which uniquely leaves members of the Black community vulnerable.

In addition to poverty and joblessness, mental illness is also bidirectionally correlated with houselessness. Unhoused people are often poverty-stricken and disaffiliated, making it challenging to attain medical or social support (Saluda, 2023). Thus, houselessness is another trigger for psychosis (Padgett, 2020). When not living close to medical facilities, many people may find it difficult to travel large distances to find medical care. Predominantly Black neighborhoods, which are more likely to be impoverished, have more public hospital closures and fewer primary care physicians than predominantly White neighborhoods, and many lack proper resources for effective medical treatment (Caldwell et al., 2017).

Stigma of Mental Disorders Within the Black Community

Joblessness and houselessness are external factors that prevent Black individuals from seeking care, but stigma within the Black community can internally prevent Black individuals from seeking care as well. As explained above, due to a general mistrust of the healthcare system, there is a disinclination to seek medical care, particularly for mental health. Furthermore, some Black individuals believe that they will be discriminated against for mental illness and feel uncomfortable speaking about mental health, sometimes within their own social circles (Alvidrez et al., 2008; Keating & Robertson, 2004; *The Annual State of the Communities Report With Diverse Communities*, 2019). This issue can be related to unemployment concerns, where being diagnosed with a mental health condition can make finding a job more difficult (Bouwmans et al., 2015).

Conclusion

Schizophrenia is disproportionately diagnosed amongst Black patients, and this discrimination is perpetuated by physician bias. Such outcomes result in a reluctance from Black individuals to seek treatment from an already untrusted healthcare system. Black communities are largely underrepresented in clinical studies, and Black clinicians are few, which may contribute to poor treatment outcomes. Unemployment, houselessness, and stigma hinder Black patients from accessing treatment, as well. These structural systems of oppression work in conjunction to keep Black individuals in a cycle of oppression that does not allow them to find proper care. For the healthcare system to properly serve its patients, these issues must be addressed and improved upon through the use of resource allocation for impoverished areas, enhanced physician education, inclusive diagnostic tools, and programs to aid individuals in acquiring jobs and homes.

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Unraveling The View Of Athletic Performance: Uniting Genetics, The Environment, & Psychology By Rishika Rastogi



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Abstract

Genes play an incredibly important role in the many characteristics of life, from determining a person's appearance, to the likelihood of getting certain diseases and disorders. Significant research has been conducted throughout the years to examine the roles of genetics in athletic performance. In fact, the roles of genes with genetic interactions, along with environmental factors and psychology such as lifestyle, training, and motivation, play an important role in sports performance that must also be considered. In this review paper, current research and progress in understanding the roles of genes, environmental influences, and psychology in an athlete's performance will be examined.

Introduction

Athletic performance, a mesmerizing interplay of skill, determination, and physical prowess, has captivated the human race for centuries. Across sports disciplines, athletes push the boundaries of human achievement, showcasing feats that appear almost superhuman. As researchers and enthusiasts alike seek to understand the factors shaping this type of athletic excellence, a fundamental question arises: What are the roles of genetics, environmental factors, and psychology in the development of athletic performance-related traits, and how do they influence sports performance?

This review paper will dive into this complex interaction, and expand the holistic view of an athlete's capabilities. In the first subsection, genetic factors and their influences on an individual's characteristics, such as metabolic pathways, muscle fiber, height, and body composition, will be discussed as they've been a focal point in sports performance research thus

far.[16] To continue, the connection between genes and the environment remains overlooked but is equally as important.[5] Factors such as lifestyle and training can significantly impact an athlete's trajectory.[3] However, beyond the realm of the physical, the psychological aspect of sports performance is equally vital. The human mind can often determine the difference between victory and defeat.[10] Confidence, mental resilience, focus, and the ability to manage pressure are just a few of the psychological factors that can tip the scales in a competitive setting. Therefore, this paper aims to evaluate the roles played by genetics, environment, and psychology in shaping athletic performance-related traits.

Genetics

Throughout the numerous studies conducted in the past decade, genetic factors have garnered substantial attention due to their potential to shape an individual's physiological attributes that contribute to athletic potential. Specific genes that have been linked to enhanced athletic performance are found in different metabolic pathways, muscle fiber compositions, and height.[1] It’s important to note this exploration of genes associated with athletic performance is thanks to advancements in genetic research methodologies.[16] For example, studies employing twin, family, and population-based designs have unveiled the heritability of various physiological traits relevant to sports, showing the substantial influence of genetics.[17] Not only that, a comprehensive review of existing literature highlighted the consensus that genetic factors can influence an athlete's potential and achievement, as numerous genes and genetic variations have been identified as potential contributors to athletic performance-related traits.[18] The ACE I/D polymorphism and ACTN3 R577x gene, for instance, is associated with endurance performance due to its impact on cardiovascular function.[2] Variants of the ACTN3 gene influence muscle fiber composition, where the presence of a specific variant is linked to enhanced sprinting and power-related performance as they have multiple repeated rapid muscle contractions.[26] To continue, the ACTN3 577R allele and ACE D allele dominant model account for 0.92% and 1.48% of sprint time variance, respectively.[18] These genes exert their effects by influencing crucial physiological pathways, again proving how the intricate web of genetic interactions shapes athletic performance.

Other research efforts have also pinpointed specific genetic variants associated with superior athletic performance. For instance, studies investigating the R577X variant of the ACTN3 gene have found an overrepresentation of the "RR" genotype in elite sprint and power badminton athletes.[20] Such findings demonstrate the potential for genetic profiling or testing to predict an athlete's predisposition to specific disciplines, allowing for tailored training regimens, and new talent identification strategies. As we move on beyond the ACE and ACTN3 genes, other candidates have emerged as potential influencers of athletic performance.[2] The AMPD1 gene, found in the skeletal muscles used for movement, where it plays a role in producing energy, has been linked to endurance performance and metabolism. Genetic variants in the COL5A1 gene, which provides instructions for making a component of type V collagen, may contribute to tendon and ligament integrity, affecting injury susceptibility.[21] Genetic variants affecting metabolic pathways also play a crucial role in an athlete's energy utilization and

efficiency. Polymorphisms in genes like AMPK, a phylogenetically conserved fuel-sensing enzyme that is present in all mammalian cells, have been shown to influence oxidative stress response, and glucose metabolism.[3] These pathways dictate an athlete's ability to produce energy aerobically, thereby impacting their endurance capabilities.

Genes involved in muscle fiber composition also contribute significantly to an athlete's specialization in power or endurance disciplines. Variants in the ACTN3 gene, as mentioned earlier, determine the ratio of fast-twitch to slow-twitch muscle fibers.[4] These genetic influences on muscle fiber composition can shape an athlete's responsiveness to specific training interventions, optimizing their performance potential. Genetics also play a role in determining an athlete's height and body composition, influencing factors like bone density and lean muscle mass. Genetic variants associated with height, such as those within the HMGA2 gene, can impact an athlete's biomechanics and leverage in certain sports.[21]

Gene Interactions

Along with individual genes, genetic interactions stand as key determinants that shape an individual's athletic abilities, revealing dynamics that span from singular genes to intricate networks. It transcends the simple linear effects of individual genes, as they represent the interconnected relationships that genes establish with each other leading to collaborative or opposing effects on the ultimate phenotypic outcomes.[5] Within the sphere of athletic performance, the significance of these interactions becomes profoundly evident. For example, a gene responsible for muscle growth might not independently dictate an athlete's potential. Instead, its effects could be amplified or modulated by the presence of other genes that impact metabolic processes, inflammation responses, or neuromuscular coordination.[7] It is the collective effort of multiple genes working in unison that shapes an individual's athletic potential. This polygenic architecture results in a distribution of athletic performance across the population with extreme phenotypes being rare due to the nuanced genetic factors.[19] This complexity drives the patterns of heritability observed in various studies, where at the core of athletic performance genetics lies a fundamental truth: the influence of genes is rarely controlled by a solitary master gene.[24] However, it is essential to recognize that these genetic influences are context-sensitive. A genetic variant that imparts a competitive edge in one sport or environment may not yield the same advantage in a different context.[8] This emphasizes the role of environmental factors in mediating how genetic potential is realized.

Additionally, the interplay between genetic factors and environmental stimuli can lead to epigenetic modifications, introducing an additional layer to the genetic landscape of athletic performance. Modern advancements in genome-wide association studies (GWAS) have unveiled many genetic variants associated with various performance-related traits.[23] These genetic markers are frequently dispersed across the genome, collectively shaping an individual's unique athletic profile.[22] Therefore, the complex nature of genetic influences and the cumulative contributions of multiple genes intertwine to define athletic abilities for a specific facet of performance. For instance, the genetic makeup of a sprinter might encompass genes governing fast-twitch muscle fibers, oxygen transportation, and energy metabolism, and understanding

these genetic intricacies is not only pivotal for unraveling the genetic basis of athletic performance but also for tailoring training approaches and personalized strategies to optimize an athlete's potential.[25]

Environmental Factors

While often overlooked, environmental influences hold paramount significance within the intricate mosaic of athletic performance-related traits [6]. Among these environmental factors, training stands as a pivotal determinant that shapes an individual's athletic capabilities, carving a distinctive path toward excellence. Training constitutes a cornerstone of athletic development, offering a systematic approach to enhance physiological, biomechanical, and psychological attributes.[8] Through deliberate regimens, athletes fine-tune their bodies to adapt to the demands of their chosen sport. While genetic factors provide the blueprint, it is the training environment that sculpts an athlete's potential into tangible performance gains.[7] And training is not an isolated endeavor; it unfolds within a complex nexus of environmental conditions. Factors such as altitude, temperature, humidity, and terrain interlace with training protocols to induce physiological adaptations that are essential for peak performance.[7,8] Altitude training, for instance, stimulates increased red blood cell production due to decreased oxygen availability, enhancing an athlete's endurance capacity.[7] Similarly, training in hot or cold environments can elicit adaptations in thermoregulation, affecting an athlete's ability to sustain performance under diverse conditions.[9]

Ultimately, genetic predispositions set the boundaries of an individual's potential, while environmental conditions and training modulate the extent to which that potential is realized.[7] An athlete with a genetic propensity for endurance may exhibit superior performance gains through altitude training, whereas another athlete with genetic attributes favoring strength might excel in power-oriented disciplines.[7] Plus, genetic variants can interact with environmental stimuli to produce unique outcomes.[7] Epigenetic modifications, influenced by environmental factors like nutrition and training load, can activate or suppress certain genes, ultimately influencing an athlete's response to training stimuli.[7] On this idea, (GWAS) has identified genetic variants that influence an athlete's response to training stimuli. These variants, when coupled with environmental conditions, can offer insights into personalized training strategies, optimizing an athlete's potential. Longitudinal studies examining athlete development over time have unveiled the interplay between genetic predispositions and training adaptation, and by tracking an athlete's progress and analyzing genetic markers, researchers can unravel the nuanced relationship between nature and nurture in the realm of athletic performance.[7]

Therefore, environmental factors, particularly training, hold a profound influence on athletic performance-related traits. Between training protocols, environmental conditions, and genetic predispositions, a unique path toward excellence is found as they all guide the design of personalized training approaches that harness an athlete's genetic advantages within their environmental context.

Psychology

Sports psychology is an area of psychology that investigates the mental components that influence the performance of athletes.[10] Sports psychologists assist athletes with performance enhancement techniques, motivation for increased performance, and stress and anxiety management, and they additionally provide psychological training to aid with performance.[10] They mention how physical training is crucial, but the way athletes show up psychologically on competition day and manage mental focus during their performance is equally important.[10] In fact, exercise genetics/genomics is an emerging study subject that addresses genetics and athletic performance strengths, weaknesses, opportunities, and threats.[11][14] Thus, athletic performance improvement is multidimensional, encompassing interactions between genes and the environment and developments in exercise physiology.[15]

Athletes' performance in sports is determined not just by their physical skills, but also by psychological factors.[12] A lack of confidence and stress management, for example, can be detrimental to sports performance.[13] A closer examination of the psychology of extraordinary athletic performance has revealed that specific psychological qualities are required to function effectively on the field.[10] Even the most physically gifted athletes can struggle to achieve success if they lack the proper mindset.[10] Attention, self-confidence, stress control, anxiety, motivation, discipline, and moods are all capable of having a direct effect on an athlete's performance.[12] Therefore, it is essential to consider both psychological and genetic factors when evaluating an athlete's performance. Ignoring either factor can lead to inaccurate assessments of an athlete's abilities and potential.[10] And by looking into this, coaches and athletes can develop effective training programs that address both the physical and psychological aspects of performance. This can lead to improved athletic performance outcomes and help athletes reach their full potential.[12]

Conclusion & Discussion

In the hopes of unraveling the web of factors influencing athletic performance, this review has delved into the dynamic interplay between genetics, environment, and psychology. The in-depth examination of genes associated with athletic ability reveals the crucial influence of genetics in determining a person's inclination to excel in sports. A review of the literature led to the identification of particular genes, each having distinct roles, variations, and connections with athletic attributes. All of these factors work together to impact an athlete's abilities ranging from the metabolic pathways that regulate energy production, to the composition of muscle fibers that determine strength and endurance. The connection between genes and genetic interactions provides a glimpse into the networks where multiple genes come together to influence performance.

Additionally, this review explored how environmental factors play a role in shaping an athlete's performance. Training serves as a bridge between their foundation and real-world outcomes. The interaction between predisposition and training methods has been found to shape an athlete's potential, and epigenetic changes add another level of complexity by highlighting how gene expression dynamically responds to influences. And although psychology may appear

separate from genetics at first, research has revealed connections between characteristics and genetic elements demonstrating the overall nature of athletic performance.

When numerous logistics should also be considered, there is a connection between an athlete and their genetic composition. It’s also important to note more studies need to be conducted on different types of sports, and in a broader audience. There needs to be more representation within women's sports and other age groups. Nevertheless, to get a true understanding of athletic performance, a comprehensive examination of both genetic predisposition and environmental interaction is needed. Athletic excellence is not merely a result of nature or nurture, but rather a connection between the two. Ultimately, athletic performance is a multifaceted outcome influenced by genetic predisposition, environmental factors, and psychological attributes.

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The Effects of COVID-19 To Economic Indicators In Australia By Eron Lin

Abstract

From 2018-2023, Australia's economic landscape changed drastically due to global challenges and technological shifts. Ultimately, the onset of the pandemic and the Delta variant's impact and global climate changes influenced trade and domestic financial behaviors. Inflation and interest rate changes altered spending, reflecting changing demographics in housing trends. Labour market shifts, especially unemployment, were driven by external factors and pandemic effects. In this paper, I review the impact of the Covid-19 pandemic on several economic indicators in Australia. Specifically, financial management frequently faces difficulties due to the interplay between inflation, unemployment, economic growth and distribution of income; According to Okun's Law, unemployment and economic growth have an inversely proportional relationship, but excessive growth can lead to high inflation and unemployment; The Phillips Curve also shows an inverse relationship between inflation and unemployment, coupled with the NAIRU, which defines an unemployment rate that keeps inflation steady. Furthermore, rapid economic development can exacerbate income inequality, particularly when combined with inflation, emphasizing the complexities of these interconnected economic challenges for policymakers. Prioritizing and effectively managing these economical challenges is considered difficult and by implementing macro and micro-economic conventions, policy-makers are capable of addressing these issues, which will be further analyzed in this paper.

Keywords

Behavioral and Social Sciences; Other; Australian Economics; COVID-19; Economic indicators

Introduction

The COVID-19 pandemic, emerging in late 2019, rapidly evolved into a global health crisis with profound implications across various sectors.[1] Among these, the economic impact has been particularly significant, reshaping economies worldwide. This paper delves into the specific context of Australia, examining the pandemic's multifaceted effects on the country's key economic indicators from 2018 to 2023. The aim is to comprehensively analyze how the crisis has altered Australia's economic landscape, focusing on trade, financial behaviors, inflation, interest rates, and labor market trends.[2]

Australia, known for its robust economy and resilient financial systems, was not immune to the pandemic's shocks.[3] The sudden imposition of lockdowns, travel bans, and other public health measures, while essential for managing the health crisis, had immediate and far-reaching economic repercussion.[4] This paper begins by establishing the pre-pandemic economic conditions in Australia, providing a baseline for evaluating the COVID-19 impact. The analysis then transitions into a chronological overview of the pandemic's progression and its corresponding economic impacts.

A critical aspect of this paper is the evaluation of policy responses. It examines both macroeconomic strategies, such as fiscal and monetary policies implemented by the government

and the Reserve Bank of Australia, and microeconomic aspects, including consumer behavior and business adaptations. These analyses are essential to understand not just the immediate effects of the pandemic, but also the efficacy and long-term implications of the policy responses.

Furthermore, the paper explores the sector-specific impacts of the pandemic. The disruption to global supply chains, for instance, had significant consequences for Australia's trade-dependent sectors. Similarly, the labor market faced unprecedented challenges, with certain industries experiencing severe job losses, while others, like technology and healthcare, saw growth.[4] The paper provides a detailed analysis of these sectoral shifts, offering insights into the pandemic's uneven economic effects.

In its conclusion, the paper not only summarizes the key findings but also contemplates the post-pandemic economic landscape of Australia. It discusses potential long-term changes in economic structures and behaviors, providing a forward-looking perspective. This includes considerations of how the pandemic might accelerate existing trends, such as digitalization and remote work, and how these shifts could reshape Australia's economic future.

Methods

This study utilizes publicly and freely available data to conduct a comprehensive analysis of the Australian economy in the context of the COVID-19 pandemic. The primary data sources include government reports from the Australian Bureau of Statistics, economic databases such as the Reserve Bank of Australia, and peer-reviewed articles from academic journals. These sources were selected for their reliability, breadth of information, and relevance to the Australian economic context. However, it is important to acknowledge the limitations inherent in these sources, such as potential biases in government-reported data or the lag in publication of the most recent economic indicators.

The data analysis was conducted using a combination of statistical methods and econometric models. Descriptive statistics provided a foundational understanding of the data, while more complex econometric techniques, such as regression analysis, were employed to examine relationships between various economic indicators. The choice of these methods was guided by their suitability to address the research questions, focusing on the economic impact of the COVID-19 pandemic on different sectors and demographics in Australia.

Graphical representations played a crucial role in this analysis. Pie charts were used to illustrate the distribution of economic impacts across different sectors, while time-series diagrams were employed to assist in theoretical analysis. The decision to use specific types of graphs was based on their effectiveness in conveying complex economic relationships in a comprehensible manner.

The theoretical framework of this study is rooted in a blend of Keynesian economics and supply-side theories, providing a balanced perspective on both demand and supply shocks caused by the pandemic. This theoretical lens was crucial in interpreting the data, particularly in understanding the multifaceted effects of COVID-19 on the Australian economy.

Comparative analysis with other countries was also conducted to provide a global context. This comparison highlighted unique aspects of the Australian economic response to the pandemic and offered insights into different policy approaches.

Interpreting the data involved a critical examination of the trends and patterns identified in the analysis. Conclusions were drawn based on the significance of these findings, taking into account the economic theories and the current global economic climate.

The study acknowledges its limitations, including the assumption that the available data accurately reflects the economic reality. Future research could expand on this study by incorporating more recent data, exploring additional economic indicators, and employing different analytical methods to provide a more comprehensive understanding of the pandemic's impact.

Economic Growth

Economic growth is conventionally measured as the percentage rate of increase in real gross domestic product (GDP).[3]

Economic growth is typically calculated using the following formula:

$$Economic\ Growth\ (\%) = \frac{GDP\ in\ current\ year - GDP\ in\ previous\ year}{GDP\ in\ previous\ year} \times 100\%$$

The Gross Domestic Product (GDP) is synonymous with aggregate demand when analyzed through its expenditure approach.[3] Accordingly, the GDP is deconstructed into its fundamental components, taking into account the contributions from distinct sectors:

$$AD = Consumption\ (C) + Investment\ (I) + Government\ Spending\ (G) + (Exports\ (X) - Imports\ (M))$$

Per Keynesian theory, short to medium-term economic growth is predominantly driven by demand factors, whereas long-term growth is attributed to the supply side, represented by Y.[5]

$$Y = Consumption\ (C) + Savings\ (S) + Government\ Taxation\ (T)$$



Figure 1: Australian GDP Quarterly growth

The economy experienced an average growth rate of 2.1%, as of October 2023, which fell from the 3.4% of average growth rate of the economy in the 2022-2023 financial year, illustrated by Figure 1.[6]

Yet, between 2013-2019, the Pre-COVID era, growth was below 3% p.a.,[6] largely attributed to sluggish productivity growth, explained by the governor of the RBA Phillipe Lowe where "Productivity growth was slowing before the pandemic and it is entirely possible that the disruptions caused by the pandemic made things worse". The economy faced a V-shaped recovery during the COVID-19 pandemic, rebounding sharply, as evidenced in Figure 2, fueled by significant government interventions, including an injection of the $89 billion Job-Keeper package, illustrated by the spike in government expenditure in 2020 and 2021, keeping business in operations.

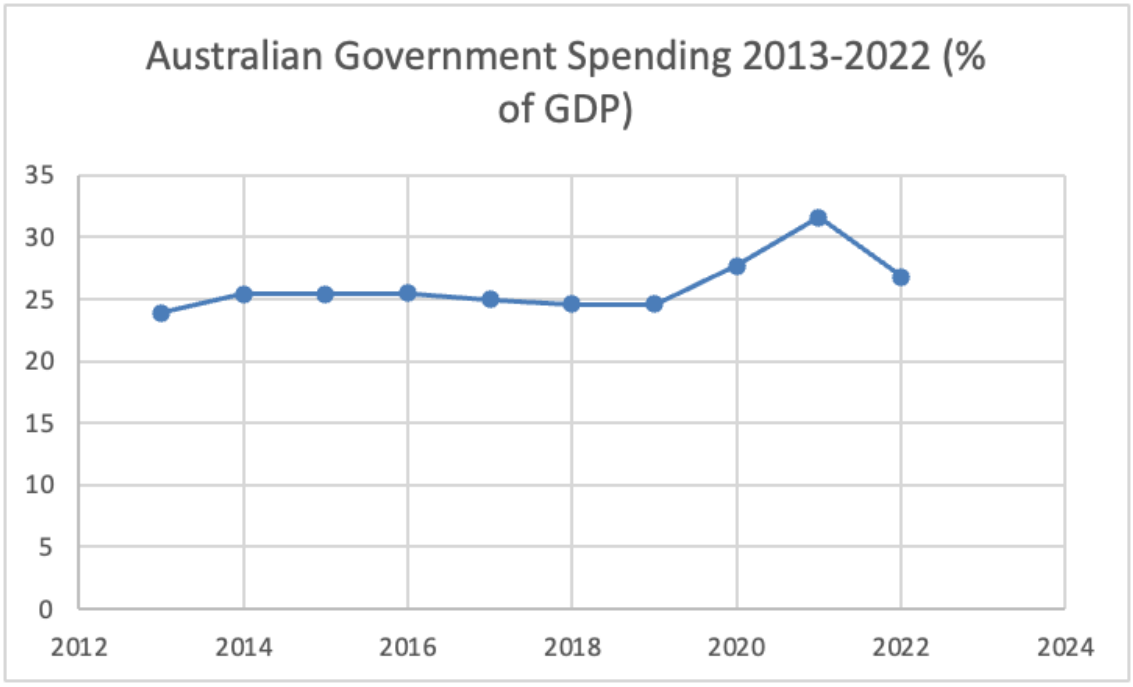


Figure 2: Australian Government Spending 2013-2022 (% of GDP)

These fiscal (macro) expansionaries, induces a greater proportional surge in Australia's GDP, thereby fostering growth, referring to Keynes "multiplier theory," where one individual's consumption translates into another's income.[3] An increase in government expenditure (G) results in an increase in aggregate demand, shifting the demand curve up, resulting in an increase in real GDP.

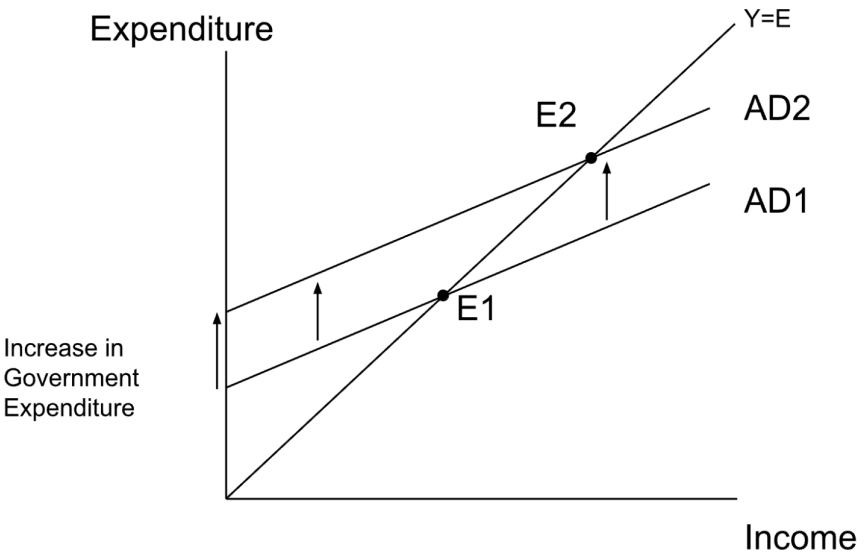


Figure 3: Income Expenditure Analysis

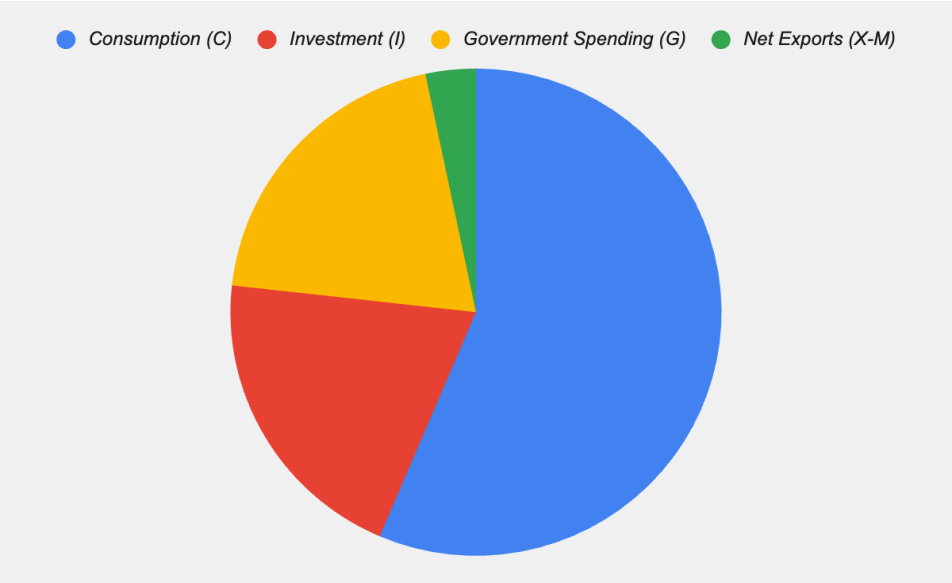


Figure 4: contributions to Australia's economic growth in 2023

Figure 4 shows that the economic growth in June 2023 was driven mainly by exports and government expenditure. The spike in exports was mainly contributed by the fallout from Russia's invasion of Ukraine, which led to an anticipated $460 billion in Australian resource and energy export revenues in 2022-23.[7] However, as energy prices revert to pre-invasion levels, export revenues are currently declining, illustrated by Figure 5.

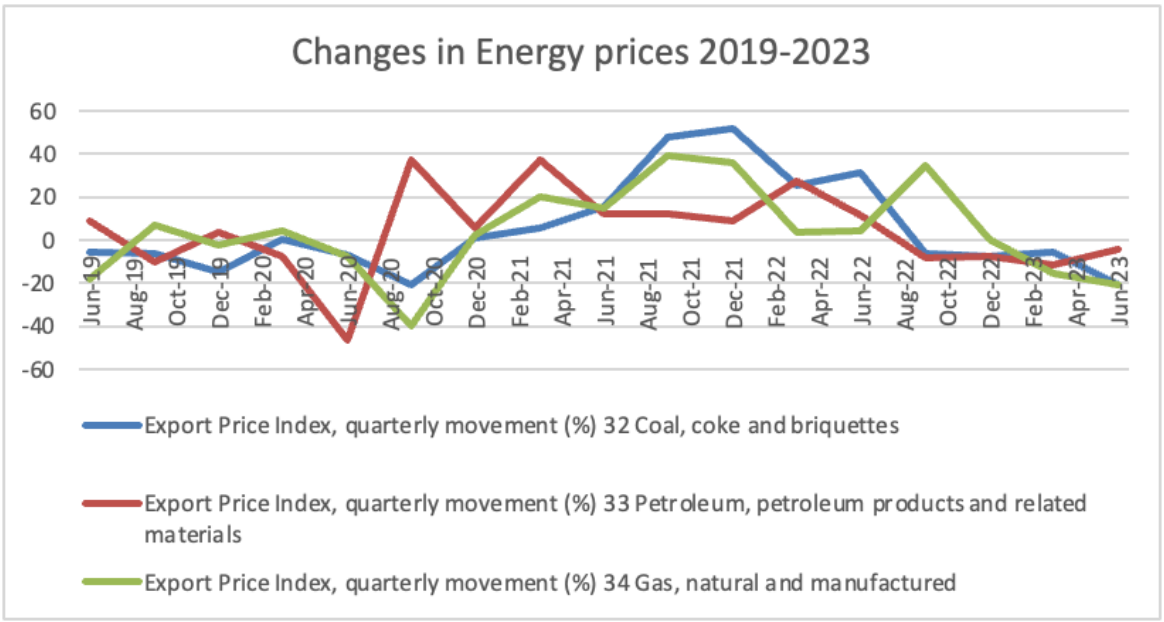


Figure 5: Changes in Energy Prices 2019-2023

Economic growth can stem from enhanced productive capacity (Aggregate Supply), which is significant for long-term non-inflationary growth.

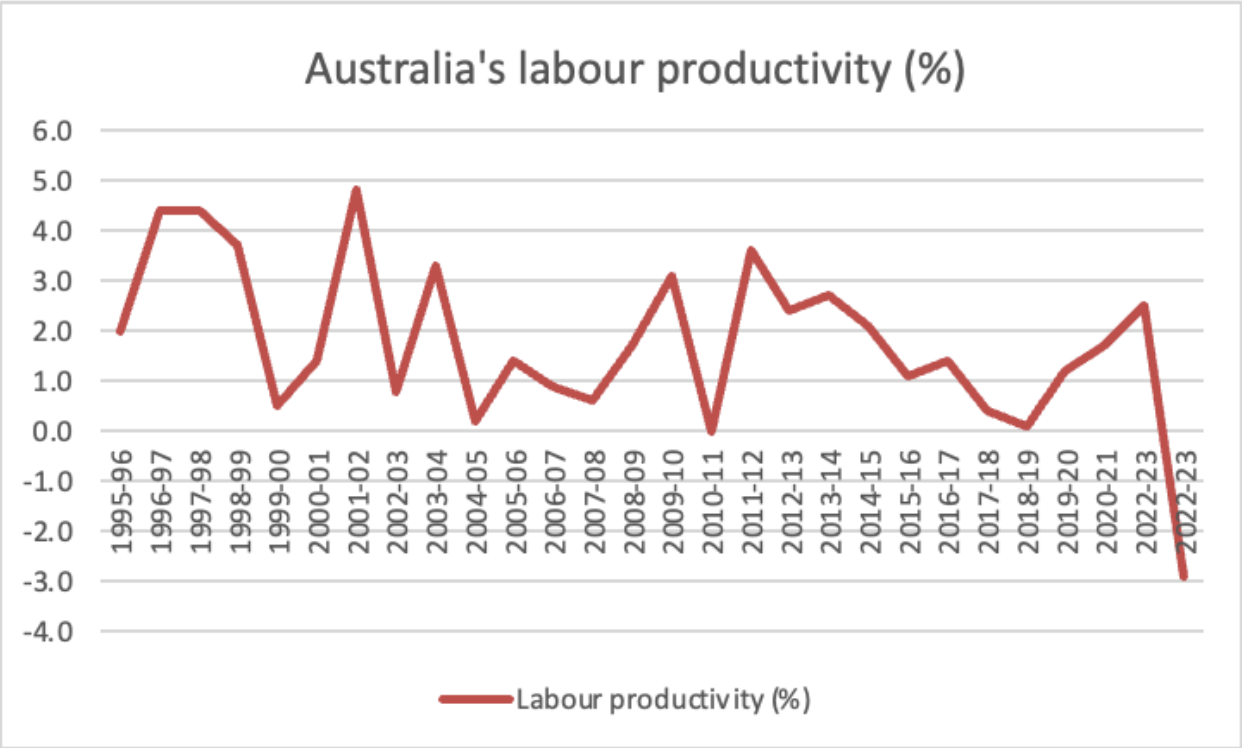


Figure 6: Australia's labor productivity (1995-2023)

As depicted in Figure 6, productivity saw significant growth of on average 2.2% p.a from 1995 to 2004 due to technological advancements and industrialization. Yet, it shows a slowdown between 2004-2017 of on average 1% p.a from diminished investment and innovation. While the pandemic spurred productivity via remote work efficiencies, post-COVID economic conditions with higher loan rates and lower investments are stalling its growth, with approximately on average 0.4% p.a.[8] Low productivity growth is now a primary concern for Australia, supported by the comments from famous treasurer Jim Chalmers, who said boosting productivity was "vital to boosting wages and living standards".

Supply-side growth's main benefit is long-term, non-inflationary economic expansion, illustrated by Figure 7, as an increase in productive capacity results in an increase in supply, which allows for growth without inflationary pressures.[3]

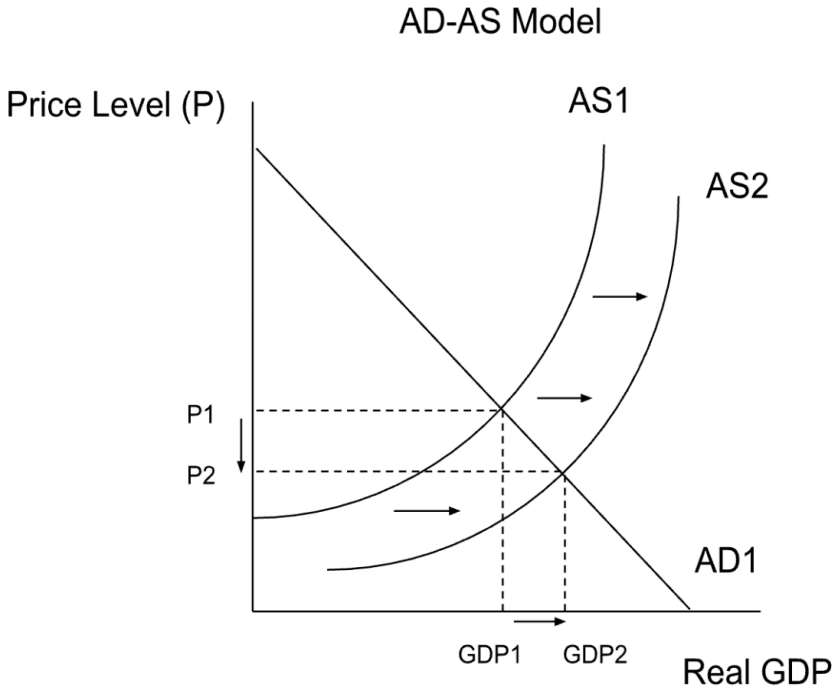


Figure 7: AS-AS model of increased economic growth due to increase in productivity

Unemployment/ Underemployment

In Australia, the unemployment rate represents the proportion of the labor force that, while actively pursuing and available for employment, remains unemployed;[3] unemployment rate is calculated by the formula:

$$Unemployment\ Rate\ (\%) = \frac{Number\ of\ Persons\ Unemployed}{Total\ Labour\ Force} \times 100\%$$

Whereas, the underemployment rate quantifies the proportion of the labor force that, while employed, is not operating at full capacity, either due to a preference for more hours or the availability to undertake additional work;[3] which is defined by the formula:

$$Underemployment\ Rate(\%) = \frac{Number\ of\ Persons\ Underemployed}{Total\ Labour\ Force} \times 100\%$$

After the COVID-19 pandemic, Australian cyclical unemployment rose in 2020. Cyclical unemployment develops as economic activity declines. The COVID-19 pandemic restricted global travel, coupled with the domestic lockdown, increased global uncertainty and lowered consumer and investor confidence to an all-time low of 79.6%,[9] illustrated by Figure 14. The decrease in economic growth in the Australian economy reduces demand for goods, services and labor, raising the unemployment rates. According to the Keynesian Recessionary Gap, even if

the aggregate demand equals the aggregate supply, expenditure may not be enough to fully employ resources.[3] Illustrated by Figure 8, full employment is at Y2, hence economic unemployment is the difference between Y2 and Y1.[3] Thus, cyclical shifts after the COVID-19 pandemic increased unemployment to 7.3% in 2020.[8]

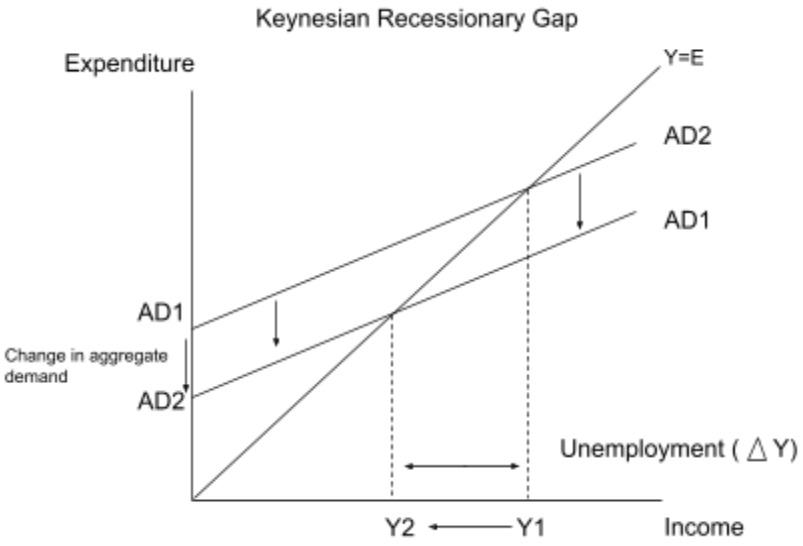


Figure 8: Keynesian Recession Gap resulted by a decrease in aggregate demand

The NAIRU, or the unemployment level where inflation is stable, was surpassed in 2022 with a 3.4% unemployment rate, below the RBA's estimated NAIRU of 4.25%. This low rate, a 48-year record, consisted mainly of structural or frictional unemployment, with minimal cyclical unemployment, mitigated by the Jobkeeper stimulus in which people did not become unemployed, but rather underemployed. This decline follows a peak of 7.4% in unemployment, illustrated by Figure 9, during the COVID period in July 2020, coinciding with a 0.3% deflation from weak demand.[10] This trend aligns with the Phillips curve, where low inflation correlates with higher unemployment.[3]



Figure 9: Australian Unemployment rate 2019-2023

In addition, the Fair Work Commission's decision to raise the minimum wage by 8.6% to $883 per week, which began 1st of July in 2023 due to the current inflationary pressures, is expected to have a substantial influence on the Australian labor market. When the minimum wage surpasses the market equilibrium, it may result in a surplus of labor,[11] illustrated by Figure 10, where there is an excess supply of workers who are seeking employment at the higher wage rate, but the number of available job posts is insufficient to accommodate them all. Employers, in light of escalating wage expenditures, may opt to reduce workforce or working hours, potentially exacerbating unemployment rates, resulting in an impact in the labor markets.[3]

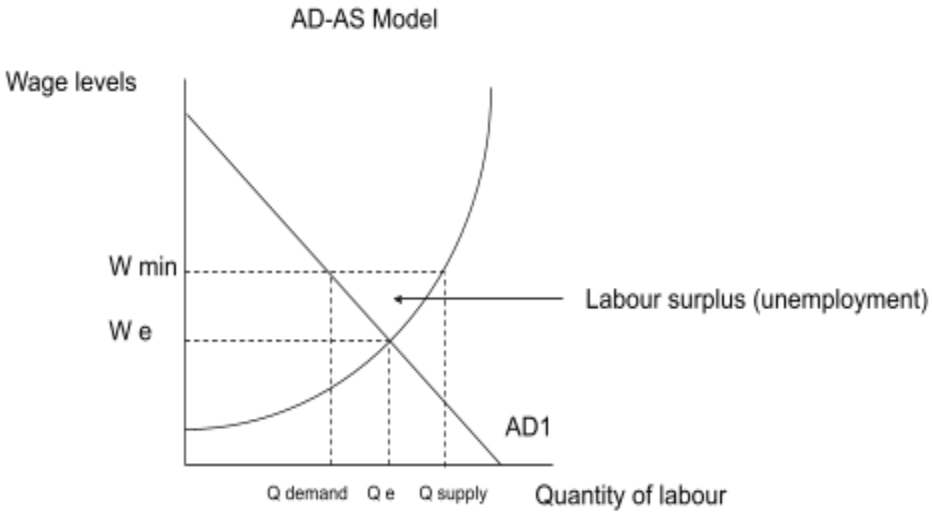


Figure 10: AD-AS Model of the effects of a minimum wage

Inflation

Inflation, which is commonly referred to as an economic problem, measures a sustained increase in the level of prices in the economy. The measurement of headline inflation is the Consumer Price Index (CPI), illustrated by Figure 11,[12] which calculates the price rise of a representative basket of goods consumed by a typical household in Australia.[3]

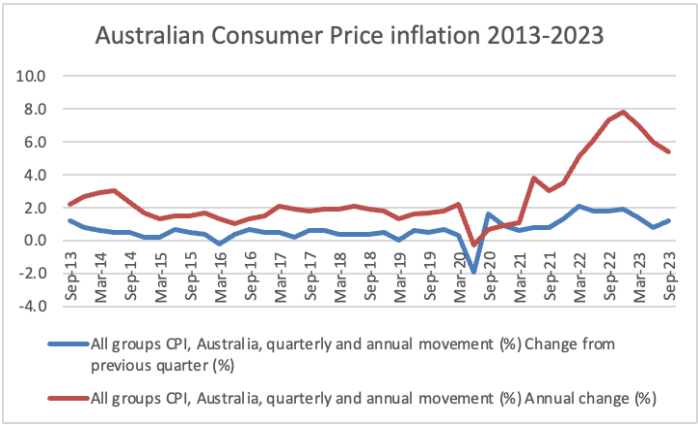


Figure 11: Australian Consumer Price inflation 2013-2023

The inflation rate can be calculated using the formula:

$$Inflation\ rate\ (\%) = \frac{CPI\ (current\ year) - CPI\ (previous\ year)}{CPI\ (previous\ year)} \times 100\%$$

The headline rate of inflation may sometimes be a misleading indicator as it factors in the prices of commodities that may be volatile, for example oil prices in the current environment.[3] Observing the underlying inflation, which adjusts the headline inflation rate for temporary external factors, such as wars or natural disasters that affect prices, may be considered more accurate. There are three main types of inflation that may occur in the economy, that is, cost-push, demand-pull and inflation due to consumer expectations.

The level of demand pull inflation, which happens when aggregate demand exceeds the economy's potential for productivity, rose between 2016 and 2018, largely driven by an increased demand for resources by China, because of their need to finish the One Belt One Road (OBOR), and due to expansionary monetary policy.[13] Consequently, aggregate demand grew through the increase of exports, illustrated by Figure 12. As output cannot react as indicated below, a higher demand in the short-run will result in an increase in price and demand pull inflation.[3] The figure also illustrates how real GDP will rise from GDP1 to GDP2, coupled with the increase in price level of goods and services from P1 to P2. As a result, the CPI increased to 2.1% in this period.[14]

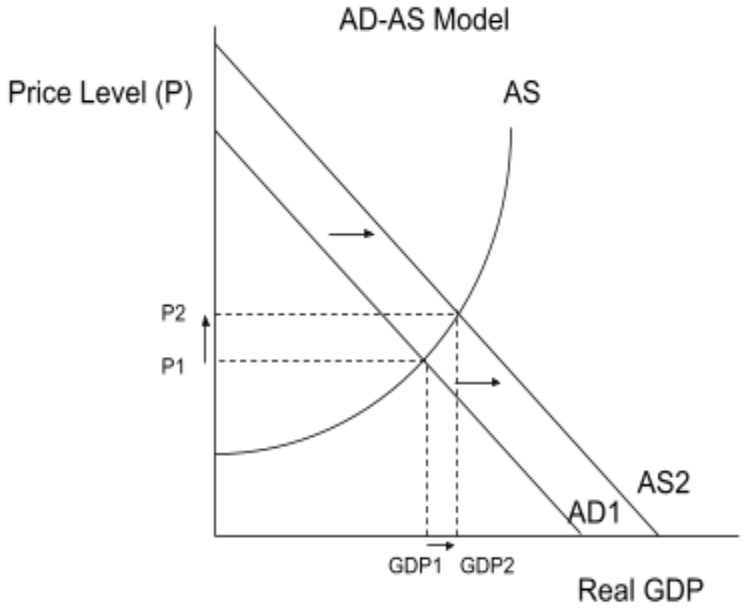


Figure 12: AS-AS model showing demand-pull inflation

Whereas, cost-push inflation, which occurs when manufacturing costs rise and are passed on to consumers in the form of higher prices, reached a significant level in 2011. Natural disasters in Australia in January of that year, including Cyclone Yasi and the Queensland Floods, decreased the supply of the country's agricultural and mineral resources.[15] Suppliers were then forced to pass on the expenses to customers, illustrated by Figure 14, which shows a decrease in aggregate

supply moving from AS1 to AS2, resulting in the establishment of a new equilibrium at a higher price and a lower output level.[3] As a result, the 2011 natural catastrophes increased cost-push inflation, as seen by the CPI increasing to 3.3%, illustrated by Figure 11.

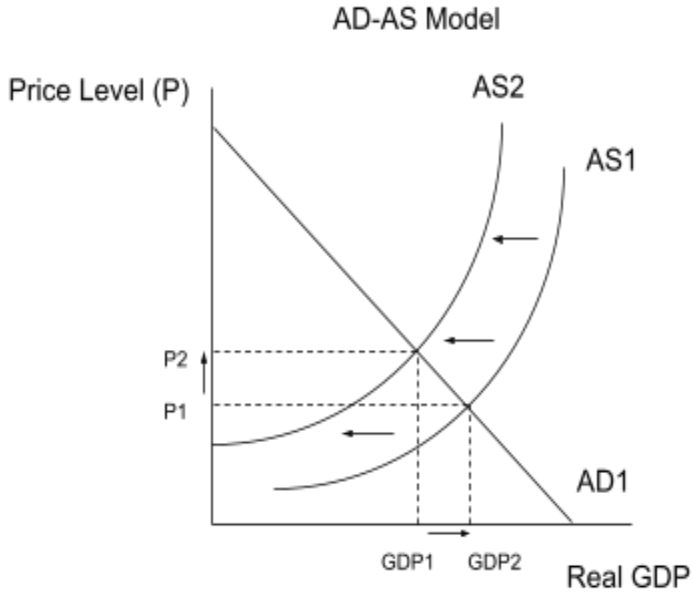


Figure 13: AD-AS model showing cost-push inflation

Post-pandemic, inflation ascended to an unprecedented 30-year pinnacle of 7.3% p.a.,[16] illustrated by Figure 11, influenced by a confluence of both demand and supply-side dynamics. The increase in aggregate demand from an escalation in consumption and governmental expenditure, amplified the concomitant demand-pull inflationary pressures.

While some disruptions were immediate during the pandemic's peak, supply chain disruptions have persisted post-pandemic, which resulted in a cost-push inflation, where bottlenecks at major global ports, shortages of shipping containers, and transportation issues have continued to drive up costs by decreasing the productive capacity. The post COVID cost-push inflation is illustrated by Figure 13.

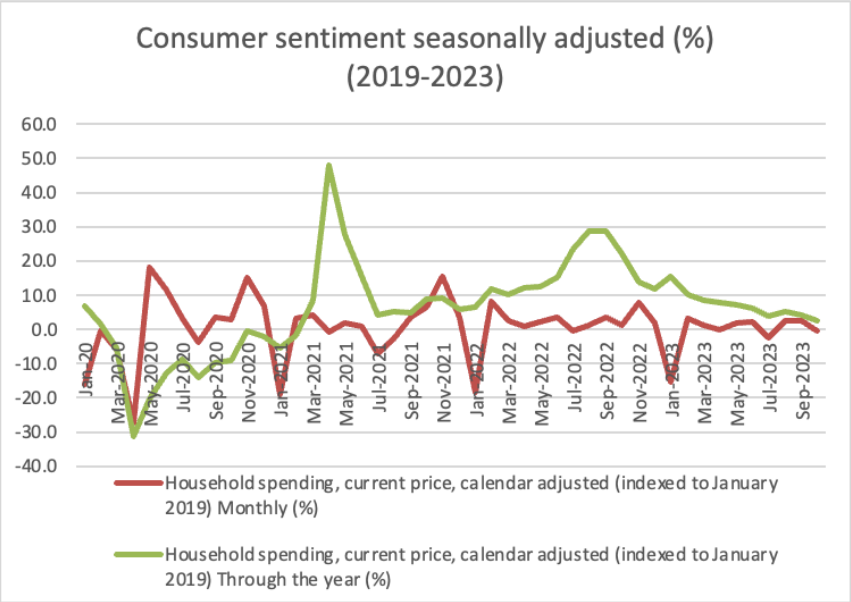


Figure 14: Australian consumer sentiment observed through household spending 2019-2023

Figure 14 depicts the sky-rocketed consumer sentiment from early 2020 to early 2021 reflecting a significant increase in consumer confidence and spending, which resulted in the demand-pull inflation of increased consumption. It also illustrates the plummeting consumer sentiment from late 2021 to 2023, which reflects a decline in aggregate demand, which was primarily resulted by the implementation of the contractionary monetary policy.[17] However, there exists a time-lag in the effects of Consumer Sentiment on GDP and inflation, which accounts for the persisting high inflation post-COVID at 6% as of October 2023.[18]

Distribution of Wealth and Income

Income/wealth equality refers to how evenly income/wealth is distributed throughout the economy. The GINI coefficient, derived from the Lorenz curve, illustrated by Figure 18, is the primary indicator of income and wealth equality.[3]

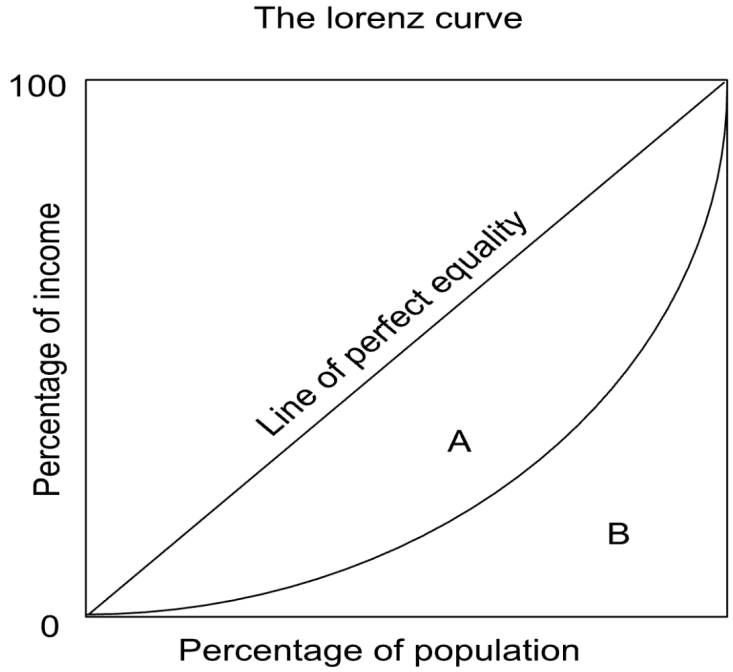


Figure 15: The Lorenz Curve

If income were distributed fairly across the entire population, the Lorenz curve would be a 45-degree diagonal line passing through the graph's origin. In a scenario of perfect inequality, the concavity will continue to increase until the curve forms a right-angle triangle.[3]

The GINI coefficient is a single statistic that measures the dispersion of the distribution of income across the population[3]. It is calculated by the formula:

$$GINI\ coefficient\ =\ \frac{Area\ (A)}{Area\ (A)+Area\ (B)}$$

Australia's Gini Coefficient fell from 0.328 to 0.324 between June 2018 and June 2020.[19] This shows that income disparity has decreased little during this time period; although the average Gini Coefficient for Australia from 1995 to 2020 is 0.313,[19] indicating that income inequality is higher in the recent context compared to the historical average, partially due to rising rents and the housing market.

Furthermore, Australia's income inequality sought an increase in 2007, peaking in 2008 with a Gini Coefficient of 0.336,[19] illustrated by Figure 16, which was mainly contributed by the 2008 financial crisis which significantly increased the income inequality in Australia. Whereas, Australia's Gini coefficient in 2023 is forecasted to be approximately 0.34,[20] which is still regarded as relatively high compared to the historical average.

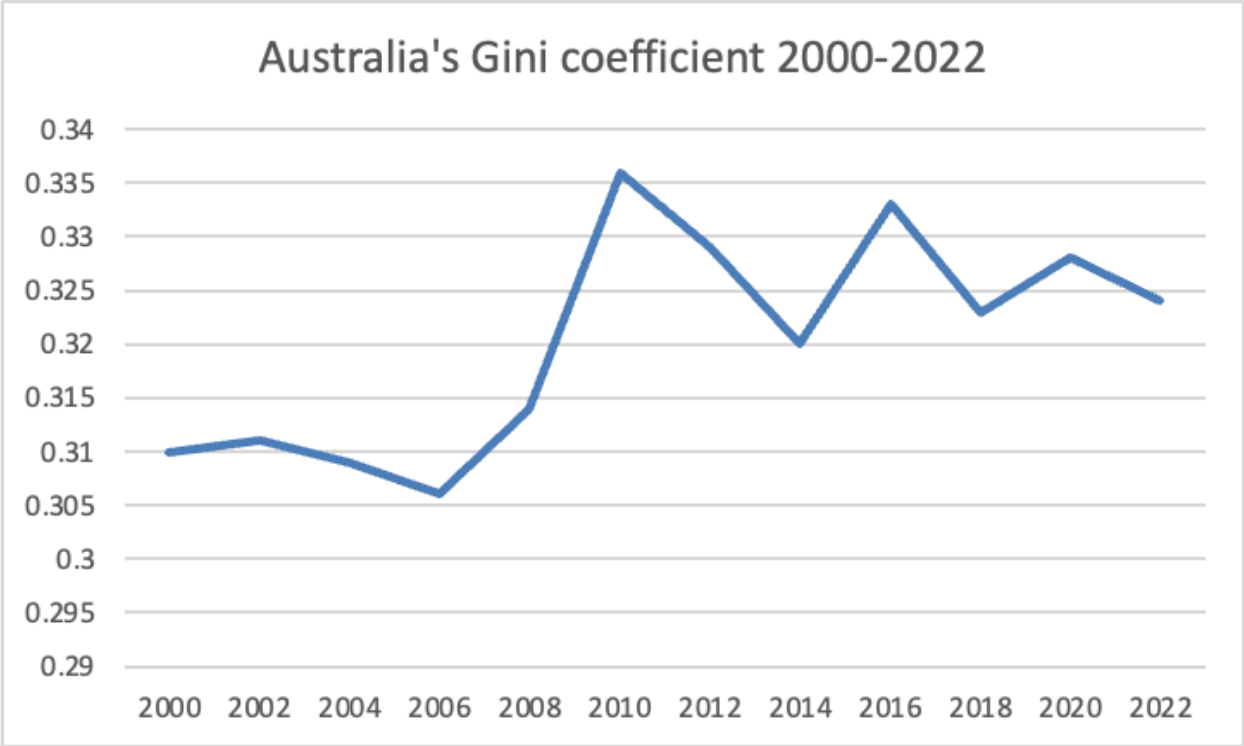


Figure 16: Change in Australia's Gini coefficient 2000-2022

Conclusion

Economics management is often challenged by the complex interplay of key factors such as inflation, unemployment, economic growth, and income distribution. These elements are not only deeply interconnected but also frequently at odds with each other, making the task of policy formulation and implementation a delicate endeavor. Okun's Law, a fundamental economic principle, suggests that there is an inversely proportional relationship between unemployment and economic growth. Essentially, as an economy grows and output increases, unemployment rates typically decrease due to the creation of more job opportunities. However, this relationship is not linear nor simplistic. Excessive growth, often fueled by overstimulation of the economy, can paradoxically lead to high inflation. When an economy grows too quickly, it can outpace the labor market's ability to adapt, leading to a shortage of skilled workers and, consequently, increased wage demands. These factors can contribute to inflationary pressures, complicating the economic landscape. Additionally, the Phillips Curve, another cornerstone of economic theory, indicates an inverse relationship between inflation and unemployment. This curve suggests that with lower unemployment rates, inflation tends to rise as employers pay more to attract workers, driving up consumer prices. Conversely, higher unemployment typically leads to lower inflation. The Non-Accelerating Inflation Rate of Unemployment (NAIRU) is a concept intertwined with the Phillips Curve, denoting an equilibrium unemployment rate where inflation remains steady. NAIRU underscores the challenge for policymakers in identifying the optimal level of unemployment that balances the need for economic growth without triggering runaway inflation.

The dynamics of rapid economic development further complicate this scenario. While growth is generally desirable, it can exacerbate income inequality, especially when paired with inflation. Rapid growth often disproportionately benefits the affluent, widening the wealth gap. This inequality is further intensified when inflation erodes the real income of lower-wage earners, reducing their purchasing power and deepening economic disparities.

For policymakers, these dynamics present several implications. First, there is a need for a nuanced understanding of the economic environment and the specific phase of the economic cycle in which their country operates. Policymakers must carefully consider the timing and scale of interventions, whether they are fiscal stimuli or monetary policy adjustments, to avoid overheating the economy or stalling growth.

Second, the relationship between these economic factors necessitates a holistic approach. Policies aimed solely at curbing inflation or reducing unemployment in isolation might lead to unintended consequences in other areas. For instance, aggressive measures to curb inflation could inadvertently spike unemployment, leading to economic stagnation.

Third, addressing income inequality should be an integral part of economic management strategies. This involves implementing policies that not only stimulate economic growth but also ensure that the benefits of this growth are equitably distributed. This could include progressive taxation, investment in social services, and policies that support wage growth among lower-income earners.

Lastly, the concept of NAIRU implies that maintaining a certain level of unemployment is necessary for stable inflation. Policymakers should, therefore, focus on the quality of employment and ensuring that the labor force is equipped with the skills necessary for the evolving job market. This approach might involve investing in education and training programs to increase the employability and productivity of the workforce.

In summary, the interplay between inflation, unemployment, economic growth, and income distribution presents a complex web of challenges for economic management. Policymakers must navigate these intricacies with a balanced, informed, and multifaceted approach to ensure sustainable and inclusive economic growth.

Acknowledgements

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