|CURIEUX|

ACADEMIC JOURNAL

September Issue

Issue 31: Part One

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Predicting Stock Prices Using Machine Learning By Vikram Krishnaswamy

Abstract

This project designed a predictive model that can accurately predict changes in stock prices for companies in the technology sector. This paper focuses on how the information contained in companies' quarterly reports and macroeconomic data contribute to their stock price. The input data came from various sources including FRED, AlphaVantage, SEC EDGAR, and Yahoo! Finance. The data was manipulated and shaped into training data to build a Regression and Classification model. This model will then predict stock prices based on the shaped data. There will be a discussion afterward about how accurate the model is, the use cases for this type of work, and which pieces of data were the most important for the model to predict prices accurately.

Introduction

The stock market is widely regarded as one of the best ways to build and maintain wealth. The average annual returns of the S&P 500, widely considered the sentinel benchmark of the US stock market, have been around 12.84% since 2012 (Investopedia). Other investments such as real estate and bonds have yielded only 3-5% per year on average ("What Is Appreciation in Real Estate? | Gatsby Investment"). The low barriers to entry and profitable returns make stocks a highly sought-after financial vehicle.

While investing in stocks can be highly profitable, it is also highly volatile, as stock prices are notoriously difficult to predict. Therefore, retail and institutional investors have attempted to create optimal investment strategies to predict future stock prices. Yet, for the most part, humans have yielded sub-optimal results. Stock prices depend on many individual variables, which may not all be accessible when making investment decisions. The fact that most, if not all, investment advice websites have a legal disclaimer explaining that they can not be held liable for their advice further emphasizes that no one can correctly account for all the variables that affect stock prices.

However, recent advances in quantitative finance have demonstrated that computers may be better equipped to predict stock prices than humans. While using computers to trade has its

challenges, such as data quality and model accuracy, computers can process and analyze vast amounts of data quickly and efficiently.

This paper aims to contribute to the ongoing efforts to develop more accurate and reliable methods for predicting stock prices, with the ultimate goal of helping investors make more informed and profitable investment decisions.

This paper will explore several models using data from FRED, AlphaVantage, SEC EDGAR, and Yahoo! Finance.

Literature Review

For centuries, academic researchers have been trying to identify which variables affect stock prices. Eventually, two approaches emerged: fundamental analysis and technical analysis. Fundamental analysis involves leveraging financial metrics to assess the intrinsic value of a stock, thereby aiding in the determination of whether the stock is overvalued or undervalued. The fundamental analyst assumes that the stock price will eventually converge toward its valuation. Though this method may seem logically sound, not all fundamental analysis methods are effective. Different analysis methods could lead to differing views on the intrinsic price of a stock (Petrusheva and Jordanoski).

Technical analysis is a method used by investors and traders to analyze financial markets by examining historical price and volume data. It revolves around the belief that previous market patterns can provide insights into future price movements. This approach involves studying various technical indicators, such as moving averages, support and resistance levels, and chart patterns, to identify potential buying and selling opportunities. Though technical analysis is not based on any reproducible finding, it can be used to make short-term decisions that result in immediate profit and influence long-term strategy. Additionally, there are many computer algorithms that can conduct technical analysis. This paper is mainly focused on fundamental analysis while factoring in micro and macroeconomic variables used in technical analysis (Petrusheva and Jordanoski).

In Nobel prize-winning financial economist Eugene Fama's paper introducing the random walk theory, Fama questions the logic behind both technical and fundamental analysis. In the random walk theory, the stock market does not instantly absorb information, and the same piece of information can have different interpretations in various analyses. Therefore, even if a

fundamental analyst identifies a significant disparity between the intrinsic price and market price, the market price will not rise to match the intrinsic price unless the analyst's information becomes publicly available and is universally understood. Depending on the valuation methods used, the presence of information can lead to over-correction or under-correction in the stock market, contributing to the difficulty of predicting day-to-day fluctuations. While open to interpretation, technical analysis can be unreliable and resemble a speculative guessing game. As a result of these factors, numerous studies have indicated that stock market price changes are independent, and resemble a "random walk" rather than a predictable pattern (Fama). If this hypothesis is to hold, predicting stock prices precisely, whether through traditional means or using machine learning, should be nearly impossible.

A study conducted by Ati Herawati and Angger Setiadi Putra published in the European Research Journal investigated the impact of fundamental factors, such as financial ratios, on the stock price of food and beverage companies in Indonesia. The key metrics that the study focused on were Debt to Equity ratio, Return on Assets, Current ratio, Price to Earnings, and Total Asset Turnover. The study was performed using panel data regression analysis and three approaches: Common Effect, Fixed Effect, and Random Effect. The researchers found that metrics such as Return on Assets, and Total Asset Turnover had a significant correlation with stock price. The findings of this study show that fundamental factors can play a role in stock price, but other variables need to be considered as well (Herawati and Putra). Although this study was conducted on the Indonesian market, similar dynamics about fundamental valuation should still hold because widespread information and similar dynamics that exist in the Indonesian markets also exist in US markets.

This paper will be trying to predict the effects of the information in quarterly reports on the price of various technology sector stocks. Though there have been mixed results in the past, by combining fundamental and technical factors with machine learning, my model shows some ability to predict changes in stock prices accurately.

Methodology–Data Gathering

To identify which companies to study, I chose 25 of the biggest technology or telecommunications companies and considered the past five fiscal years' worth of data for each company. I focused on a specific industry rather than the stock market at large to limit the

number of confounding variables in the study. If a more diverse selection of companies had been included, there may have been industry-specific nuances limiting my model's ability to make predictions about the market.

All of the data for this study fell under three general categories: financial data about the company, macroeconomic data, and stock price data. I chose company metrics that reflect their ability to earn profit in the future, as most valuations of a company are based on a discounted cash flow model. I also analyzed data on the company's current financial state by looking at its revenue, assets, and liabilities. I selected economic factors that would accurately reflect public opinion around the market. For example, one of the biggest drivers of stock prices is what consumers predict about the economy, leading to the inclusion of consumer sentiment in the model.

One dilemma faced when training the model was whether to use data from the peak of the COVID-19 global shutdown or to disregard the data. I finally decided on using the data, as my thought process was that the economic factors should be able to explain the price changes even if the financial fundamentals can not.

Data Processing

Company-specific financial data was from two primary sources, AlphaVantage and Yahoo! Finance. I relied on macroeconomic data from the FRED API. The financial data from the AlphaVantage API and the stock price data from Yahoo! Finance did not require preprocessing. However, the macroeconomic data from FRED had many missing entries and required preprocessing. To impute the missing values, I used linear interpolation and regression to approximate the missing values.

Approaches and Normalization

My first approach was to predict a numerical value for the final price after the quarterly report was released. However, even though this approach yielded an adjusted R-squared of around 0.8, it also yielded a very high root mean squared error, making it unsuitable for any practical applications. Therefore, instead of trying to predict the numerical value of the final price, I tried to predict the percent change in the closing stock price between the day before and after the report was released.

In order to make sure that all of my input variables had a similar scale, variables were normalized using z-scores and log scaling. For most cases, I used log scaling on the fundamental financial aspects of the data, as many variables conformed to the power law distribution. Alternatively, most of the economic variables conformed to a normal or bimodal distribution, so I used the z-score method to reduce their scale. The results of the normalization for my original method are shown in Figures 1 and 2 below.

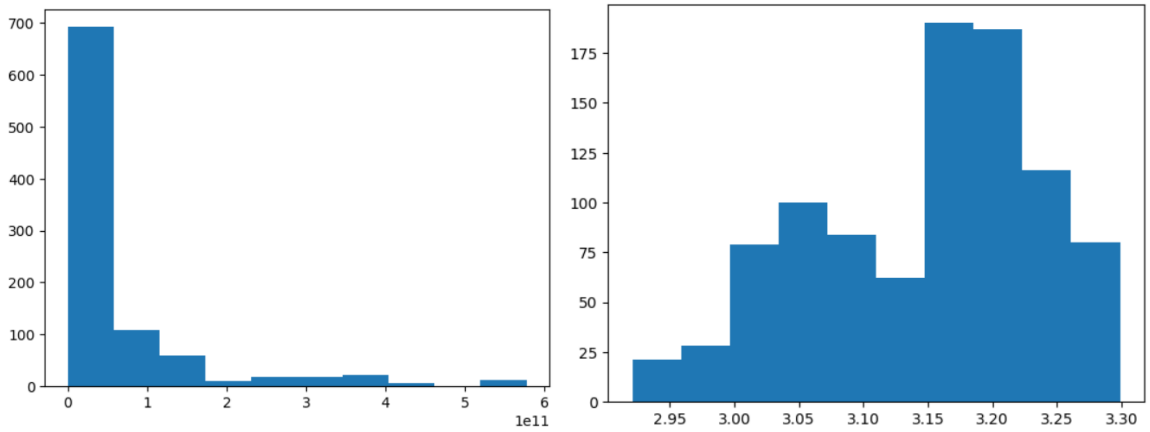

Figure 1:

Frequency distribution of Total Assets before (left) and after (right) normalization. The x-axis scale is 10^{11}.

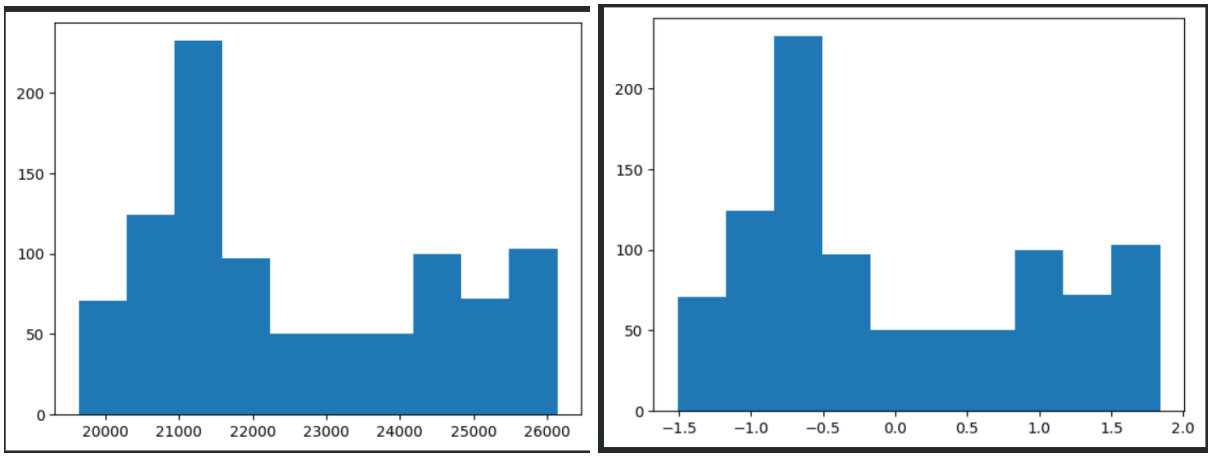

Figure 2:

Frequency distribution of GDP before (left) and after (right) normalization. The x-axis scale is 10^{11}.

To normalize all of my data in the latter approach, raw numerical data was transformed into percent change in decimal form. For example, under the total revenue column of my data, I stored the percent change in revenue between the current report and the last fiscal quarter. Since every variable was then on a similar scale, there was no need to use any additional methods such as log scaling and z-scores.

Feature Selection

To select an optimal combination of input features, I plotted the correlation of every input variable with every other input variable and the output variable. Figure 3 shows the correlations. "SP" stands for the change in the S&P 500 index; "Cons_sent" stands for the change in Consumer sentiment (taken from FRED); "Fin_Stress" stands for the change in Financial Stress (taken from FRED).

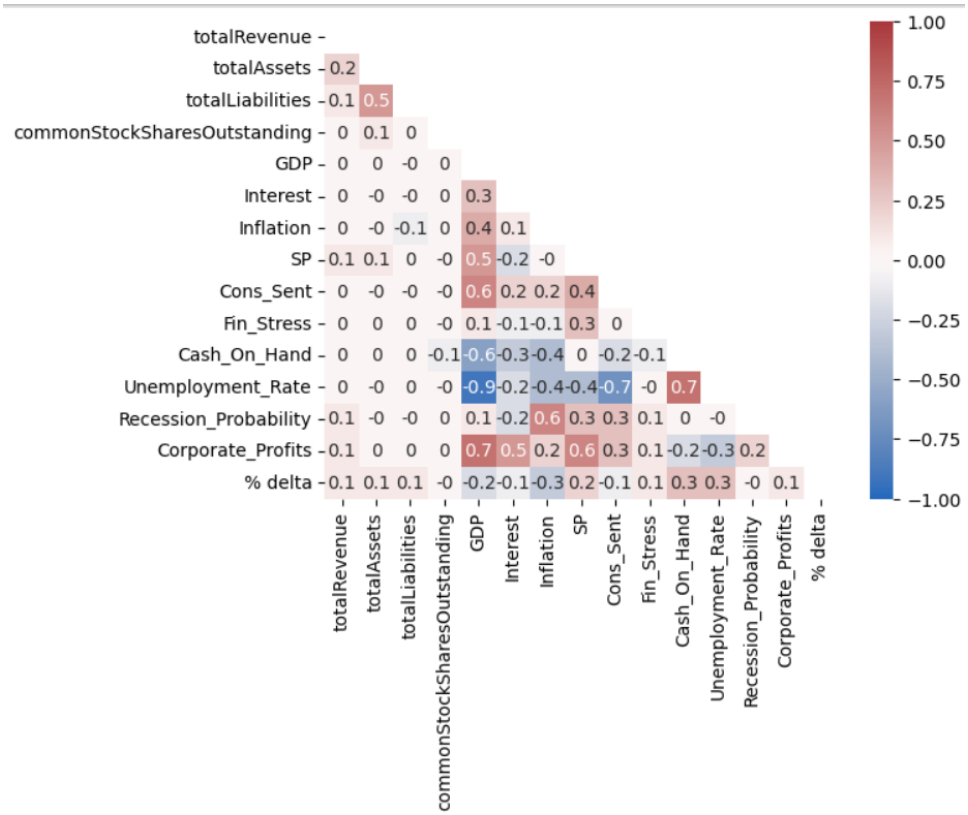

Figure 3: Heatmap of correlations between all variables. All values are correlation coefficients calculated using the Pearson method.

From my original set of input variables, I removed all of the variables that had no correlation with the percent change in stock price, labeled "% delta" in the heatmap. In order to further reduce the number of input variables, I removed input variables that had correlation coefficients of 0.7 or higher with other input variables. For example, the correlation coefficient between GDP and Corporate profits is 0.7, so I looked at which variable had a stronger correlation with the output variable and kept it in the model. In this case, GDP was kept in the model, and corporate profits were removed. After removing a significant amount of the collinearity, the final set of input variables included the percent change in total revenue, total assets, total liabilities, shares outstanding, GDP, interest rates, inflation, the S&P 500, consumer sentiment, financial stress, and cash on hand.

Model Calibration

Stock prices were predicted using two different approaches. First, regression algorithms were used to predict the percent change in price between the day before the report was released and the day after the report was released. After testing over 30 different regressors, the models that had the highest adjusted R-squared values were the XGB Regressor, Ada Boost Regressor, and Decision Tree Regressor.

The second approach classified the stock price as increasing (represented by a one) or decreasing (represented by a zero). After testing over 30 different classifiers, the models that had the highest accuracy were the Calibrated Classifier CV, Logistic Regression, and Ridge Classifier.

Results and Discussion–Adjusted R-Squared and Accuracy values

Regression

Model	**Adjusted R-Squared**	**Root Mean Squared Error**
XGB Regressor	0.51	0.31 (in %)
Ada Boost Regressor	0.46	0.32 (in %)
Decision Tree Regressor	0.42	0.34 (in %)

Classification

Model	Accuracy	F1 Score
Calibrated Classifier CV	0.67	0.73
Logistic Regression	0.66	0.72
Ridge Classifier	0.65	0.72

(All values reported under the classification models are the result of a 10-cross-fold validation)

Interpretation

My best adjusted R-squared value of 0.51 shows that around 51% of the changes in stock prices can be explained by changes in the input variables. Surprisingly, most of the variables that had a higher correlation with the stock price were related to macroeconomic conditions, rather than data describing the companies' financial position (Figure 3). However, it is notable that every financial metric used had a positive correlation with changes in stock prices, as expected. A potential explanation for the macroeconomic factors playing a larger part in the stock price could be that a part of the data was taken during the COVID-19 global shutdown. At the time, financial fundamentals may not have been able to explain changes in the stock price as well, leaving the model to rely on the macroeconomic data instead.

Looking at the accuracy and F1 score values, the classification models did much better than a random selection. To evaluate how well my models did at distinguishing whether the stock price would increase or not, I plotted a confusion matrix (shown below).

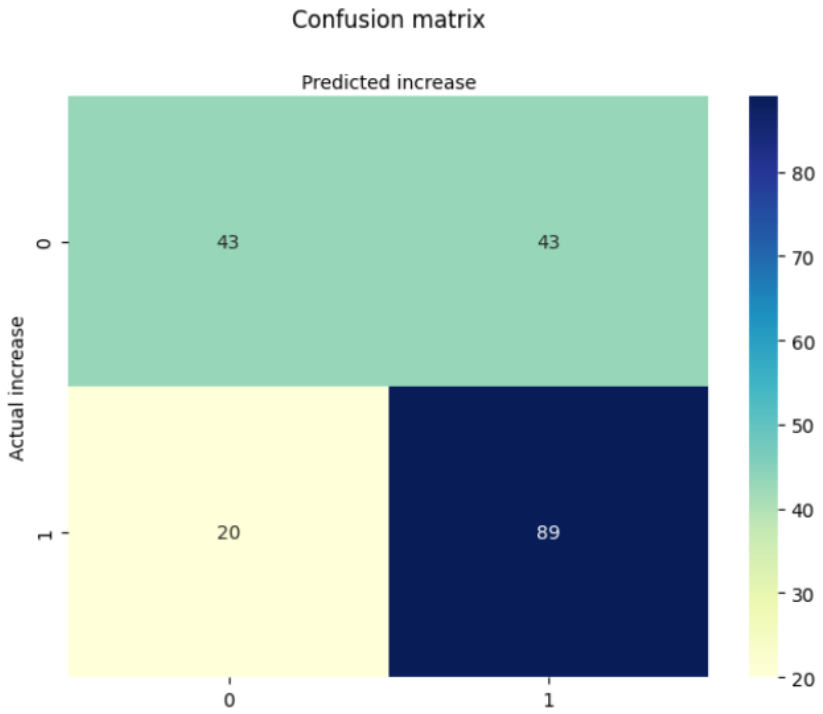

Figure 4: Confusion matrix for Calibrated Classifier CV. A 1 in the matrix represents the stock price increasing while 0 represents the stock price decreasing

Based on the confusion matrix, it is evident that my model has a problem with false positive results. In the context of predicting stock prices, false positives may be one of the worst types of mistakes a model can make, as the people using the model would expect to make money off the prediction. When the model predicts that the stock price will increase, there is a 67.4% chance that the prediction is true. However, even if the model returns a false positive, an investor could still hold their shares and make a profit later on

Another devastating error that the model could make is a false negative. If an investor shorts a stock based on the model, they could potentially incur huge losses that could not have come as a result of a false positive.

Limitations

If I were to repeat this study and had access to more resources, I would gather data from more companies and include more data that represents public sentiment about the economy, the products the company sells, and the company itself. In this study, I could only gather around 950 data points to use without paying for any premium data sets/API services. If I had access to more

data, the models may have yielded better results. Another weakness in the study is that the model included little data related to what the public thinks about a company. In the end, the price of a stock is completely dependent on the demand for the stock. Therefore, by including sentiment data, the models may have been able to predict the stock price more accurately.

I started this paper by saying that the fact that most financial websites have a disclaimer that explains the website can not be held liable for their advice. In hindsight, predicting stock prices accurately is an extremely difficult task due to the extremely complex market dynamics, and perhaps even the random walk theory. Based on my results, I now find myself understanding why such websites have disclaimers attached to them.

Despite the limitations, such as the need for access to more comprehensive data and addressing false positive and false negative errors, this paper demonstrates the potential of combining fundamental and technical factors with machine learning to achieve some degree of predictability in stock prices. By continuing to refine and enhance these prediction models, investors can make more informed and potentially profitable investment decisions in the stock market.

Data Sources

Financial data: https://www.alphavantage.co/documentation/

Macroeconomic data: https://fred.stlouisfed.org/docs/api/fred/

Price data: https://pypi.org/project/yfinance/

Acknowledgment

All ideas and research conducted in this study are my original work. I did have the help of a mentor that works in data science who gave me small hints when I needed them and to point me to any resources I could use. In total, my mentor spent less than 10 hours helping me with my project.

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Assessing Accuracy of Different Machine Learning Models for Obesity Classification By Akash Danda

Abstract

According to the CDC and AMA(American Medical Association, Obesity is considered a chronic disease. Obesity today is more of a problem than ever before. Worldwide, obesity affects around 1 billion people and in the United States alone around 80 million. As time progresses, the population with obesity is on an upward trend. With more fast food, increased use in technology, and decreased physical exercise, obesity is becoming more prevalent especially among the youth. Obesity is a complex multifactorial disease and it is important to determine what factors actually cause obesity and how to prevent it. In the past, there haven't been many predictive classification models for predicting obesity. This paper explores the effectiveness of 5 different classification models for predicting obesity: logistic regression, decision trees, random forest classifier, naive bayes, and neural networks.

Introduction

Obesity can lead to many chronic illnesses and diseases. Individuals with obesity have far higher chances of heart disease, stroke, diabetes, hypertension, and gallbladder disease. There is an upward trend for obesity. Obesity worldwide has nearly tripled since 1975. In 2020, 39 million children under the age of 5 were overweight or obese. Researchers have studied different factors contributing to obesity but there isn't just one specific set of factors that directly causes obesity. There are many controversial definitions of what obesity actually is. In this study, I use the definition from the World Health Organization. An adult is obese if their BMI(Body Mass Index) is greater than or equal to 30. An adult is overweight if their BMI is greater than or equal to 25 but less than 30. For this paper, I use UC Irvine's dataset: "Estimation of obesity levels based on eating habits and physical condition". From this dataset, I used certain factors to account for obesity: gender, age, height, weight, family history, individual consumption of high caloric food, meals eaten per day, food consumption between meals, whether individuals smoke, whether individuals track their calories, frequency of physical activity, usage of technology, water consumption, most used source of transportation, and alcohol consumption. This dataset consisted of over 2000 individuals with different backgrounds and factors. I used different

machine learning algorithms to see which one was the most effective in predicting if a person is obese. I used logistic regression, decision trees, the random forest classifier, neural networks and naive bayes. For naive bayes, I assessed the accuracy of the Gaussian, Multinomial and Bernoulli classifiers.

Methodology

From the archives of UC Irvine's database on machine learning datasets, I was able to use the dataset, "Estimation of obesity levels based on eating habits and physical condition". Since this study is considered a classification study, individuals either were assigned a 0 or 1. 0 meant the individual wasn't obese. 1 meant the individual was obese. Regardless if an individual was in class 1, class 2, or class 3 of obesity, they all were assigned a value of 1. If an individual was considered underweight, normal weight, or overweight, they were assigned a value of 0.

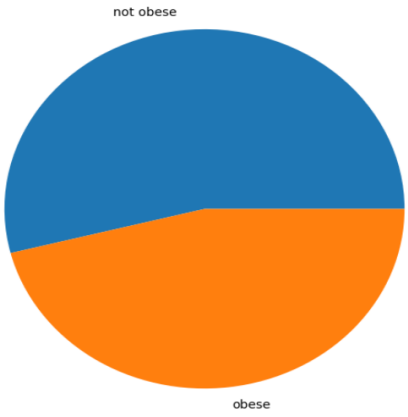

Figure 1. Obesity Results

In the dataset, 1149 individuals weren't considered obese(blue). 972 individuals were considered obese(orange) which includes all three classes. The independent factors were also all assigned numerical values to make it easier to conduct the proper analysis. Height was measured in meters and weight was measured in kilograms. For family history, 0 means somebody in the family was obese, 1 meant no one in the family was obese. Consumption of high caloric food was broken down into two categories: 0 meant the individual usually didn't consume high caloric foods, 1 meant the individual consumed high caloric foods frequently. Meal consumption was broken down into 3 parts: 1 for 1-2 meals, 2 for 3 meals, 3 for more than 3 meals. Food consumption between meals was split into 4 parts: 0 for never, 1 for sometimes, 2 for frequently,

3 for always. Smoking had 2 different responses: 0 for no, 1 for yes. Daily consumption of water had 3 different answers: 1 for less than one liter, 2 for one-two liters, 3 for more than two liters. Calorie tracking had 2 responses: 0 for doesn't track, 1 for does track. Frequency of physical activity was split into 4 different responses: 0 for no physical activity, 1 for 1-2 days weekly, 2 for 3-4 days weekly, and 3 for 5-7 days weekly. Use of technology daily was split into 3 different responses: 0 for 0-2 hours, 1 for 3-5 hours, and 2 for more than 5 hours. Alcohol consumption was split into 4 parts: 0 for never, 1 for sometimes, 2 for frequently, 3 for always. Primary sources of transportation were also split into 3 parts: 0 for automobiles, 1 for public transportation, and 2 for walking. After cleaning the data, the next step was scaling the data. Scaling the data played an important role in the accuracy of some of the classification models like neural networks, and logistic regression. However it isn't necessarily as significant for naive bayes, decision trees, and random forest classifiers. The decision tree model doesn't necessarily require scaling because the process of splitting was less based on absolute values and more based on relative comparisons. The same applies for random forest classifiers. The Naive Bayes model isn't significantly affected by scaling as features are independent of each other. After scaling the data, I applied the different machine learning models to the data. Note: I applied some of these models to the data before scaling to see the difference in accuracy.

Results–*Numerical Results*

Before scaling the data, the logistic regression model, the accuracy was 94.1%. After scaling the data, the accuracy of the model was 95.6% which is a 1.5% increase. The training size was 70% while the testing size was 30% of the data. I used a random state of 42 for the train test split.

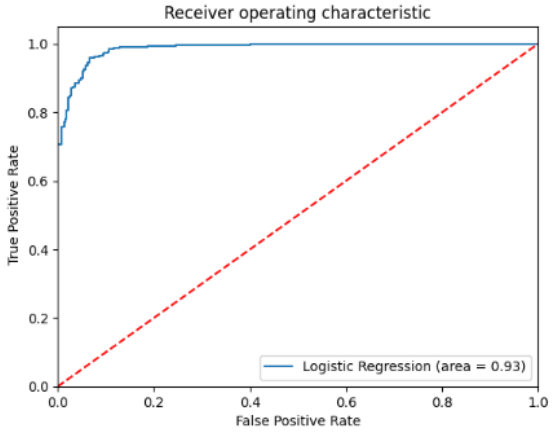

Figure 2. ROC Curve

Above is a receiver operating characteristic (ROC) curve of the logistic regression model which plots the true positive rate(TPR) against the false positive rate. The closer the TPR is to 1, the more accurate the model is. In this model, the TPR is 0.93 which means it is very successful in distinguishing the positive and negative outcomes. Next, I created the Naive Bayes classifier and there were three specific ones: Gaussian, Multinomial and Bernoulli. Bayes theorem states that there is independence between features between the features which isn't necessarily true with this dataset. For example, physical activity can have a direct effect on the eating habits of the individual. Naive Bayes is also primarily used for text classification. These factors can explain why these classification models aren't very accurate.

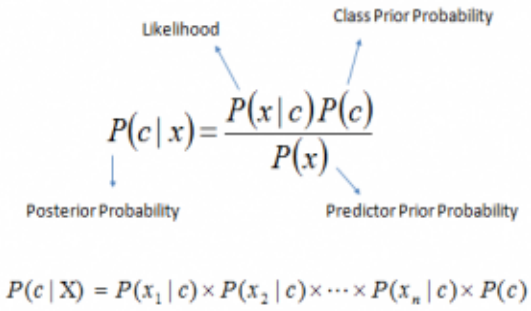

Figure 3. Naive Bayes: Analytics Vidhya

Above is a figure that explains the math behind the Naive Bayes algorithm. The Gaussian classifier had a 77.6% accuracy. The Multinomial classifier had a 86.9% accuracy, and the Bernoulli classifier had a 63.1% accuracy. Next, I created a decision tree classifier for this dataset. With a test size of 30% and a random state of 42, the model had a 96.8% accuracy. Even though the decision tree model has a very high accuracy, it is important to consider the fact that decision trees don't generalize data well and it can be very unstable as small variations in data can lead to drastic changes. This is why I considered a random forest classifier as it prevents overfitting by using multiple trees. After the decision tree model, I created a random forest classifier which had a 97.5% accuracy. I made the model so that there were 30 "n_estimators" which represented the amount of trees in the Forest. I set the "max_leaf_nodes" at 12 to restrict the growth and to prevent the classifier from becoming hypersensitive.

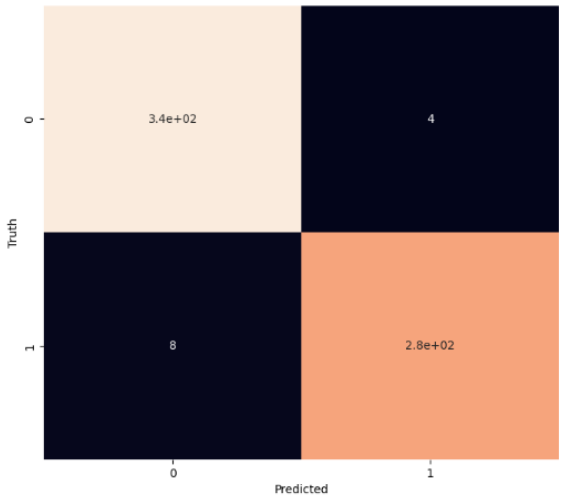

Figure 4. Confusion Matrix

After that, I mapped a confusion matrix for the random forest classifier. The numerical values for the true positive and true negative were much higher than the values of the false positive and the false negative. The true positive had a value of 342, the true negative had a value of 280, the false positive had a value of 4, and the false negative had a value of 8. Finally, the neural network model that I created had an accuracy of 92.76% for the training data. It had a loss of 15.02%. There were 256 epochs and the first one had an accuracy of 64.7%. The last one had an accuracy of 93.2% which is a 28.5% increase. The validation results were actually an improvement in comparison to the training results.

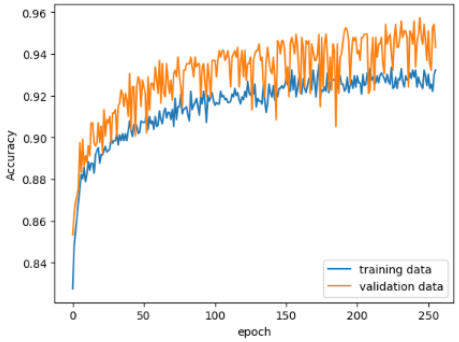

Figure 5. Training vs Validation Results

In figure 3, it can be seen that the accuracy of the validation data is slightly higher than the training data. For the validation data, the neural network had an accuracy of 95.43% and a loss of 11.68%.

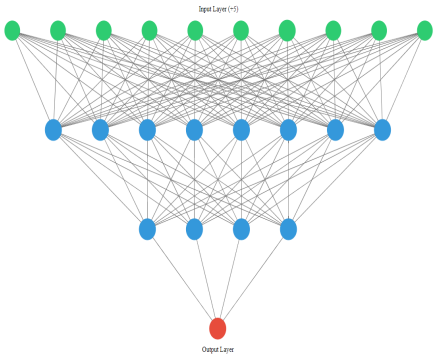

Figure 6. Neural Network 1

The input layer had 15 units, however in the figure it only shows 10 units. On the top it says +5 to represent the additional 5 units. The neural network had 3 dense layers. There are 8 units in the first layer, 4 in the second layer, and 1 in the third layer. In the first two dense layers, I used the Rectified Linear Unit activation function to prevent exponential growth in the computation required. In the last dense layer, I used the sigmoid activation function. I used the root mean squared propagation optimization (rmsprop) algorithm which uses an adaptive learning rate. I used the binary crossentropy loss function which is used for binary classification.

Out of all the models, it can be seen that the random forest classifier was the most successful as it had the highest accuracy and the naive bayes classifiers were the least accurate. Specifically, the Bernoulli classifier had the lowest accuracy.

Conclusion/Limitations

The accuracy of a significant portion of these models were extremely high. It is possible that part of this reason can be because of overfitting. However, for a random forest classifier, it is less likely that overfitting is an issue compared to something like a decision tree. The Naive Bayes classifiers weren't the best for obesity classification compared to something like text classification. It is also a possibility that some of these models have a bias towards this dataset and fail to generalize to data the model hasn't seen. For this study, I analyzed 15 different factors that contribute to obesity, however there are potentially more factors that have an effect in some way. However, through the observed results, the random forest classifier has the highest accuracy by a slight margin.

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The Arab Spring: Broken Dreams By Zaina Taha

What was the Arab Spring?

The Arab Spring was a series of demonstrations and revolutions across the Middle East and North Africa from 2010 to 2012 that demanded a shift from authoritarian rule to democracy as a response to the decades of totalitarian regimes that controlled the region. It was initially sparked on December 17th, 2010, after the self-immolation of a Tunisian street vendor, Mohammad Bouazizi, in protest of the government's arbitrary refusal to allow him to sell his goods and provide for his family, symbolic of the country's ongoing oppression at the time (Lageman). His demands and actions reverberated across Tunisia, leading to the Jasmine Revolution and, eventually, the resignation of the long-time president, Zine El Abidine Ben Ali. This change inspired the rest of the Arab world to follow in Bouazizi's footsteps in seeking an end to dictatorial rule. However, while the Tunisian protests brought about change in Tunisia, they were unable to do so in other Arab countries, affecting not only the peace and stability in the Middle East, with full-scale civil wars occurring in several countries, but that of the rest of the world as well. The Middle East is a flashpoint for many conflicts involving foreign powers, including the 9/11 attacks, the Iraq War, and the Israeli-Palestinian conflict, showcasing how the stability of the world is heavily dependent on that of the Middle East. The Middle East is additionally an important region due to its vast energy reserves, which the majority of the world depends on, meaning that instability in the Middle East can have a significant impact on the world economy. Due to the inability of the other nations to execute reform, Tunisia is currently the sole democratic country in the Arab world, raising questions about the flaws and shortcomings of the Arab Spring that hindered democracy. The Arab Spring failed to bring about democracy in the Middle East due to a lack of autonomous working-class strength, foreign intervention, and the involvement of Islamic fundamentalism.

The Lack of Autonomous Working-Class Strength

One of the major factors that contributed to the failure of the Arab Spring was the lack of autonomous working-class strength. The dictators of the Middle Eastern countries had many Communist-inspired ideas that were strategically planned in order to maintain power over their respective countries. One of these ideas included a deal they offered to the masses that would

limit their ability to exert independence: to give up their collective bargaining and trade unions in exchange for financial security. Many Middle Easterners were in desperate need of a secure supply of resources, as evidenced by a Carnegie article, "How Poverty and Inequality Are Devastating the Middle East", "...has for decades left the Arab region with tens of millions of semi-educated young people without steady jobs or steady income, languishing without hope in the dead-end informal labor market and politically impotent" and were left with no choice but to surrender their trade unions (Khouri). As a result, without a means of protecting and furthering their rights, citizens were unable to organize and form a cohesive voice, leaving the countries in leadership vacuums. Tunisia, on the other hand, had a history of organizing structures and was able to form and maintain labor unions, such as the Tunisian General Trade Union, as they refused to surrender their ability to voice their rights. This is evidenced by the words of a journalist in a Jacobin interview, Anand Gopal, who had gone to the Middle East during the Arab Spring, stating:

> There were activists and militants in the UGTT who tried every step of the way to democratize it, to fight for union democracy, to fight for accountability. They were building power within the UGTT, so that when a moment of opportunity arose, when the uprising took place, they were able to move on that (Gopal).

It is because of these trade unions, which even played a role in Tunisia's independence from France in 1956, that the Tunisians developed the organizational skills and experience to lead a successful revolution (Beinin). This lack of independent working-class strength played a role in the failure of the Arab Spring protests, as they limited the citizens' ability to exert their independence and form a cohesive voice.

Foreign Intervention

The second major factor that contributed to the failure of the Arab Spring had been the foreign interventions in the Middle East that prevented the protests from achieving their desired goals. These interventions can be viewed from two angles: the anti-democratic and democratic forces.

The anti-democratic forces that intervened in the Middle East contributed significantly to maintaining the totalitarian status quo. This can be seen in the Russian interference in Syria, which supplied the president, Bashar al-Assad, with military support (Chotiner). As a result,

Russia was able to brutally crush the Arab Spring rebellions, as well as instill in citizens fear of speaking out against the dictatorship, and they were instead subdued into a silent acquiescence to the authoritarian system. This is evidenced through an article entitled "What Bashar al-Assad Wants" by the New Yorker, which states:

That's where the chemical weapons come in. They're lethal and efficient. And they did what they were intended to do. The offensive against Douma is proceeding, with Assad offering the rebels and residents there a choice of evacuation by bus, or probably death or imprisonment if they stay. It's not a pretty picture (Filkins).

However, Russia was not the only country that helped crush pro-democracy protests in Syria. China also extended its political influence to the Middle East during the Arab Spring, vetoing several attempts at the United Nations Security Council to punish Assad for his tyrannical rule in Syria, thus contributing to the continuation of his repressive regime (Phillips). This is additionally seen through Saudi Arabia's intervention in Bahrain to assist the government in putting a halt to the Arab Spring protests. These Saudi Arabian forces enforced a brutal crackdown, with their military squashing protests and preventing any opposition to the government (McEvers).

The refusal of democratic forces to intervene in the Middle East also played a role in preventing the rise of democracy. This can be seen through the United States' reluctance to interfere in the Middle East after the negative consequences that previous conflicts, such as the War on Terror and the Iraq War, left for the country. As stated in an article entitled "Arab Spring: When the US Needed to Step Up, It Stood Back" by The Conversation, the United States was "fearful of getting bogged down in the Middle East" (Bentley). For example, following the toppling of Mu'ammar Al-Qadhdhāfī in Libya, the United States had the opportunity to intervene and help the democratic forces fill the power vacuum, however, refrained, and Libya consequently descended into chaos (Daragahi). On the other hand, many progressive voices, such as Noam Chomsky, claim that democratic countries, such as the United States, refrained from playing a part in removing dictatorial control in the Middle East out of their own self-interest. The United States has traditionally dealt with dictatorial regimes in the Middle East, as it is easier to exert influence by swaying the dictators to their own whims. On the other hand, dealing with democratically elected governments can prove to be complicated as there is no one

person to deal with. Additionally, democratically elected governments are answerable to their own people and are not beholden to foreign powers.

These foreign interventions by democratic and non-democratic forces played a role in the failure of the Arab Spring protests, as they maintained the status quo of a totalitarian government.

The Involvement of Islamist Fundamentalism

Finally, the third major factor that contributed to the failure of the Arab Spring had been the involvement of forces of Islamic fundamentalism. In many countries, fundamentalist groups such as ISIS came into being due to power vacuums. By convincing citizens that they would remove dictators, these organizations acquired the support of the masses who were desperate to oust the dictators. It is worthy to note, however, that these fundamentalist organizations did not acquire power through violence, but rather through a combination of strategic exploitation of the lack of leadership within the democratic forces, as well as through their extensive social welfare programs. This is recounted in an interview of a Tunisian man, in the article, "Arab Spring After 10 Years: Understanding Islam, Democracy and Western Imperialism" stating:

I asked him how someone who imbibes so freely can vote for an Islamist Party. Without missing a beat he told me that he had been jailed by Ben Ali for five years and during that time the only organization that gave his family money was Al-Nahda. The party while underground established networks of social aid that kept many poor families alive ("Arab Spring after 10 Years: Understanding Islam, Democracy and Western Imperialism").

Once these fundamentalist groups made inroads through these strategic tactics, however, they ruthlessly seized control of sizable territories, leaving even less possibility for civilian autonomy. As a result, the dictators were reduced to the lesser of the two evils, providing them with the justification to be the ones to be supported. Eventually, these Islamic fundamentalist groups instilled such a significant amount of fear in the masses that they began to scale back their demands, preventing the emergence of democracy within the region.

Conclusion

In conclusion, while the Arab Spring protests were able to bring about a transformative shift in the government of Tunisia, they were unable to do so in other Arab countries due to a

lack of autonomous working-class strength, foreign intervention, and the involvement of Islamist fundamentalism. Rather, it has engulfed numerous countries, such as Syria, Yemen, and Lebanon, in full-fledged civil wars that are still raging today, leaving thousands of individuals either dead, severely injured, or displaced (Byman). Detractors, including political leaders, journalists, and scholars specializing in the region, may argue that the cultural and religious norms of the Middle East were incompatible with democracy and, therefore, the protests were destined to fail. However, in actuality, many Arabs had the desire for democracy and were willing to make sacrifices to ensure its establishment within the region; it was only the political and institutional pitfalls outlined in this paper that ultimately failed them. However, although the majority of the protests proved to be unsuccessful, the Arab Spring has inspired hope for the prospect of democracy in the Middle East in the near future. The protestors' sheer courage and perseverance in seeking to create a change in their country is the first step toward a successful revolution, and Tunisia’s example alone proves that democracy in the Middle East is possible. Ultimately, it proves that if individuals are impassioned enough, there is hope for piecing together the shattered remains of broken dreams.

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The Effect of Video Topic on the Popularity of YouTube Channels By Dori Chau

Abstract

As video-sharing platforms like YouTube continue to get more popular, competition between online influencers has increased. Therefore, it is vital for creators to understand factors that can affect the popularity and increase the visibility of their content. A mixed method approach of content analysis and predictive analytics was used to discover the trends of how the topic of video content affects the popularity of both YouTube videos and channels. The results concluded that YouTubers should consistently post content with topics that have previously performed well in order to generate more views and accumulate more subscribers. Doing otherwise will not only result in less views, but could also lead to a potential loss of followers. This research can lead to new conversations regarding the effects of video topic on other video-sharing platforms like TikTok as well as introduce the Gacha community into the field of professional studies.

Introduction

The Internet has witnessed the exponential growth in popularity of online video content platforms over the past decade with YouTube being the most successful example (Cheng et al., 2008). Established in early 2005, YouTube provides content creators with the opportunity to establish a professional career in the video-sharing community (Cheng et al., 2008). As a content creator with a channel of more than 35,000 subscribers and 3.5 million total views myself, I recognize that understanding factors that influence the virality of videos is essential to a successful career on the platform. While many previous studies have analyzed the effects of video properties and measures of viewer sentiment, no study has yet to analyze the relationship between the topic of the content itself and the success of YouTube channels which my study does.

Review of Literature

One of the most popular video-sharing platforms is YouTube, in which over 1 billion users collectively watch millions of hours of video content every day, generating billions of views and most importantly, advertisement revenue (Hoiles et al., 2017). Perhaps one of the most

unique aspects of the platform is its YouTube Partnership program. Implemented in 2007, the YouTube Partnership program has turned YouTube into an opportunity for individuals to develop a professional career, leading to substantial growth in its popularity (Berger et al., 2019). Naturally, this has transformed YouTube into a competitive platform in which individuals are constantly looking for ways to boost the visibility of their content. Many pre-existing studies have determined that a plethora of different factors ranging from metrics as vague as the number of subscribers a channel has to others as specific as the color contrast of the video thumbnail all affect the popularity of video content on YouTube (Hoiles et al., 2017). However, no study has yet to link the connection between video content itself or more specifically, the topic of content, and video and channel performance, which my study does.

Popularity Metrics

Many studies identified view count as a primary indicator of video popularity as well as agreed that there are several factors that can affect it. According to Cristos Goodrow, YouTube's search and recommendation systems consider hundreds of signals to determine how to rank its videos (creatoracademy, 2020). Findings by William Hoiles, Anup Aprem, and Vikram Krishnamurthy, all associated with the Institute of Electrical and Electronics Engineers (IEEE), further expand on this claim by concluding that YouTube popularity metrics can be measured by dominant meta-level features including video category, the number of keywords, Google hits, and much more (Hoiles et al., 2017). This study also claims that a large number of subscribers is vital to increasing view count and that video properties such as the thumbnail and title will also affect the popularity of content (Hoiles et al., 2017). Additionally, this study determines that first day view count is an accurate indicator of the future performance of videos. However, these findings contradict with a similar study that collected a large amount of data from User Generated Content (UGC) systems including YouTube. Results concluded that second day records rather, are more useful in predicting the near-future popularity of video content (Cha et al., 2007). Another study conducted by Park, Naaman, and Berger concluded that measures of viewer sentiment also have significant effects on the visibility of content as well as video popularity (Berger et al., 2019). This study found that the number of comments, favorites, and average ratings are all accurate predictors of view count on YouTube (Berger et al., 2019). The findings presented in this research agree with Aggrawal's study which also supports the notion

that other measures of audience satisfaction such as the number of likes, dislikes, and shares affect a video's overall performance (Aggrawal et al., 2018). Conclusions include that more likes, comments, and shares are associated with a greater number of views and vice versa (Aggrawal et al., 2018). A study by Khan and Vong captured the effect of publishing data on virality with findings that concluded video publish date has an inverse proportional relationship with chances of content going viral (Feroz Khan & Vong, 2014), results consistent with previous studies (Cha et al., 2007). Furthermore, video virality can also be affected by audience retention, or the percent of a video viewers consumed, as concluded by a study conducted by Altman and Jiménez (Altman & Jiménez, 2019).

The Gacha Community

YouTube communities allow content creators to freely express themselves in spheres that act as online safe havens for the individual (Farrell, 2018). One of the more underrated communities is the Gacha community which is relatively known compared to more populous communities that focus on themes like beauty, vlogging, and music (Farrell, 2018). Defined as a roleplaying video game accessible to users on a mobile device, Gacha allows individuals to create original characters using a variety of customizable options such as different hair, clothes, and colors (2020). Founded in 2015 by Lunime, otherwise known as Lucas Lee, Gacha has grown to become a group of artists that have designed more than 10 games in total, 4 of which have become significantly more popular than the rest (2021). The creation of Gacha Studio was the first Gacha game that included a dress up feature which led to an overall rise in popularity of the community, paving the way for the rest of the main Gacha games (2021). These games included Gacha Verse and Gacha Life, both an intense step up from the previous installment as they included more customizable options such as larger ranges of style, hair, clothes, color and more features (2021). June 29, 2020, saw the release of the most recent version of Gacha, Gacha Club, which resulted in the most attraction for the Gacha community as a whole (2021). Gacha life mini movies (GLMMs) and Gacha club mini movies (GCMMs) as well as Gacha live mini videos (GLMVs) and Gacha club mini videos (GCMVs) have also led to the popularization of Gacha as a whole (2021). Examples of other Gacha-related content include animations, memes, video edits, Gacha comics, team videos, movies, TikTok/short videos, tutorials, and speedpaints (2021). Additionally, according to one of the most popular GachaTubers, RosyClozy, who

currently has more than 1.6 million subscribers and is known for her hit ongoing series “The Music Freaks”, GachaTubers make a range of different content, but there are also GachaTubers that focus on one particular type of content (How to Become a Successful GachaTuber 2019). My YouTube channel is an example of this as while I do post a wide range of Gacha-related content, I mainly focus on creating GLMMs/GCMMs.

Call To Research

After a brief examination of my video content, I noticed that there was a distinguishable difference in the number of views my GLMMs generated in comparison to videos of other Gacha-related topics. Therefore, this leads me to pose the question of: To what extent do variations in the topic of content affect video performance in a Gacha related YouTube channel? Although there has been a considerable amount of research done on how YouTube metrics affect the popularity of video content, there are many different variables that still require further investigation. Previous studies have considered the effects of social endorsement or measures of viewer sentiment which includes the number of likes, dislikes, comments, shares, and favorites. Others found that the properties of the video itself like the length or title also have tremendous effect on YouTube's recommendation system. However, there has not yet been a study examining how the content itself, or more specifically, the topic of video content, effects the overall performance of both YouTube videos and channels in terms of view and subscriber count. Additionally, the Gacha community is heavily understudied in comparison to other communities on YouTube. In other words, the number of scholarly articles focusing on the Gacha field are practically nonexistent. Thus, the research regarding these two subjects is incomplete, leaving a gap in knowledge concerning how different topics of content truly affect the success of a YouTube channel. I hypothesize that content with video topics that have previously performed well in terms of view count will continue to perform better than other topics and thus, will lead to a more successful.

Method Alignment

To gather data for my research, I chose to perform a content analysis because this was the method used by many previous studies that also analyzed YouTube popularity metrics. For instance, a study conducted by researchers from Cornell Tech and the University of Pennsylvania

performed a content analysis using a dataset housing a sample of 1,125 random YouTube videos to draw conclusions on the effects of video view duration (Park et al., 2021). Berger, Niebuhr, and Zellers also used similar methods by gathering and analyzing material taken from the videos of ten different content creators to draw conclusions about whether acoustic features in audio correlate with overall video performance (Berger et al., 2019). Similarly, several studies that investigated the correlation between meta-level features of YouTube channels and the popularity of videos primarily used parametric models in which the view count served to estimate the model's parameters (Park et al., 2021). Therefore, I determined to rank the popularity of my videos through view count not only because this was the method used by previous studies, but because of its significant influence on the YouTube recommendation system (creatoracademy, 2020). However, a primary difference between my study and previous studies is that I performed a content analysis on my own channel instead of gathering data from others. Conducting a study on my own video content would not only be more convenient, but also lead to more precise conclusions because of my access to hyper specific data which would have been unavailable to other researchers. I also chose to use predictive analytics in addition to content analysis so that I can use the conclusions from this study to predict the popularity of my future uploads based on the topic of that video. Additionally, I chose to research the heavily understudied Gacha community primarily because my channel focuses on Gacha-related video content. My research aims to introduce Gacha into the field of professional studies as well as help researchers understand how YouTube popularity metrics extends to underrated online communities as well. One of the first steps I took to conduct my research study was to divide all the videos I published within the past few years into 2 different datasets based on the topic of the content. I decided that my first dataset would only house GLMMs or my channel's primary topic of content because they are what I prioritize creating and the other, a combination of secondary topics that include content like GLMVs, animations, speedpaints, edits, and more. Since GLMMs tend to outperform my other videos, this division would also allow for a closer and more organized way of analyzing why certain videos are more popular than others. Additionally, I analyzed the subscriber count growth of each of my video to determine how video topic affects the success of a YouTube channel as a whole. According to Tasmanian Times, subscriptions also represent viewers that are most likely to share content through their social networks as well as return to watch more which is critical to growing influence on the platform (*YouTube subscribers vs.*

YouTube views – what is more important? 2023). Now, in order to gather the necessary data for my research, I used YouTube Studio, a convenient way for content creators to access analytics as broad as the total number of likes a video received to the number of a views a particular video got on a specific date all in a single application. Although previous research has determined how different popularity metrics like the number of comments, subscribers, likes, etc. affect the overall performance of a YouTube video (Hoiles et al. 2017), there has yet to be a study covering the effects video topic on the popularity of channels. However, this area of study is vital as having a better understanding of the significance of video topic will help content creators better understand yet another way to boost the visibility of their videos and thus, the success of their career on YouTube.

Methods

No other researcher analyzing popularity metrics on YouTube has also been a YouTuber themselves. Therefore, they lack access to detailed video analytics unlike me. In my research, I intended to use this access to ensure that my study was thorough and yielded the most accurate results. With this in mind, my methodology was self-designed to fit the perspective of a YouTuber researcher.

To conduct my research, I first identified the topic of each of my YouTube videos and then divided them into categories that were specific to the Gacha community (ex. GLMMs, GLMVs, animations, speedpaints, edits, etc.). Based on this information, I then created three distinct datasets to make my findings and analysis more robust. The first dataset included a sample of 24 videos whilst the second was a set of 17, all of which were published within the same time margin of August 16, 2020, to October 30, 2022. Note that Dataset 1 only included GLMMs, my channel's primary topic, whereas Dataset 2 included secondary topics that were anything but GLMMs. For instance, Dataset 2 housed a wide range of video topics like GLMVs, animations, subscriber specials, video star edits, and more. Dataset 3 included all the videos I had published since the start of my channel (41). I then used YouTube Studio, a convenient application designed to help content creators manage their channel (*Navigate youtube studio - YouTube help*), to view the video properties of each of my videos. For the purposes of my research, I mainly focused on gathering the number of views and subscribers each individual video had accumulated per day up until 30 days after it was published. To do this, I first opened

YouTube Studio on my desktop browser. I was taken to my channel dashboard by default and from there, I clicked on the content tab located on the left side of my screen which gave me an overview of the total number of views, likes, and comments each of my videos have generated since I uploaded them. However, in order to reach the level of precision with my data that I hoped to achieve, I then opened the specific analytics of each individual video to pinpoint the exact number of views and subscribers each video had accumulated by a set number of days after it was published which I was only able to do because my research involved the use of my own YouTube channel. I then created two Microsoft Excel spreadsheets - one for view count and the other for subscribers gained - for each of my three datasets where I went on to record the data YouTube Studio provided me. From there, I created three separate arrays for organizational purposes; I created a 24x30 array for Dataset 1, a 17x30 array for Dataset 2, and a 41x30 array for Dataset 3.

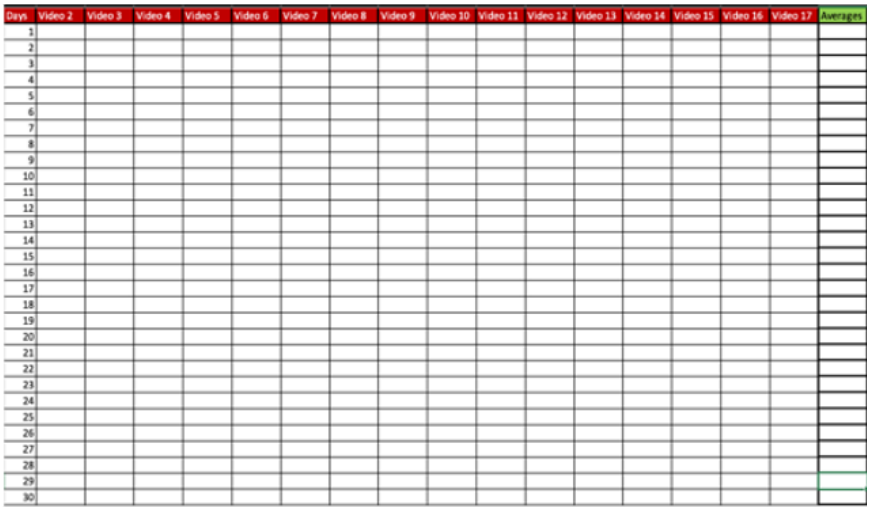


Figure 1. 17x30 array created for Dataset 2.

Each row represents the number of views each video generated whilst the columns represent days after publication. The right-hand most column of each array represents the average number of views accumulated up until that specific day of all the videos in the dataset which was calculated by adding the number of views of all the videos and then dividing that value by the number of videos in the dataset. I then created an additional array for each dataset to model the number of subscribers my channel accumulated from each video by following the same procedure. To reduce the chance of a mathematical error, I re-averaged all my values for a

total of three times per array. Next, I used Microsoft Excel to create two sets of line graphs to model the growth in both view and subscriber count for a more thorough analysis. The independent variable for the graphs was time in days since published (up until 30 days) while the dependent variable was either view or subscriber count which had already been calculated previously. My first set of graphs consisted of two lines with one representing Dataset 1 and the other representing Dataset 2 to highlight the difference in the growth in view count as well as the number of subscribers accumulated as a result of video topic. My second set of graphs included the addition of a third line representing Dataset 3 to compare the view and subscriber count growth of the videos in Datasets 1 and 2 to the growth of all the videos in my YouTube channel combined. I then created two mathematical models based on the slopes of Datasets 1 and 2. To do so, I first generated a line of best fit from each graph and then use those lines to generate two accurate line equations. I then converted the equations into mathematical models by substituting the x and y variables with their respective axis label; the x was replaced with "Days After Publication" and the y was replaced with "View Count." Afterwards, to really go in-depth with my analysis, I imputed my collected data into a statistical analysis program known as JASP. There, I ran heteroscedastic T-Tests on my data to determine if the difference in view and subscriber count between Datasets 1 and 2 was statistically significant. I compared my two datasets with Dataset 3 to draw conclusions on how video topic impacted the overall performance of my channel. After running these statistical analysis tests, I looked at the p-values of the results as well as comparisons of the mean values between groups to determine which results were relevant enough to be included in the discussion of my results. A p-value of 0.05 or less was used as a marker for statistical significance and any tests resulting in p-values less than that were included and discussed.

Results, Findings, and Analysis–*I. View Count Growth*

I created an array for each dataset that modeled the performance of my videos as a function of video topic. After inputting in my data, I averaged the number of views my videos accumulated throughout the span of 30 days. Upon completion of my calculations, I ended up with 30 averaged values for each of my three datasets. Statistical analysis tests using the analysis software JASP and comparisons of the means of my three distinct datasets were then used to come to conclusions about the correlations between the different variables in my research study.

I first noticed that there was a clear distinction between the number of views and subscribers I gained from videos of my primary topic, GLMMs, in comparison to secondary topics, non-GLMMs. From my calculations, I found that Dataset 1 accumulated an average of 6,207 views on the first day after it was posted and 62,029 by the 30th day. On the contrary, the videos in Dataset 2 only accumulated an average of 98 views on the first day and 270 by the 30th day. Therefore, we can conclude that my GLMMs dramatically outperform other types of Gacha-related content during the first 30 days of being published and thus, I should continue to upload GLMMs to increase the popularity of my YouTube channel. This also supports my initial hypothesis of how mini movies are the most popular form of Gacha content. However, there has not been much research on the Gacha community and further research with a larger sample size and more in-depth information may yield different, more statistically significant results. For a more thorough analysis, I then used Excel to generate two logarithmic line graphs. The graph in Figure 2.1 only includes Datasets 1 and 2 to compare the performance of my content based on differing video topics. I noticed the difference in the interval of range values for both graphs; the y-values, which represent average view count, in Dataset 1 range from 0 to 70,000 whereas in Dataset 2, they only range from 0 to 300. The graph in Figure 2.2 includes the addition of a third line representing the average view count of all the videos in my entire channel, Dataset 3, to draw conclusions on how video topic also effects the performance of a YouTube channel as a whole. As seen by this graph, my GLMMs benefit the number of views my channel generates tremendously in comparison to videos with other Gacha-related topics.

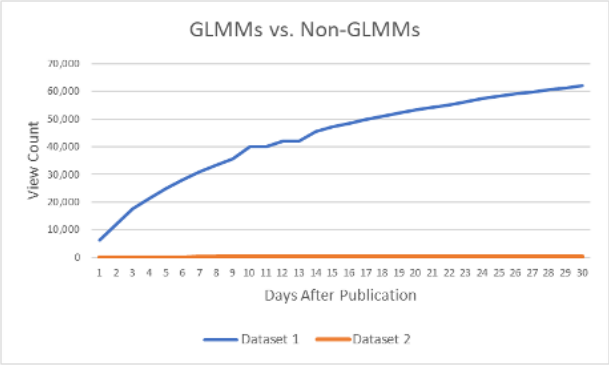


Figure 2.1

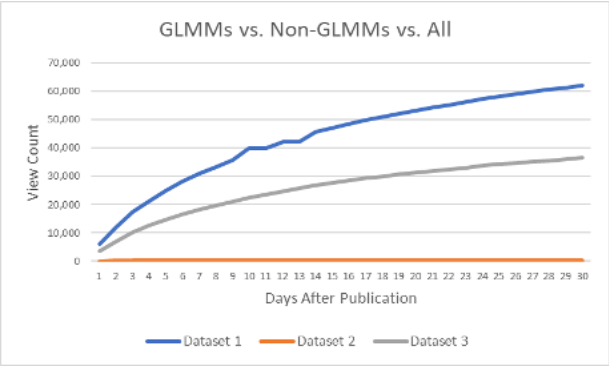


Figure 2.2

Afterwards, using the slopes of both graphs, I derived two mathematical models from the slopes of Datasets 1 and 2. Figure 3.1 was derived from Dataset 1 and Figure 3.2 from Dataset 2. These

formulas make it possible for me to make an accurate prediction about the average number of views a GLMM or non-GLMM related video will accumulate within the first month before uploading it. To use them, I would only have to substitute a number greater than 1 for “Days After Publication.” I then ran an Independent Samples T-Test through JASP to see if there was a correlation between video topic and the average view count of a video. As seen in Figure 4, there is a significant relationship between video topic and view count as the p-value is less than 0.001, passing the significance threshold of 0.05 that was used for all subsequent analyses.

Independent Samples T-Test

	t	df	p
Average View Count	15.207	58	< .001

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
Average View Count	Main	30	43535.367	15610.948	2850.156	0.359
	Other	30	192.567	46.185	8.432	0.240

Descriptives Plots

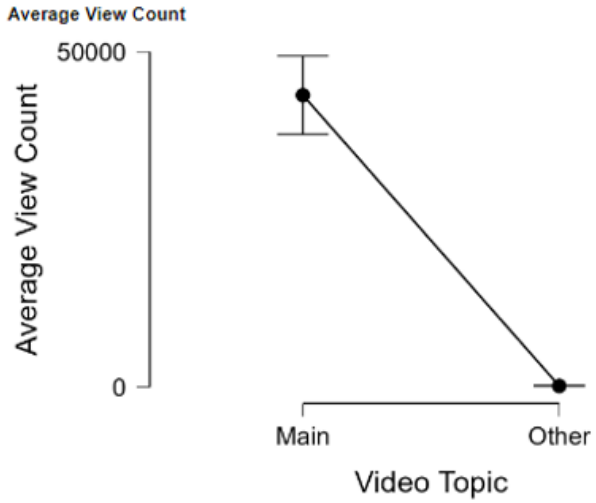


Figure 4. T-Test was used to determine whether there was a significant difference in the popularity of GLMMs and non-GLMM related content. The popularity of the videos was measured through calculations of the average view count of my videos rounded to the nearest tenth. This test indicates that GLMMs are more likely to generate more views than non-GLMMs.

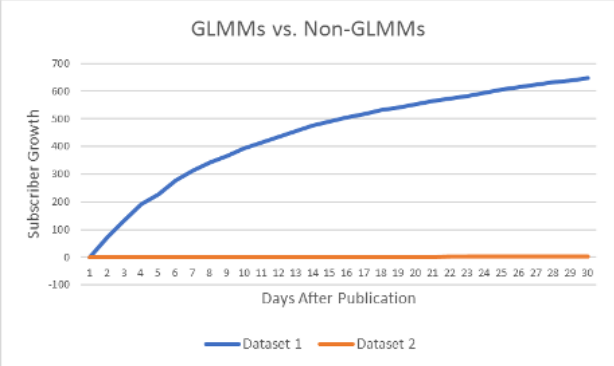
Further analysis of the mean values amplified these results as GLMMs gathered an average of over 43,000 views per video, while non-GLMMs had a mean of only 192. According to these findings, videos with primary topics tends to gather more views than secondary topics.

Additionally, we can conclude that videos that have previously performed well will continue to perform well in comparison to content that has previously not.

II. Subscriber Growth

In addition to view count, I analyzed how video topic affected the number of subscribers my videos gained to determine the effects on the YouTube channel itself. Similar to how I analyzed view count, I first created an array for each dataset, but with the columns representing the number of subscribers accumulated within a one-month time span instead while the rows still represented days after publication. Upon completion of my calculations, I ended up with 30 averaged values for each of my three datasets. Again, statistical analysis tests using the analysis software JASP and comparisons of the means of my three distinct datasets were then used to come to conclusions about the correlations between the different variables in my research study.

I calculated the average subscriber growth of each dataset separately and found that the videos in Dataset 1 grew an average of 444 subscribers during the first 30 days after it was posted whereas the videos in Dataset 2 gained less than 1 with some even gaining less than 0. This drastic difference leads me to conclude that content creators will not only gain more subscribers when posting videos with primary topics, but also that posting secondary topics could potentially result in a loss of subscribers. Just like before, I then created two logarithmic line graphs with my averaged values. Figure 5.1 models the subscriber growth of Datasets 1 and 2 in which the growth in Dataset 1 (the blue line) is shown to be much greater. Figure 5.2 includes the addition of the average subscriber growth of all the videos of my YouTube channel to draw comparisons on how the subscriber growth of both datasets affects the subscriber growth of my channel overall. It can be seen that Dataset 1 is pulling the gray line representing Dataset 3 up whereas Dataset 2 is pulling it down.



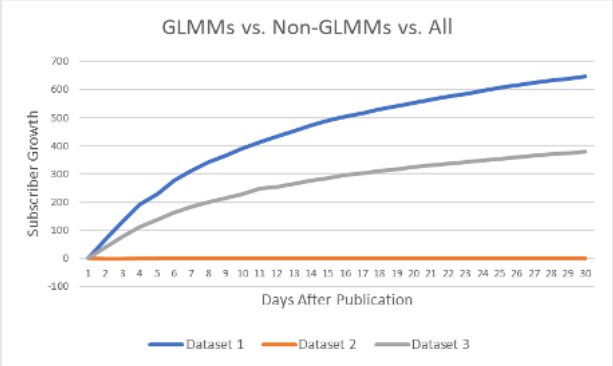


Figure 5.1 **Figure 5.2**

Similar to my previous analysis of view count growth, I then created two mathematical models derived from the slopes of the graphs of Datasets 1 and 2. Figure 6.1 was derived from Dataset 1 and Figure 6.2 from Dataset 2.

Figure 6.1 Subscriber Count = 208.97ln(Days After Publication) - 76.32
Figure 6.2 Subscriber Count = 0.60ln(Days After Publication) - 0.80

By substituting in a number greater than one for "Days After Publication", these formulas make it possible for me to make an accurate prediction about the average number of subscribers my channel will gain after uploading a GLMM or a non-GLMM video. A T-Test was used again to find the significance of the correlation, if there was any, between the number of subscribers gained from a video and the topic of content. Based on previous research, I hypothesized that there might be some differences between the subscriber growth of my GLMMs and non-GLMM related videos because of their difference in view count. The T-Test showed a correlation between the two factors, with a p-value of less than 0.001, which is less than 0.05, indicating statistical significance.

Independent Samples T-Test

	t	df	p
Subscriber Growth	13.579	58	< .001[a]

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
Subscriber Growth	Main	30	443.727	178.702	32.626	0.403
	Other	30	0.690	0.559	0.102	0.809

Descriptives Plots

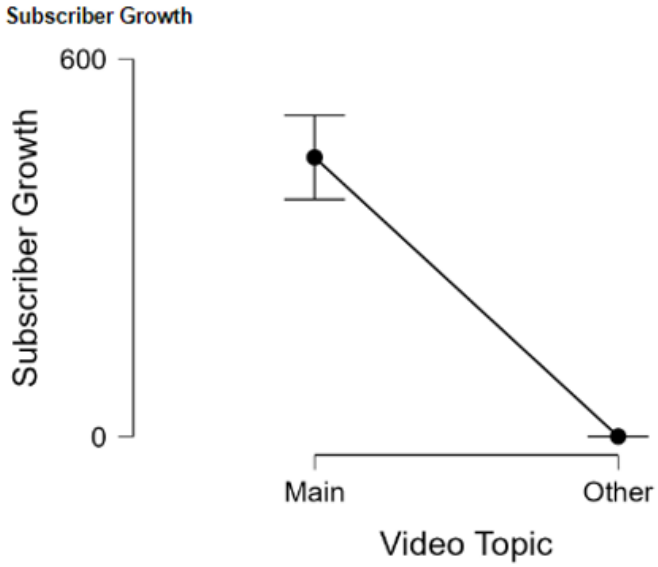


Figure 7. T-Test was used to determine whether there was a significant difference in the popularity of GLMMs and non-GLMM related content. The popularity of the videos was measured through calculations of the average subscriber count of my videos rounded to the nearest tenth. This test indicates that viewers are more likely to subscribe after watching GLMMs rather than non-GLMMs.

Analysis of the mean values further validated my initial hypothesis as they showed the tremendous difference in the average number of subscribers gained as a function of video topic.

For instance, GLMMs gained an average of over 440 subscribers per video, while non-GLMMs gained less than 1. From this, we can not only conclude that videos of primary topics tend to be the most successful, but also that posting secondary topics can harm the overall performance of YouTube channels as well by causing a loss of followers.

Limitations

A main limitation of my research was that the number of videos in Datasets 1 and 2 were not the same. Therefore, when calculating the average view count or subscriber count of my videos, I used different divisors. Additionally, the equations I created (Figure 3.1, 3.2, 6.1, 6.2) were derived from the data from my YouTube channel. Therefore, they are only accurate predictors of the view and subscriber count of my channel specifically. Another limitation I encountered was that some videos of mine have copyright claims. These claims may have affected view count as copyright owners can choose to restrict that particular video from appearing in certain countries and on websites that may include YouTube. Finally, though my videos range from a variety of different topics, they are all Gacha-related content. Therefore, my findings on how GLMMs outperform other Gacha content may not be useful to YouTube Creators who are not a part of the Gacha community.

Implications

The findings of my research on how video topic affects view and subscriber count will help content creators better understand what type of content they should post to be more successful on YouTube. For instance, posting videos of primary topics will generally outperform videos of secondary topics. This understanding is vital for influencers as it can help them achieve a more successful online career as a whole. My study can also be used as a model for future research on how video topic affects the view and subscriber count in other YouTube communities like beauty and vlogging. Furthermore, my study can be used as a model for research on not just YouTube, but on other video-sharing platforms like TikTok as well. My research also opens the door for new research on the Gacha community which is important as the number of scholarly articles on Gacha practically are nonexistent.

Conclusion

Video topics have a tremendous effect on the popularity of both YouTube videos and channels. Videos of a channel's primary topic will generally accumulate more views within the first 30 days of being published. In contrast, content with secondary topics will experience a much slower growth in view count. Primary topics will also result in the gaining of more subscribers whereas secondary topics will not only gain less subscribers but could potentially result in the loss of them. Therefore, YouTubers should consistently post content with topics that have previously performed well to increase popularity on their content as well as on the success of their channel as a whole.

Future Directions

Future researchers should focus on studying the effect of video topic on other YouTube communities in order to increase the possibility of finding statistical significance in results as well as research more on the Gacha community. Additionally, my study used data from my videos only so my results may not be representative of all YouTube channels. Future researchers may want to study a larger sample size involving multiple channels to get more precise data and results.

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Impacts of Pediatric Psychostimulant Use Among Children with ADHD By Eileen Lam

Abstract

Psychostimulants, such as methylphenidate and amphetamine, are commonly prescribed medications for individuals afflicted with attention-deficit/hyperactivity disorder (ADHD), a neurodevelopmental disorder often occurring in childhood that can persist well into adulthood. Yet, the full beneficial effects of these medications on individuals with ADHD are important to consider. This review aims to evaluate the positive impacts of methylphenidate and amphetamine used to treat children, adolescents, and adults with ADHD. PubMed was searched to find articles between 2006 and 2023 using these keywords: (1) methylphenidate, (2) amphetamine, (3) psychostimulants, and (4) attention-deficit/hyperactivity disorder (ADHD). The search identified 65 articles. However, many studies involved animals, pregnancy, and other drugs and were excluded given the current interest in the impacts of methylphenidate and amphetamine in individuals with ADHD. Five relevant literature reviews and research articles were selected for discussion here. Results shown in these articles indicate that methylphenidate and amphetamine provide short-term beneficial effects on concentration, attention span and cognitive processes in individuals with ADHD. This is caused by increasing dopamine and norepinephrine activities in several brain regions responsible for cognition and executive functioning activities. Thus, methylphenidate and amphetamine have been identified as having beneficial effects on behavioral and neurocognitive outcomes including academic performance, driving, attentiveness, and task completion. Furthermore, neuroimaging data from children and adults with ADHD using stimulant medication exhibited significantly less overall gray matter volume reductions in brain structures, i.e., the basal ganglia and frontal cortex, that are germane to executive functions. Psychostimulant medications were found to diminish the abnormalities in the cortical thinning, and therefore gray matter volume, compared to the cohort of ADHD individuals who are not taking psychostimulants. However, further consideration of the long-term beneficial effects of stimulants required.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a clinical condition most commonly occurring in children and adolescents. ADHD was initially identified in children (Chang et al.,

2019), but rates of prevalence are increasing in adults (Lahey et al., 1994; Barkley et al., 2002; Weiss et al., 1985; Faraone et al., 2006). Many neurotransmitters and brain structures play a role in ADHD (Purper-Ouakil et al., 2011; Cortese 2012; Faraone et al., 2015). ADHD is a condition that is a common neurobiological disorder with features that include inattention, hyperactivity, and executive dysfunction (Barkley et al., 1997; Downey et al., 1997; Wender et al 2001). The illness is estimated to affect up to 10% of children and 5% of adults worldwide (Spencer et al., 2013). ADHD is further associated with high rates of adverse functional outcomes including comorbid psychiatric disorders, academic impairments, accidents and injuries, and car accidents among many others (Boland et al., 2020).

The primary medications of ADHD involve stimulation which result in increased production of neurotransmitters, specifically dopamine (DA) and norepinephrine (NE). These systems affect the brain function by moderating executive function, working memory, emotional regulation, and reward processing (Faraone et al., 2015). Multiple randomized controlled trials (RCTs) have assessed the efficacy of medicines like stimulants, for reducing the symptoms of ADHD in children, adolescents, and adults (Chang et al., 2019). Some benefits of these medications are described here further. Therefore, this paper had three objectives: (1) to conduct a review on the positive impacts of psychostimulants and medications used to treat ADHD, (2) to describe the effects of ADHD medication that is applied in academic performance, and (3) present neuroimaging findings in the brain associated with ADHD.

Discussion–Neurotransmitters and Neurochemicals

ADHD treatment options include methylphenidate, commonly known as ritalin and amphetamine, commonly known as adderall. There are many neurotransmitters which play critical roles in ADHD symptomatology and therefore are targets of these ADHD medications. The mechanism of action of methylphenidate and amphetamine includes inhibiting the reuptake of dopamine and norepinephrine into the presynaptic neuron by blocking the dopamine transporter and norepinephrine transporter. This blockage results in increasing levels of dopamine and norepinephrine in the synaptic space (dela Pena et al., 2015; Zhu and Reith et al., 2008). Increased dopaminergic and noradrenergic activity in the prefrontal cortex may account for its efficacy in ADHD therapy (dela Pena et al., 2015). Dopamine plays an important role in initiation of motor responses, attention, reaction to novelty, and processing of reward involving

the prefrontal cortex, caudate nucleus accumbens, and cerebellum (Arnsten and Pliszka, 2011; Kesner and Churchwell, 2011). Dopamine controls the brain's reward and pleasure centers and produces the feeling of motivation that makes a person want to take action to achieve their goals (Mehta et al., 2019). For people with ADHD, their level of dopamine is decreased because of an increased reuptake of dopamine back into the neurons. This leads to reduced levels of extracellular dopamine (Gold et al., 2014; Volkow et al., 2001, 2005). This means that there is a reabsorption of dopamine which prevents it from re-entering into the presynaptic neuron that would release it and binding to the postsynaptic cell. This results in a decrease in inattention, restlessness, and impaired learning for people with ADHD. Methylphenidate and amphetamine act as dopamine reuptake inhibitors leading to these effects (Volkow et al., 2005). With a decrease in dopamine reuptake, methylphenidate and amphetamine help individuals with ADHD to counter their symptoms.

Another neurotransmitter that plays a role in ADHD is norepinephrine (NE). Its mechanism of action is similar to that of dopamine where NE maintains mood arousal and behavior (Arnsten and Pliszke, 2011). Specifically, NE levels have been associated with alertness, mood maintenance, and feelings of loneliness, tiredness, fatigue and depression. Individuals with ADHD often present with low arousal which is due to decreased NE cells firing. ADHD medications increase firing by NE-containing cells, which cause the increased release of NE. In turn, this results in a person being more alert (Murburg 1994). ADHD drugs like amphetamine and methylphenidate increase synaptic availability of dopamine and norepinephrine through individual pathways to alleviate ADHD symptoms (dela Pena et al., 2015; Zhu and Reith et al., 2008; Faraone et al., 2015). ADHD is also linked to a dysfunction in serotonin (5 hydroxytryptamine), acetylcholine, opioid, and glutamate pathways (Faraone et al., 2018; Cortese 2012; Maltezos et al., 2014; Blum et al., 2008; Potter et al., 2014; Elia et al., 2011).

Academic Performance

ADHD medication is associated with changes in academic performances in children as well. Treatments can either assist or decline the childrens' academic outcomes. A review paper by Boland et al., 2020 assessed eight studies analyzing impacts of ADHD medication on academic performance Five of the eight papers showed that ADHD treatments were associated

with significant increases in test scores, less absences, improvements in reading and significant improvements in grade point averages. (Jangmo et al., 2019; Keilow et al., 2018; Lu et al., 2017; Marcus and Durkin 2011; Barbaresi et al., 2007). This may be because ADHD medication reinforces the brain's reward and pleasure centers via increased levels of dopamine and thus helps people with ADHD regain the feeling of motivation. However, other work identified remarkable declines in academic performance. Specifically, two of the eight papers showed that some individuals taking ADHD medication exhibited worse school performance and lower test scores (van der Schans et al., 2017; Zoega et al., 2012). This could be due to an incorrect ADHD diagnosis, a comorbid learning disability, or a mood/anxiety disorder. Therefore ADHD medication might not work in such cases. Great outcomes such as better test scores, less amounts of absences, and better grade averages were also shown in longitudinal studies which assess ADHD medication that effects at multiple timepoints in the same participants (Biederman et al., 2009, 2019).

Neuroimaging Findings in ADHD

Structural Magnetic Resonance Imaging (sMRI) and functional MRI (fMRI) are types of neuroimaging techniques that allow for the examination of detailed anatomy and dynamic functional processes in the brain. Specifically, these processes allow us to see the differences in brain structures, such as reduced gray matter volume and changes to thickness of major brain structures implicated in ADHD. These techniques also allow for the comparison of individuals with ADHD on and off medication as well as compared to controls. A review by Spencer et al., 2013 compared MRI findings from groups of individuals with ADHD with and without a history of psychostimulant use to a non-ADHD unmedicated control group. All studies in the review had a case-control design and five of six studies had a cross-sectional design. One of six studies was a longitudinal study. Two studies had a process of reducing concentration of substances called washing out in medicated subjects before the scan. One study did not wash out subjects of the scan and three studies did not mention if medicated subjects were washed out for the scan (Spencer et al., 2013). Washing out indicates that there was a decrease of the concentration of a substance in the medicated subjects. The study showed that there was a difference between having medicated subjects washed out and having medicated subjects not being washed out.

fMRI also allows us to see the effects of psychostimulants on the functioning of the brain. This is because fMRI helps find targeted areas in the brain. Spencer et al., 2013 also evaluated psychostimulant effects observed in fMRI from 20 studies. These 20 studies showcase how psychostimulants affect certain areas in the brain and the function of the brain in ADHD. The results of these studies indicate that individuals with ADHD, when compared to controls, show areas of the brain that are being most involved in ADHD. Areas such as the corpus callosum, anterior cingulate cortex, striatum, caudate, putamen, and the prefrontal cortex were most affected. Fifteen of the twenty studies were task-based in that they determined the medication effects on the activity in the striatum (Spencer et al., 2013).

fMRI studies have also shown that stimulant treatment produced greater brain response to performance on a specific task compared to controls in a parietal, a cerebellar, and an insular regions (Rubia et al., 2009; Stoy et al., 2011; Vaidya et al., 1998; Epstein et al., 2007). MRI studies did not find any worsening in areas of the brain such as frontal striatal, cerebellar, and corpus callosum regions in groups associated with stimulant-medicated groups compared to control groups. There was also an attenuation of abnormalities in portions of the regions assessed (Spencer et al., 2013; Castellanos et al., 2002; Semrud-Clikeman et al., 2006). On the contrary, alterations in brain structure were observed in unmedicated ADHD compared to control groups (Spencer et al., 2013). Moreover, stimulant medication was associated with attenuation of abnormalities in some of the regions evaluated such as the caudate, cerebellum, posterior inferior vermis, and ACC. In the cerebellum, Castellanos et al., (2002) did not find any cerebellar volume reductions in stimulant-medicated groups. Bledsoe et al., (2009) discovered that stimulant treatment over a prolonged period of time attenuated the reduction of posterior inferior vermis volumes compared to non-ADHD medicated groups. Likewise, Shaw et al., (2009) found that stimulant treatment produced similar effects in the rate of change of the cortical thickness in the right motor strip, left middle/inferior frontal gyrus, and in the right parietal occipital region as controls. All these are areas of the brain that are being most affected by the stimulant treatment. Based on these fMRI and sMRI data, chronic stimulant treatment resulted in therapeutic effects in medicated ADHD people as demonstrated by the attenuation of abnormalities in their brain structure and function.

Summary And Conclusion

In summary, recent review and meta-analytic work suggests that ADHD medication containing psychostimulants (e.g., methylphenidate or amphetamine) are effective in treating ADHD. Use of these medications in children with ADHD have led to positive outcomes and effects including improvement in academic performance and positive change in neural structure (Boland et al., 2020; Spencer et al., 2013). Children and adolescents with ADHD have a decreased level in dopamine because of an increased reuptake of dopamine that is led back into the neurons. It has been identified that these medications help return dopamine levels to normal and maintain it (Gold et al., 2014; Volkow et al., 2001, 2005). Norepinephrine is another neurotransmitter that plays an important role in ADHD because it also maintains the level of mood and behavior (Arnsten and Pliszke, 2011). Some studies found that norepinephrine regulates arousal states which means it's an important neurotransmitter to regulate overall mood, alertness and maintaining the feelings of loneliness and depression (Faraone et al., 2018). The areas of the brain that are most affected by ADHD medication and treatment are the anterior cingulate cortex, striatum, prefrontal cortex and the splenium of the corpus callosum. These areas of the brain have been affected from ADHD stimulant treatment. There were also changes in the thickness of the brain such as the cortical thickness and the right parietal occipital region. The use of psychostimulants to treat ADHD in children and adolescents are to be monitored as it can affect the brain structures and results of their academic performance. This is important because it can help physicians to recognize the effects of stimulant medication in children and adolescents with ADHD.

Acknowledgements

Thanks to my mentor Kathryn Wall for assisting with paper development and editing.

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The Effect of Microplastics on the Stress Response of Daphnia magna By Nikhita Varma

Abstract

As plastic production is an important part of creating thousands of products, it is a widely used material around the world. Its durable, sterile, and versatile qualities prevent companies from eliminating plastic altogether. On the other hand, durability is what prevents plastic from decomposing properly.

Microplastics, specifically, are a great threat to aquatic organisms and ecosystems. These tiny plastic fragments have been discovered everywhere in the ocean, from the surface to the seafloor and along the shoreline, and they can enter the ocean through several land and water sources. These pollutants can alter the physical properties of habitats, such as soil or water, which can impact the organisms that rely on these habitats for survival.

It is important to take into account the biological effect microplastics might have on organisms in the ocean. Microplastics can contain toxic chemicals, which can leach into the surrounding environment and harm organisms that come into contact with them. These chemicals can also accumulate in the tissues of organisms, leading to longer-term health effects. By having a clearer picture of how organisms might react to microplastics in their environment, it can help determine whether microplastics will negatively affect aquatic life forms. With more concern about how pollution affects organisms, the public will become more aware of ways to prevent future issues.

Background–Plastic pollution

Based on a recent report regarding plastic in the ocean, it was found that four sources of microplastic alone accounted for 1.3 billion tons of ocean plastic pollution. Without direct action to prevent additional accumulation, data shows that microplastic pollution will double to an estimated 3 metric tons of plastics in the ocean (Lau). Studies have been made reporting that every bit of plastic created still exists (Hancock). The majority of plastic waste will remain in the environment for generations due to its resistance to degradation, because of the inability to digest and break down such material. The main sources of plastic entering the oceans are land and ocean-based, with industrial activities playing a large role in this as well. (Li) If not disposed of the proper way, plastic can eventually end up in habitats and disrupt animals, even distress them.

By ingesting the plastic or even being entangled in it, the organism is prevented from growing and thriving as a developing species.

Microplastics

Microplastics, specifically, are a great threat to aquatic organisms and ecosystems. Microplastic is a widespread pollutant—less than 5 millimeters—having an effect on aquatic ecosystems all over the world. Seawater, sediments, and biota all contain synthetic fibers, according to environmental sampling (Cole). Because they are not uniform in shape, size, or type of plastic, preventing such small particles from entering the environment is a huge challenge (Know). One of the main contributors to the contamination of saltwater with plastic is thought to be river runoff.

Although the majority of research so far has concentrated on inhalation and ingestion, exposure to environmental microplastics can occur through skin contact as well (Meaza). There is a great concern over the immediate and long-term effects of microplastics on aquatic life. Since there is a great number of such a tiny substance, it is very difficult for scientists to develop a way to clean up the oceans and prevent plastics from getting into aquatic ecosystems.

Water Flea Genus *Daphnia magna*

To truly understand the biological impacts of microplastics, an organism, such as *Daphnia*, can help model the significance of such pollutants when exposed to organisms. These water fleas' lifespan is significantly impacted by the oxygen content of the environment, the availability of food, and temperature (Elenbaas).

While *Daphnia* fleas are widely used in experiments due to their small size, transparency, and ease of culture, it can be difficult to maintain them. Requiring specific water temperatures and proper food proportions, their health can be at risk if certain conditions are not put in place. These factors can greatly impact the validity of the outcome and data. Various studies have started to examine how microplastics can affect *Daphnia*, a model organism, in terms of growth and reproduction. Freshwater filter feeder *Daphnia magna* has the capacity to take in and digest tiny, suspended particles from the water.

According to certain reports, daphnia is unable to distinguish between particle size and quality, which suggests a lack of selection and potential MP ingestion (Aljaibachi). Microplastics

can be very detrimental for such delicate organisms, and ingesting the plastics can even lead to bioaccumulation. Bioaccumulation is when substances such as pesticides or chemicals gradually accumulate in an organism, through the sources that are used, such as water or food. This accumulation can pass through many generations of species as well as through predators who eat the affected organism. This shows us that when a single organism gets affected by microplastics, an entire food chain can get affected (Ebert).

Methodology

The goal of this project was to determine to what extent microplastics can cause stress for *Daphnia magna*, using simple experiments that can be conducted using easily sourced equipment and materials.

In this project, the heartbeat of the *Daphnia* was measured after exposure to microplastics in their environment and comparisons were made between the different experimental groups. Each experimental group contained different milligrams of microplastics, with respect to a negative control, 25 milligrams, 35 milligrams, and 45 milligrams of microplastics per 1 Liter of mineral water. To ensure uniformity, the – container in which the Daphnia had the same conditions, i.e.,- same temperature of water, the same species, and the size of the microplastics. By basing this experiment around the goal of determining whether *Daphnia magna* are greatly impacted by microplastics, it will help determine whether aquatic organisms in the ocean will respond similarly to the overpollution of plastic in their ecosystem.

Based on past studies and sources, it can be hypothesized that if the environment in which the *Daphnia* lives contains increasing amounts of microplastics, then the heart rate and overall stress level of the *Daphnia* will increase as a result. The *Daphnia* exposed to greater amounts of microplastics will greatly affect their heart rate, in other words, their stress. This hypothesis can be justified by the fact that microplastics have a great influence on biological signals. It may also be expected that microplastics will decrease the organism's lifespan as well as increase stress levels, resulting in a higher number of heartbeats.

Materials

For this experiment, polypropylene plastic beads were used to create microplastics. The tiny microplastics were created using a medium sized hammer and a mortar and pestle. A plastic

bag and four identical plastic containers were used as well as a 1 Liter beaker to measure a total of 12L of mineral room temperature water for the whole procedure. 24 *Daphnia magna* were purchased from Carolina Biological Supply(US) and Daphnia yeast pellets from Amazon(Aquatic Food Inc. US) were used for feed. A thermometer, micropipette, a light microscope, a 20 MP digital microscope camera attachment(Moticam US) and a concave microscope slide were additionally used to transfer and observe the Daphnia..

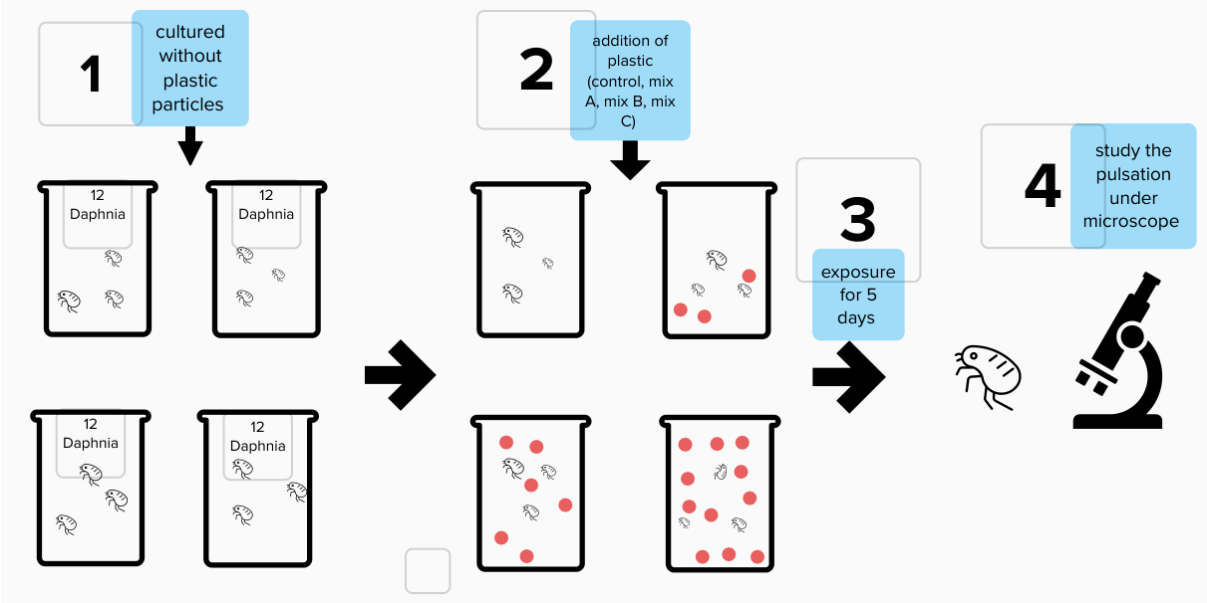

Figure 1. Procedure conducted for the experiment.

Procedure

To create the microplastics, the small plastic beads were placed into the plastic bag to crush into small pieces, using a hammer and mortar and pestle. To ensure uniformity, the sizes of the microplastics were observed under a microscope. Before beginning the trial, the concentration of microplastic was pre-tested to ensure the concentration will not be lethal to Daphnia. Utilizing a LD-50—a dose that is lethal to 50% of the population—enabled a proper method in determining a concentration high enough yet not lethal to kill the organism. After testing with various concentrations, it was found that 25 mg, 35 mg, and 45 mg of microplastic are the optimal concentrations without producing more than 50% population death.

As shown in Figure 1. Step 1, four different containers filled with 1 Liter of water had 12 *Daphnia magna* organisms placed in each container. Ensuring each container has the same

conditions(the same temperature of water, same sunlight) will ensure uniform testing. The Daphnia were fed yeast pellets daily for nutrients. In step 2, there is an addition of plastics, categorized as the control, mix A(25mg), mix B(35mg), and Mix C(45mg). After 5 days of exposure(shown in step 3), the Daphnia was inspected under a microscope (shown in step 4), focusing on the heart of the organism found under the dorsal fin and behind the eye spot. Utilizing a microscope camera attachment, the heartbeats were recorded for 10 seconds and slowed down to count. The recorded number of heartbeats were multiplied by 6 to achieve bpm. The Daphnia was then transferred back into the container for a recovery period. This procedure was repeated for trials 2 and 3.

Observation of Daphnia magna Under Microscope

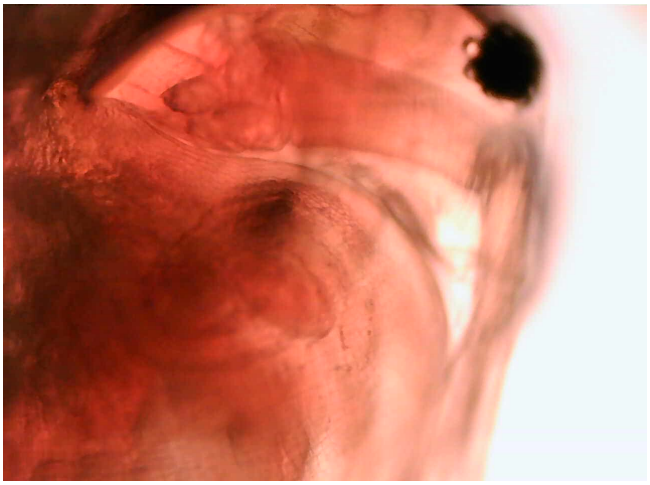

Figure 2. Microscopic observation of Daphnia heart with 400× magnification

Shown in Figure 2. the heartbeats were counted under the dorsal fin. Daphnia under the microscope turned slightly red. The daphnia was translucent when placed under the telescope, making it easier to count its heartbeats.

Data Analysis and Results–Quantitative Data

Table 1. Display of Heartbeats of 30 Daphnia Organisms From Three Trials

	control	25 mg of mp	35 mg of mp	45 mg of mp
organism 1	354	402	498	510
organism 2	342	402	498	504
organism 3	360	414	486	510

organism 4	360	402	498	510
organism 5	348	378	492	504
organism 6	342	408	504	516
organism 7	350	402	480	504
organism 8	330	372	480	510
organism 9	366	402	480	504
organism 10	354	402	486	540
Trial 2				
organism 1	354	408	486	516
organism 2	342	402	498	516
organism 3	354	414	504	516
organism 4	354	408	480	528
organism 5	366	384	486	510
organism 6	348	408	504	510
organism 7	354	414	510	516
organism 8	360	420	498	510
organism 9	360	378	486	522
organism 10	354	402	480	504
Trial 3				
organism 1	342	408	480	516
organism 2	354	372	510	516
organism 3	342	402	498	522
organism 4	342	414	498	516
organism 5	318	402	498	528

organism 6	354	366	510	516
organism 7	342	372	480	516
organism 8	360	384	510	522
organism 9	360	408	480	516
organism 10	342	414	510	516
AVG	350.2666667	398.8	493.6	514.8
STDEV	10.32451236	14.99866661	10.94714575	7.959899497

Results

Based on Table 1. it was discovered that a greater amount of microplastics in the Daphnia's environment, resulted in a higher number of heartbeats, in other words more stress. For the control, the average number of heartbeats reflects a healthy organism, 350 bpm being the normal rate for Daphnia *magna*. With the addition of plastic, the bpm increased, from an average of 399 bpm to 515 bpm. The 45 mg of microplastics resulted in the most number of heartbeats.

	control	25 mg	35 mg	45 mg
control	x	4.80E-21	2.53E-50	2.69E-57
25 mg	x	x	2.93E-35	3.35E-42

Based on Table 2., all the p values from the T-test reject the null hypothesis that states there is no significant difference between data. As all the values in green display a P value<0.05, the data points between each group are significantly different. Changing the amount of microplastics present in the environment made an impact on the health of the Daphnia heart.

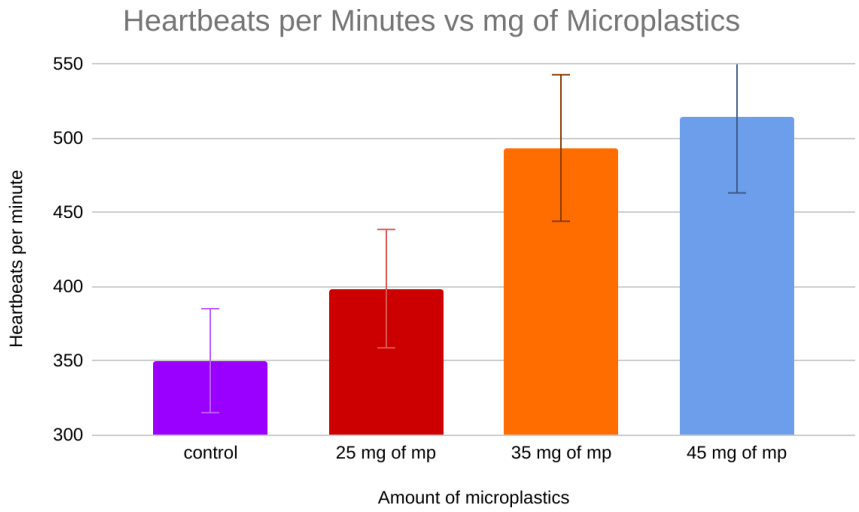

Figure 3. Heartbeats per Minute as the Function of Microplastics

Trials with increasing amounts of microplastics resulted in a higher number of heartbeats per minute. The control shows an average of 350 heartbeats while 45 mg of mp increases up to 510 beats per minute. The standard deviation is relatively all similar, which leads to the point that the data has a similar coefficient of variation.

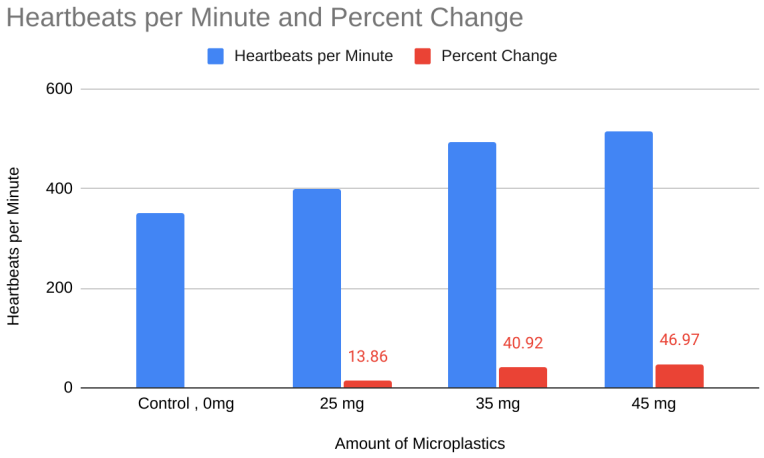

Figure 4. Percent Change Between Control and I.V.s

The percent change is significant, there is a cause and effect relationship. The change made for each independent variable is correlative to the change of each of the independent variables as shown through the percentages.

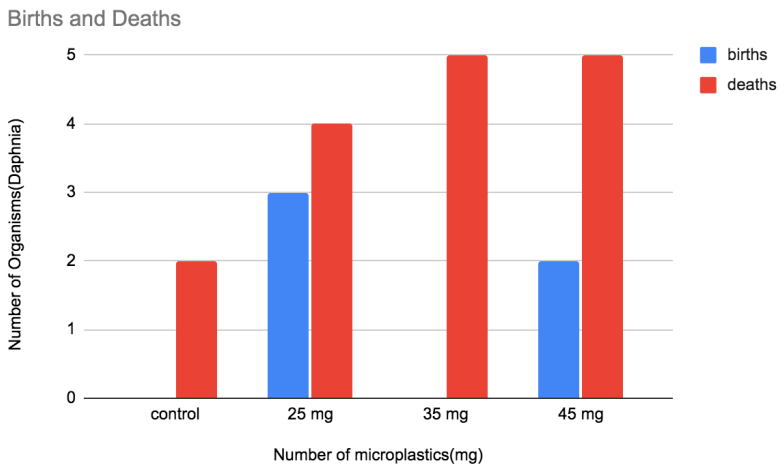

Figure 5. Number of Births and Deaths Throughout Three Trials

Figure 5. displays the birth and death rate over the experiment period. There is no correlation between the number of births and microplastics, arriving at the conclusion that the reproductive system was not affected by the chemical from the plastic. Yet the increase in microplastics does show an increase in deaths, caused by the extreme stress produced from cytotoxicity from the plastic.

Discussion and Conclusion

There is a great worldwide problem regarding plastic pollution in the ocean. As millions of plastic products are used and discarded improperly, the plastic will start accumulating in oceans and lakes, affecting the organisms living in them. Even though measures have been taken to reduce plastic waste, there will still be plastics that are nearly impossible to get rid of from the oceans. The majority of plastic waste will remain in the environment for generations due to its resistance to degradation, because of the inability to digest and break down such material. After exposing the Daphnia to different concentrations of microplastics, the heartbeats were counted to determine the stress caused by the I.V. Based on the data collected from the experiment, it can be concluded that a higher concentration of microplastics will increase the heart rate of Daphnia magna. Therefore, the hypothesis, “If the environment in which the Daphnia lives contains higher concentrations of microplastics, then the heart rate and overall stress level of the Daphnia will increase” can be accepted. Microplastics can contain toxic chemicals, which can leach into the surrounding environment and harm organisms that come into

contact with them. These chemicals can accumulate in the tissues of organisms, leading to longer-term health effects. While testing, a greater number of heartbeats were recorded when Daphnia had exposure to a higher concentration, compared to when they had exposure to a lower concentration. In comparison to other experiments, such as “Impact of Polystyrene Microplastics on Daphnia Magna Mortality and Reproduction”(Aljaibachi), this experiment saw similar results. Therefore the hypothesis can be accepted.

A future direction would be to utilize other types of aquatic organisms to get a deeper understanding of the effects of microplastics. Studying generations of Daphnia can additionally determine whether organisms are able to develop an immunity to the toxicity of plastics, studying the trend of their lifespan. Through these numerous studies, the world will have a better understanding of how microplastics affect aquatic organisms. This will help motivate a greater number of people to recycle plastics and use degradable materials. Being mindful of plastic’s effect on the environment will result in a better future on this planet.

Acknowledgments

I would like to take this opportunity to thank all those who supported me through this project. Firstly, I would like to thank Professor Manoj Varma from the Indian Institute of Science for helping me discover the big idea for this experiment. I would additionally like to thank my chemistry teacher, Mrs. Ansell, and science seminar advisor Mr. Guerin for supporting me by answering questions and guiding my experiments. Lastly, I'd like to acknowledge my parents for supporting me through my project.

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A Novel Deep Learning Approach to Coronary Artery Disease Diagnosis and Risk Assessment via Physiological Factors and Electrocardiograms By Evan Tu, Edwin He, Aayan Rizvi, and Harry Tu

Abstract

Coronary artery disease (CAD)—the most common form of cardiovascular disease—is one of the foremost causes of death worldwide due to its role in chest pain, heart failure, and heart attacks. CAD poses an immense risk to human life, with over 19 million deaths globally attributed to cardiovascular disease in 2020. Heart disease has cost the United States approximately $229 billion annually for treatment, medicine, and health care services. A low-cost and efficient way for diagnosis and risk assessment must be available to increase CAD detection and significantly reduce the chances of mortality because of early prevention methods. The high-cost barrier and inconvenience of the many CAD tests for diagnosis deter many individuals from seeking the treatment needed. This paper presents an end-to-end deep learning pipeline that utilizes an individual's physiological factors, such as total cholesterol levels and later pairs that with electrocardiogram (EKG) readings to provide a highly precise system for CAD prognosis and risk assessment. Out of six industry-standard benchmark models diagnosing for CAD using physiological information and electrocardiograms, this study's non-ensemble and ensemble approaches to CAD prognosis completely outperform state-of-the-art models, with the most exceptional physiological-oriented model being the XGBoost at 98.70% accuracy while the most performant EKG-based model being the CNN at 98.65% accuracy. The best benchmarks achieved a 95.08% accuracy for physiological data and 95.9% for electrocardiograms. This study is a step to minimize the loss of human lives on a global scale with a more efficient, accessible, and cost-friendly solution.

Introduction

In the United States, coronary artery disease (CAD) affects approximately 20.1 million adults aged 20 and older, leading to chest pain caused by narrowed coronary arteries due to plaque buildup. CAD can be fatal, weakening the heart over time and impairing blood pumping. In 2020 alone, an estimated 382,820 people in the United States died from CAD, which is also the leading cause of heart attacks affecting about 805,000 individuals annually. Globally, CAD is

the most common form of cardiovascular disease, responsible for an estimated 19.1 million deaths in 2020.

Treatment for CAD involves medication to prevent blood clots and reduce cholesterol levels in the bloodstream. Adopting a healthier lifestyle can also improve the condition, but more severe procedures may be necessary if plaque buildup progresses. Unfortunately, CAD often has no noticeable symptoms, making early prevention challenging. Various medical tests, such as electrocardiograms (EKGs), are used to detect CAD. However, the accessibility of these tests to the general public is limited, as they can be expensive, leading to individuals neglecting necessary medical care.

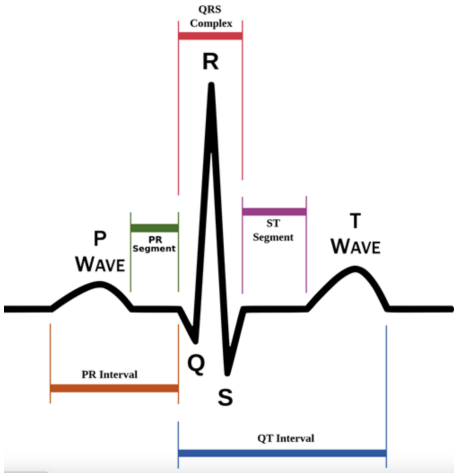
For many asymptomatic individuals, a heart attack may be the first visible sign of CAD, indicating that blood flow to the heart tissue is already blocked, potentially resulting in permanent damage or death. Surgical procedures like percutaneous coronary revascularization (PCI) may be required to restore blood flow, but they carry risks and are costly. Early detection is crucial to reduce patient risks and costs by preventing the disease from progressing to the stage where surgery becomes necessary.

Additionally, individuals need an accurate and low-cost method to assess their risk levels and determine if further examination, such as an EKG, is necessary. A convenient alternative is for individuals to input readily available data at home, such as age, sex, blood pressure, cholesterol levels, fasting blood sugar, and maximum heart rate, using devices like cholesterol and blood pressure monitors. Deep learning classification can then analyze this data and recommend if individuals should consider a more extensive examination at the hospital, saving time and costs compared to annual checkups.

Efficient and rapid analysis of EKGs is crucial to provide patients with necessary care promptly and prevent permanent damage. EKGs detect the electrical currents generated by the heart's contractions and rhythms. While traditional interpretations of EKGs can take up to two weeks, machine learning models can analyze irregularities in less than a minute. With the emergence of personal EKG devices like smartwatches, this model can also be used to analyze EKGs from at-home devices. Although personal EKGs are less accurate than professional ones, machine learning can still identify abnormalities and recommend further examination using a more accurate EKG at a hospital.

Figure 1

Diagram depicting the electrocardiogram structure with the different waves making up the recording



Irregularities in the waves, such as P-waves, and intervals between waves, such as the PR segment, can all point to the development of coronary artery disease. For example, if the Q wave is enlarged, a patient might be suffering from a myocardial infarction. If the ST segment is depressed, the heart might not be receiving enough oxygen, possibly due to plaque blockage in the coronary arteries. Machine learning can detect these subtle abnormalities in the EKG, improving the detection of coronary artery disease.

This paper presents an end-to-end deep-learning pipeline that assesses the likelihood of a patient developing coronary artery disease. The pipeline first processes the patient's physiological information and if the proposed risk is severe, determines that the patient should be examined by the electrocardiogram. Secondly, electrocardiogram graphs will be measured and taken to be classified for coronary artery disease by the pipeline. This paper compares machine learning architectures and determines the most utilized features in the model to provide valuable data for future models. It builds on previous studies, surpassing their accuracy for CAD detection. The study serves as a pillar toward a more efficient, accessible, and low-cost tool to prematurely detect and diagnose coronary artery disease on a global scale.

Methods–Datasets

This study utilizes two datasets for deep learning classification analysis. The first dataset is the Physionet PTB Diagnostic Electrocardiogram Database by Bousseljot et al. (Bousseljot et al., 2004). It is composed of high-resolution 15-lead electrocardiogram graphs from 290 male and female patients aged 17 to 87. Electrocardiograms were measured at a rate of 1000 samples per second, with 16-bit resolution. Two hundred sixteen patients were categorized under the diagnostic classes that are critical or mild indicators of coronary artery disease, and 52 patients were categorized under the healthy control class. The second dataset used to analyze physiological and other relevant health factors for the detection of coronary artery disease is a combination of four separate databases of cardiovascular disease diagnosis from the Cleveland Clinic Foundation; Hungarian Institute of Cardiology; V.A. Medical Center, Long Beach, CA; and University Hospital, Zurich, Switzerland (Janosi et al., 1988). The dataset is composed of each patient's age, sex, chest pain type, resting blood pressure, serum cholesterol levels, fasting blood sugar, if they had exercise-induced angina, maximum heart rate achieved, the EKG's ST segment depression after exercise, and if the patient is at risk of a heart attack. This paper removes some physiological data that cannot be measured at home to fit the model design better. It removed the following categories: chest pain type, if they had exercise-induced angina, and ST segment depression after exercise. The relative risk and likelihood of each patient developing coronary artery disease are then evaluated by this model using the collected electrocardiogram data and physiological information.

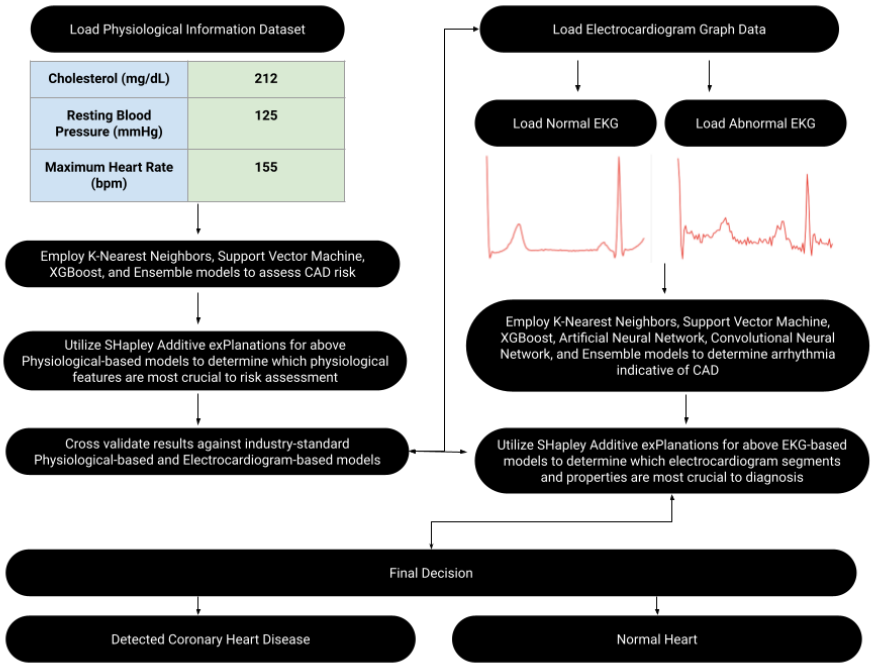
Data Preprocessing

The PTB Diagnostic Electrocardiogram Dataset was split into a 70% (10,186 samples) non-image training set and a 30% (4366 samples) non-image testing set. Electrocardiograms were collected from .dat files, which were processed and normalized into NumPy arrays for training and testing purposes. The electrocardiograms were also segmented into ten-millisecond intervals to examine what intervals were the most important, analyzing them with SHap. After the first round of data preprocessing, the data was split again in a 70/30 training/testing manner, but this time converting the .dat files into .png images. The purely-image dataset aimed to see how each respective model's performance would compare with the non-image dataset model's performance. The physiological dataset, composed of four separate databases of physiological

information, was split into a 70% (717 samples) training set and a 30% (308 samples) testing set. All data points underwent normalization to improve model accuracy and enhance training stability. Physiological data were also visualized with SHap to cross-reference with factors scientifically proven to cause coronary artery disease to validate our model after being fed into machine architectures.

Figure 2

Diagram of model pipeline that takes in physiological tabular data to evaluate a patient's risk for CAD. It will then use electrocardiogram-based models to classify coronary artery disease if the risk is severe enough.



Model Architectures

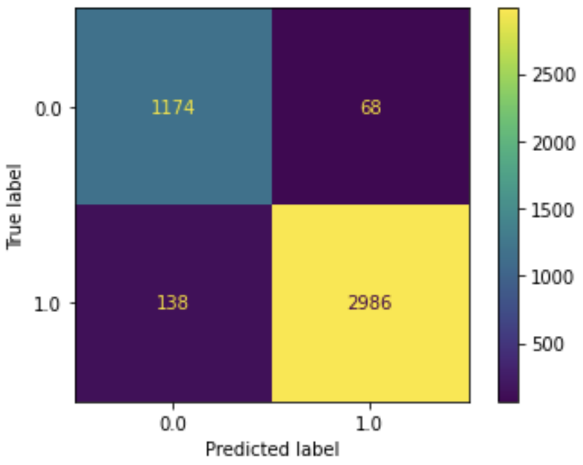
Several model architectures were employed to predict the risk of coronary artery disease (CAD). The K-Nearest-Neighbors (KNN) architecture used vector similarity to make predictions based on physiological features or EKG amplitudes. KNN is a non-parametric method that classifies based on the closest neighbors, allowing for easy integration of new models and adaptability to changes in the medical field. Extreme Gradient Boosting (XGBoost) was used to diagnose CAD

using electrocardiogram data and physiological data. XGBoost offers high predictive power and fast identification of problems, as it uses Gradient Boosted Decision Trees and ensembles the classifiers' predictions. The Support Vector Machine (SVM) is effective for high-dimensional data, making it suitable for EKGs with many data points. SVM creates a separator plane in the feature space to achieve clear separation between vectors. An Ensemble Model combined KNN and SVM, summing their probabilities to make predictions. The Artificial Neural Network (ANN) employed backpropagation and stochastic gradient descent to minimize loss. The input layer accepted EKG images, and the network learned complex features through hidden layers to predict CAD risk. The Convolutional Neural Network (CNN) was used for EKG analysis, applying filters and pooling layers to classify patterns and reduce overfitting.

Results

Figure 3

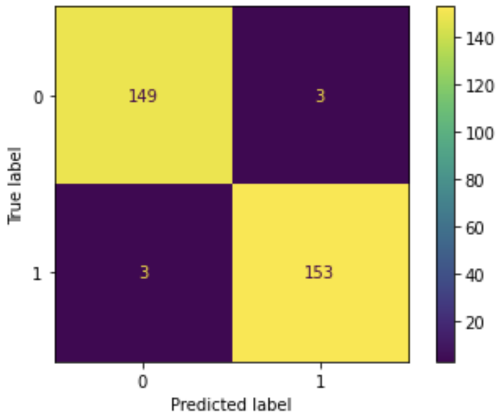
Confusion Matrix for K-Nearest Neighbors (KNN) Classification of CAD via EKGs.



The KNN model achieves a 95.28% accuracy, with 33.01% of the error being in the false positive category.

Figure 4

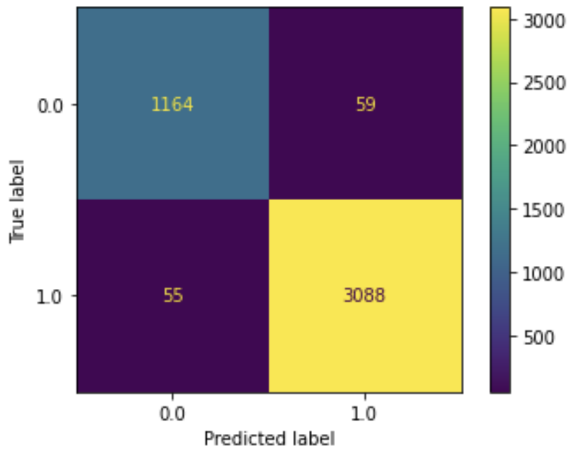
Confusion Matrix for K-Nearest Neighbors (KNN) Classification of CAD via Physiological Information.



This KNN model achieves a 98.05% accuracy, with 50% of the error being in the false positive category.

Figure 5

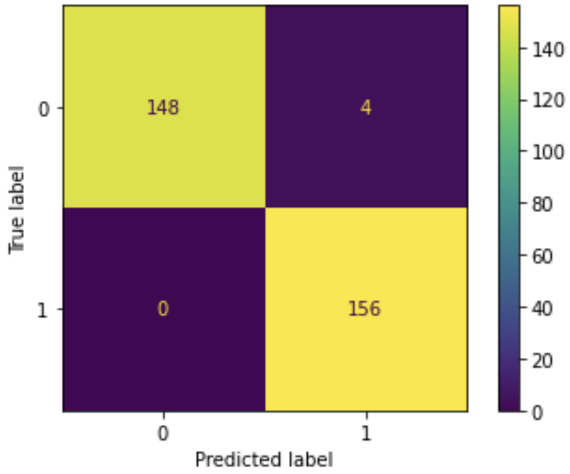
Confusion Matrix for XGBoost Classification of CAD via EKGs.



This XGBoost model achieves a 97.39% accuracy, with 51.75% of the error being in the false positive category.

Figure 6

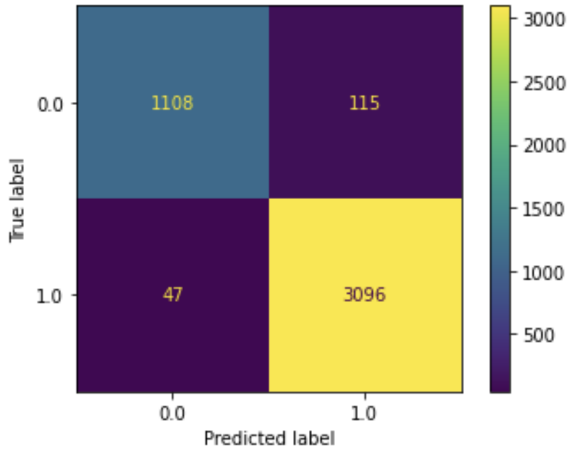
Confusion Matrix for XGBoost Classification of CAD via Physiological Information.



This XGBoost model achieves a 98.70% accuracy, with 100% of its error being false positives.

Figure 7

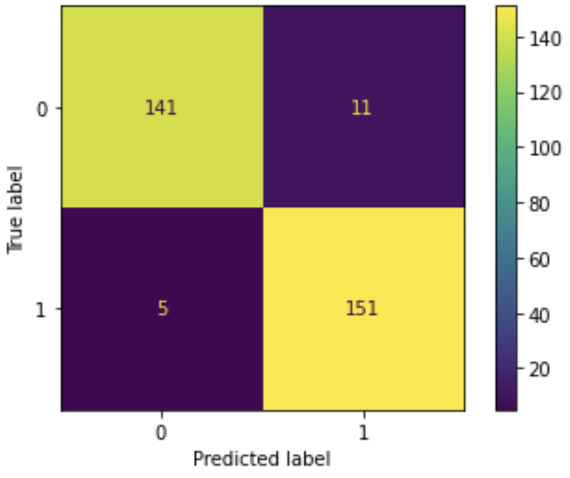
Confusion Matrix for Support Vector Machine Classification of CAD via EKGs.



This SVM model achieves a 96.29% accuracy at a false positive rate of 70.99

Figure 8

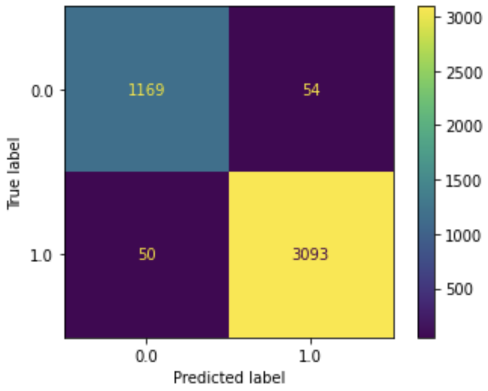
Confusion Matrix for Support Vector Machine Classification of CAD via Physiological



This SVM model achieves a 94.81% accuracy, with 68.75% of its error being false positive.

Figure 9

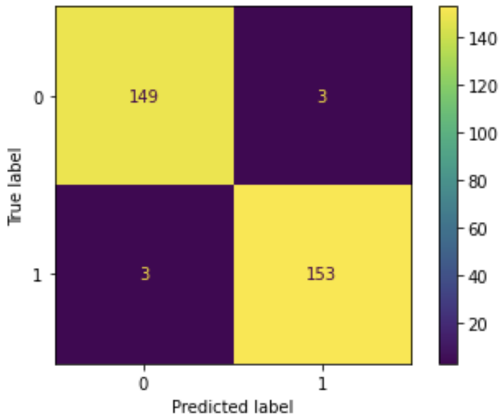
Confusion Matrix for Ensemble Classification of CAD via EKGs.



The EKG-based Ensemble Model achieves a 97.62% accuracy, at a false positive rate of 51.92%.

Figure 10

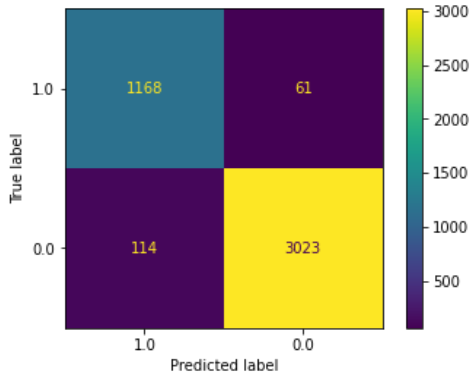
Confusion Matrix for Ensemble Classification of CAD via Physiological Information.



This Ensemble Model achieves a 98.05% accuracy, better than the individual models, showing that an aggregation of the KNN and SVM algorithms perform better together. 50% of the error is false positive.

Figure 11

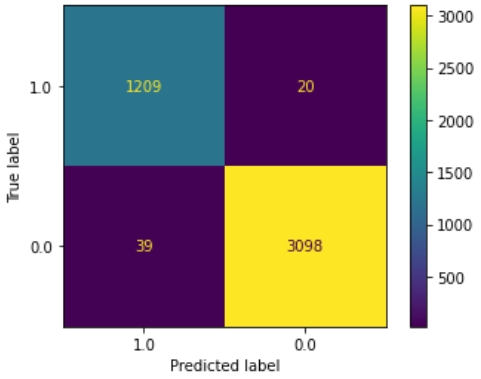
Confusion Matrix for Artificial Neural Network (ANN) Classification of CAD via EKGs.



This ANN model achieves a 95.99% accuracy. 65.14% of the error came from false positives

Figure 12

Confusion Matrix for Convolutional Neural Network Classification of CAD via EKG.



The CNN model achieves a 98.65% accuracy. 66.10% of the error came from false positives.

Figure 13

Metrics table consisting of both non-Ensemble and Ensemble approaches to predict CAD via physiological factors and EKGs. Metrics include each respective model's accuracy, precision, recall, and F1 rates.

Model	Task	Accuracy	Precision	Recall	F1
KNN	EKG	95.28%	97.78%	95.58%	96.67%
KNN	Physiological	98.05%	98.08%	98.08%	98.08%
XGBoost	EKG	97.39%	98.13%	98.25%	98.19%
XGBoost	Physiological	**98.70%**	**97.50%**	**100%**	**98.73%**
SVM	EKG	96.29%	96.42%	98.50%	97.45%
SVM	Physiological	94.81%	93.21%	96.79%	94.97%
Ensemble	EKG	97.62%	98.28%	98.41%	98.34%
Ensemble	Physiological	98.05%	98.08%	98.08%	98.08%
ANN	EKG	95.99%	98.02%	96.37%	97.19%
CNN	EKG	**98.65%**	**99.36%**	**98.76%**	**99.06%**

Discussion–Physiological Factors SHapley Visualizations

Figure 14

SHapley Additive exPlanation for K-Nearest Neighbors Physiological Model.

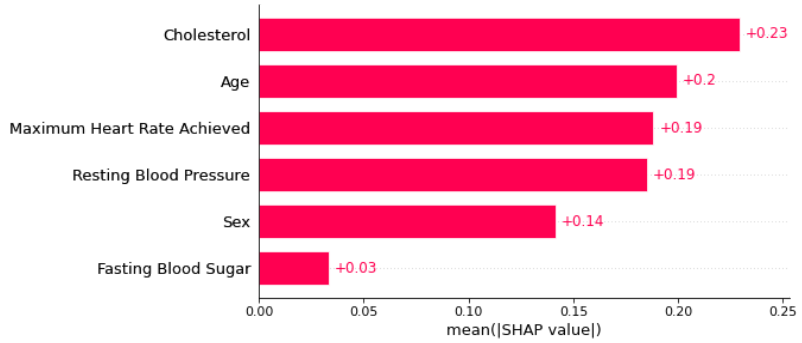


Figure 15

SHapley Additive exPlanation for XGBoost Physiological Model.

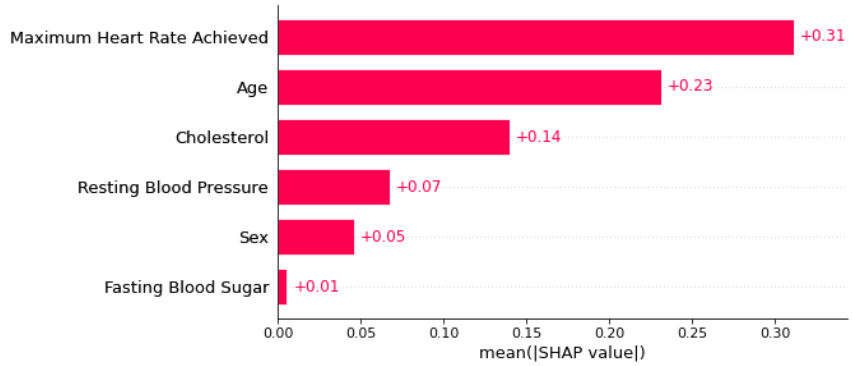


Figure 16

SHapley Additive exPlanation for Support Vector Machine Physiological Model.

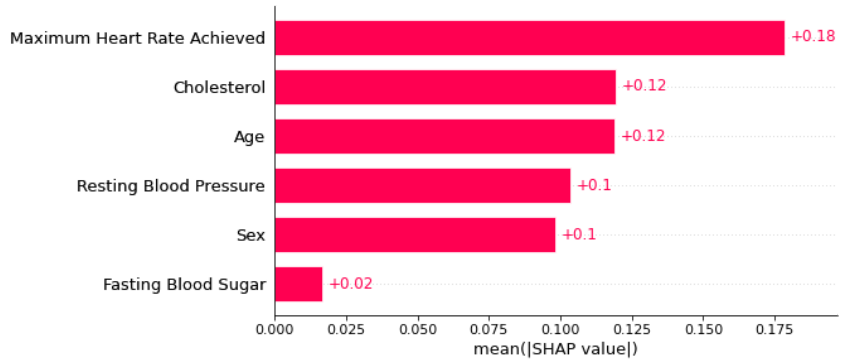
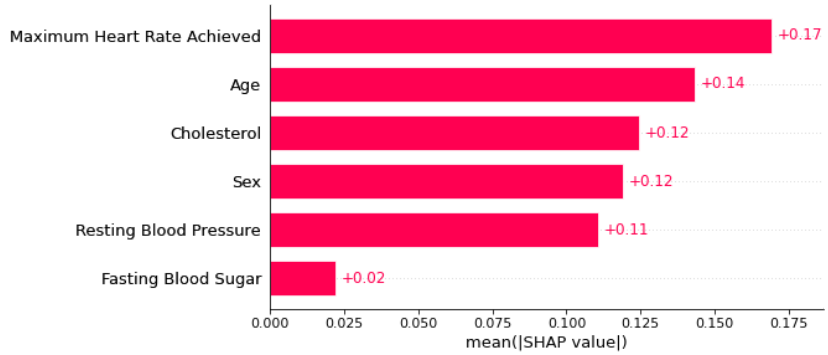


Figure 17

SHapley Additive exPlanation for Ensemble Physiological Model.



Physiological Factors SHapley Explanations

SHAP values, calculated using game theory, indicate the contribution of each feature to the model's outcome. These values are arbitrary and not standardized but provide a relative measure of feature importance. For the K-Nearest Neighbors algorithm, cholesterol and age have the highest impacts on CAD diagnosis (+0.23 and +0.2, respectively), while fasting blood sugar has a minimal impact (+0.03). In the XGBoost algorithm, maximum heart rate achieved and age have the most impact (+0.31 and +0.23, respectively). The Support Vector Machine algorithm assigns the highest impact to maximum heart rate achieved, cholesterol, and age (+0.18, +0.12, and +0.12, respectively). In the Ensemble algorithm, maximum heart rate achieved and age are the most influential features (+0.17 and +0.14, respectively).

The important features in CAD diagnosis are maximum heart rate achieved, age, and cholesterol. This is because patients with coronary artery disease typically have a higher maximum heart rate, older individuals have more time to accumulate arterial plaque, and cholesterol contributes to artery-blocking plaque formation. The attached SHAP visualizations support the prioritization of these three features in the models, demonstrating the accuracy and precision of the study. Sex, although men have a higher chance of developing CAD at a younger age, is less influential compared to these three factors. The machine architecture values sex as the fifth most important factor in KNN, XGBoost, and SVM, and the fourth most important in Ensemble, out of a total of six factors.

Electrocardiogram SHapley Visualizations

Figure 18

SHapley Additive exPlanation for K-Nearest Neighbors Electrocardiogram Model.

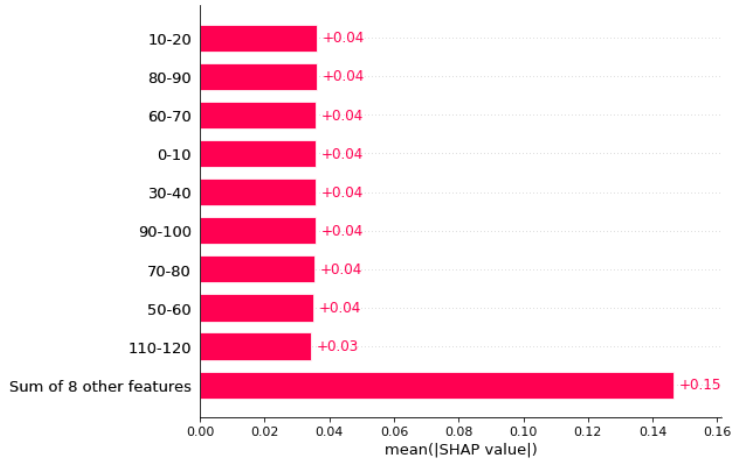


Figure 19

SHapley Additive exPlanation for XGBoost Electrocardiogram Model.

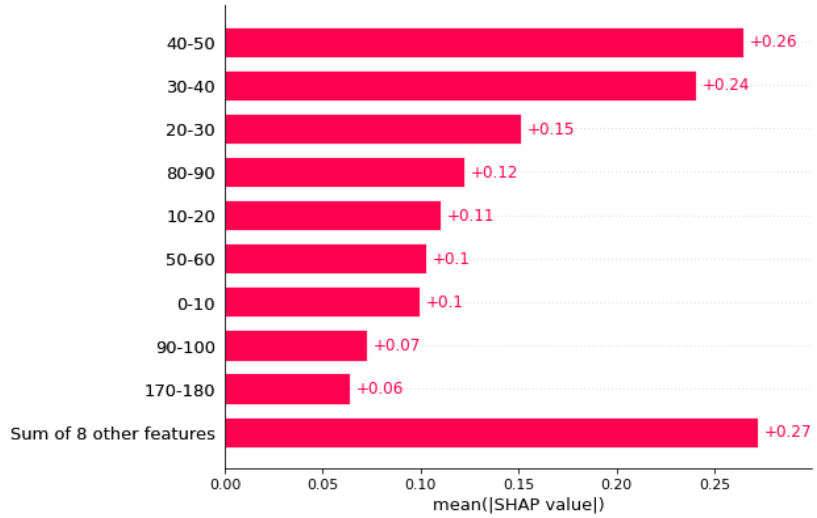


Figure 20

SHapley Additive exPlanation for Support Vector Classifier Electrocardiogram Model.

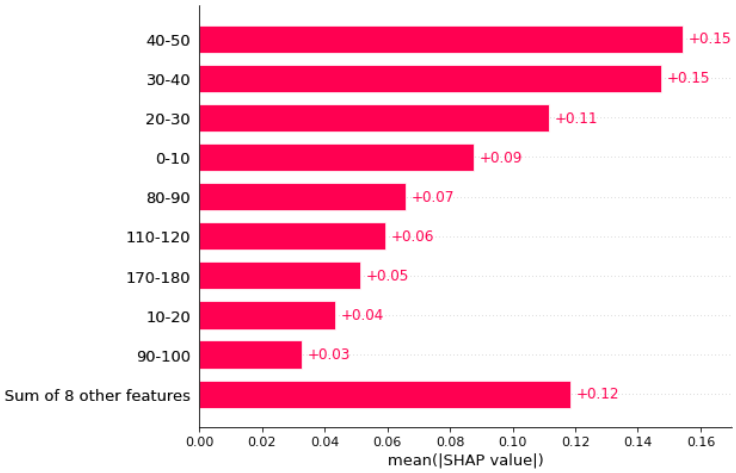


Figure 21

SHapley Additive exPlanation for Ensemble Electrocardiogram Model.

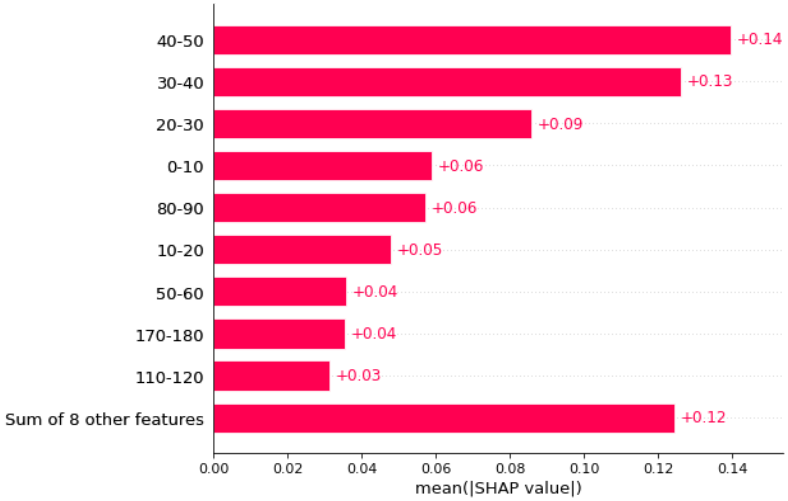
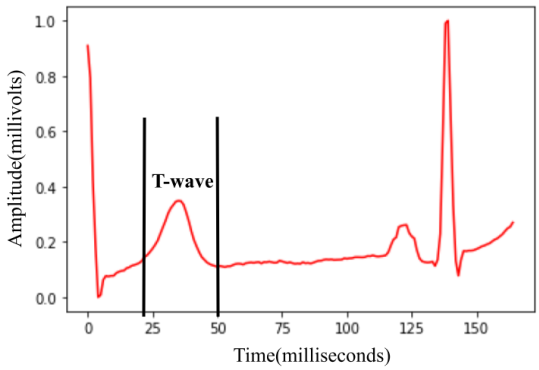


Figure 22

Graph of the EKG data—with the T-wave labeled—from the PTDB dataset utilized in the paper.



Electrocardiogram SHapley Explanations

For the XGBoost, Support Vector Classifier, and Ensemble models, the intervals 30-40 [ms] and 40-50 [ms] were given more importance in determining the classification of the EKG. This was based on SHAP values, which ranged from +0.13 to +0.24 for the 30-40 [ms] interval and +0.14 to +0.26 for the 40-50 [ms] interval. These intervals, along with the 20-50 [ms] interval that includes the T-wave, were found to be the most relevant for detecting coronary artery disease (CAD). The T-wave becomes flatter when the heart muscles receive less oxygen due to plaque buildup in the coronary arteries, making it a significant feature in CAD detection. By prioritizing the T-wave segment, these models achieved high accuracies as they focused on the relevant parts of the EKG structure.

The KNN model, on the other hand, treated all intervals equally except for the 90-100 [ms] interval, which had a slightly lower SHAP value of +0.03. This equal weighting of intervals may have contributed to the KNN model's lower accuracy compared to the other models. While the KNN model still achieved a relatively high accuracy of 95.28%, it might not be as effective in distinguishing between healthy and unhealthy patients due to its inability to prioritize the most relevant intervals like the T-wave. However, other features of the electrocardiogram, such as depression in the ST segment or elongation of the PT segment, can also indicate coronary artery disease, although they are not as distinctive as the T-wave.

In the case of Neural Networks (ANN and CNN), SHAP values and interval analysis were not shown or analyzed. Neural networks are considered Black Box models, meaning their structure and weights cannot be easily interpreted. However, since neural networks utilize gradient techniques, they likely leverage intervals similar to XGBoost and other models but can

effectively utilize them through multiple strategies to create a holistic solution to the problem at hand.

Benchmark Comparisons

Figure 23

Benchmark #1 for comparing industry-grade EKG deep learning models for CAD detection. Table from "Machine Learning Technology-Based Heart Disease Detection Models" by Umarani Nagavelli, Debabrata Samanta, and Partha Chakraborty.

Methods	Accuracy	Precision	Recall	F1-measure
Naïve Bayes weighted approach	86.00	82.34	87.25	89.21
2 SVM's and XGBoost	94.03	86.56	94.78	92.79
SVM and DO	89.4	66.1	81.3	82.1
XGBoost	95.9	97.1	94.67	95.35

Figure 24

Benchmark #2 for comparing industry-grade physiological-based machine learning models for CAD detection. Table from "Efficient Model for Coronary Artery Disease Diagnosis: A Comparative Study of Several Machine Learning Algorithms," by Ali Garavand, Cirruse Salehnasab, Ali Behmanesh, Nasim Aslani, Amin Hassan Zadeh, and Mustafa Ghaderzadeh.

Algorithms	TP	FP	Precision	Recall	*F*-measure	MCC	ROC	PRC
MLP	0.83	0.25	0.83	0.83	0.83	0.59	0.88	0.88
SVM	0.88	0.17	0.88	0.88	0.88	0.70	0.85	0.83
LR	0.86	0.21	0.86	0.86	0.86	0.65	0.87	0.86
J48	0.80	0.28	0.81	0.81	0.81	0.52	0.74	0.74
RF	0.87	0.22	0.87	0.87	0.87	0.67	0.91	0.91
KNN	0.81	0.28	0.81	0.81	0.81	0.54	0.77	0.77
NB	0.85	0.18	0.86	0.85	0.85	0.65	0.89	0.88

Figure 25

Benchmark #3 for comparing industry-grade physiological-based machine learning models for CAD detection. Table from "Machine learning algorithms for predicting coronary artery disease: efforts toward an open source solution," by Aravind Akella and Sudheer Akella.

Table 2. Performance metrics of the ML models applied on the Cleveland Heart Disease Dataset.

Model	Accuracy	Sensitivity	F1 score	AUC	Mean
Generalized linear model	0.8764	0.8000	0.8786	0.883	0.85
Decision tree	0.7978	0.7447	0.7970	0.801	0.78
Random forest	0.8764	0.8261	0.8751	0.880	0.86
Support-vector machine	0.8652	0.7959	0.8662	0.871	0.84
Neural network	**0.9303**	**0.9380**	**0.8984**	**0.796**	**0.88**
k-Nearest neighbor[1]	0.8427	0.7872	0.8419	0.847	0.83

Figure 26

Benchmark #4 for comparing industry-grade physiological-based machine learning models for CAD detection. Table from "A Machine Learning Model for Detection of Coronary Artery Disease Using Noninvasive Clinical Parameters", by Mohammadjavad Sayadi, Vijayakumar Varadarajan, Farahnaz Sadoughi, Sara Chopannejad, and Mostafa Langarizadeh.

Method	Accuracy	Sensitivity	Specificity	F1
Decision Tree	90/16	89.79	91.66	93.61
Deep Learning	79/26	90.91	31.66	86.21
Logistic Regression	**95/08**	**95.91**	**91.66**	**96.90**
Random Forest	93.44	93.87	91.66	95.83
SVM	**95.08**	**95.91**	**91.66**	**96.90**
Xgboost	91/80	93.87	83.33	94.84

Figure 27

Benchmark #5 for comparing industry-grade EKG-based machine learning models for CAD detection. Table from "Patient-Specific Machine Learning Models for ECG Signal Classification," by Saroj Kumar Pandey, Rekh Ram Janghel, Vyom Vani.

Methods	Sensitivity	Specificity	Precision	F-score	Overall Accuracy
SVM	54.42	91.12	51.26	52.82	90.09
KNN	49.09	83.96	37.58	39.16	72.56
RF	53.28	90.45	56.24	53.15	93.45
LSTM	48.09	87.95	59.81	53.31	92.16
Ensemble SVM	65.26	93.25	69.11	66.24	94.40

Conclusion

This study's performance surpasses previous benchmarks, as demonstrated by the comparisons of accuracy, precision, recall, and F1 metrics. The physiological-based and EKG models in this study are not only novel and innovative but also consistently outperform current industry-standard models.

The utilization of Google Cloud Computing platforms enables faster model execution, facilitating prompt diagnosis of coronary artery disease and potentially preventing the need for costly procedures like surgery. Google Cloud Computing offers affordable solutions and scalability, making it accessible to patients from diverse economic backgrounds. The end-to-end deep learning pipeline in this study was implemented on the Google Cloud platform, which was free of cost. For future expansion and scaling, Google Cloud provides cloud GPUs at a low price of $0.45 per hour, enabling global operation of the model.

One limitation is the occurrence of errors in the different algorithms. Ideally, both false positives and false negatives should be minimized, but false negatives should be prioritized due

to their greater impact on patient health. False negatives can lead to worsening conditions and increased healthcare costs. The proposed algorithms in this paper tend to make false-negative predictions, although the most accurate models, CNN for EKG and XGBoost for physiological data, tend to have fewer false negatives or none at all.

If the proposed model architecture performs similarly to the theoretical results, it would significantly reduce the time required for identifying heart disease, leading to early prevention and potentially saving lives. The accessibility of this machine learning approach encourages high-risk individuals to visit hospitals for further examinations, providing conclusive results for coronary artery disease without concerns about misdiagnosis. Hospitals also benefit from this approach as it filters out unlikely patients, reduces diagnostic procedures, and saves time and money.

Furthermore, this research identifies aspects of machine learning models that can enhance accuracy. For EKG readings, optimization-based algorithms such as CNN and XGBoost perform well, utilizing gradient-based optimization techniques. For physiological tabular datasets, models that focus on the features themselves rather than arbitrary boundaries achieve high accuracy, as observed with KNN and XGBoost. This paper provides valuable insights for future researchers to refine their own algorithms based on these attributes.

Overall, the proposed end-to-end deep learning pipeline in this research paper serves as a foundation for a low-cost, rapid method of diagnosing coronary heart disease, benefiting hospitals, patients, and potentially saving lives through improved detection.

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Decreased Proportion of Teen and Young Adult Licensed Drivers in Recent Years in California By Brian Chang

Abstract

This study examined 2014 to 2021 data and discovered a declining proportion of teen and young adult drivers in recent years during and after the COVID-19 pandemic. The rate of decrease from 2019 to 2021 was 17.2% in 16 years old, 16.7% in 17 years old, and 9.3% in 18 years old. It also compared this decrease to the previous declining trend after the last economic recession and speculated the factors contributing to this phenomenon.

Introduction

Studies have shown that the number of teenagers getting licensed has been on the decline in the last decade. Using annual state-by-state counts of driver licenses by age provided by the Federal Highway Administration (FHWA), studies by Sivak and Schoettle (1, 2) found that in 2010, 28% of 16-year-olds had a driver's license, down from 31% in 2008 and 46% in 1983. Similarly, licensed 17-year-olds were down to 46% in 2010 from 50% in 2008 and 69% in 1983 (1, 2). Shults and Williams (3) used data from annual Monitoring the Future Surveys of high school students to estimate the licensure rate among high school seniors from 2006 to 2015. During their study period, the proportion of high school seniors that reported having a driver's license declined by 11%.

Researchers suggest that key factors in the decline have been the recession, economic difficulty, and the high level of teen unemployment. A survey by Schoettle and Sivak (4) showed that the top primary reason was "Too busy or not enough time to get a driver's license," with 38% choosing this response. Second was "Owning and maintaining a vehicle is too expensive," chosen by 17% as the primary reason. Similar surveys done by the Allstate Foundation (5) and the AAA Foundation for Traffic Safety (6) found that teens wait to get licensed primarily for practical or economic reasons.

Due to the last recession and economic downturn in 2008, the proportion of teen and young adult drivers has been declining and has not recovered to the same levels as those seen before the recession. Recently, with the negative socioeconomic effects of the pandemic, I

hypothesize that the proportion of teen and young adult drivers is declining in recent years during and after COVID-19.

Methods

I extracted the number of teens and young adults (16-19 years old) who obtained driver's licenses in 2014-2021 from The Highway Statistics Series published by the Federal Highway Administration, U.S. Department of Transportation (7). The total population of teens and young adults was obtained from the U.S. Census Bureau, Population Division (8, 9). Annual estimates of population count by year, age, and sex for California were downloaded from the Census website (8, 9). Data for the years 2014-2019 and 2020-2021 were projections based on the 2010 and 2020 censuses, respectively.

The proportion of licensed 16-year-old drivers was calculated using the number of 16-year-old drivers divided by the total number of 16-year-old in each year. The proportion was calculated in the same fashion for other ages by sex for each year from 2014 to 2021. Since 2020 may be the year that received the most impact due to the temporary closure of the driving instructions service and the Department of Motor Vehicles, the rate of change was calculated by (proportion in 2019 – proportion in 2021)/proportion in 2019 to reflect the magnitude of change in recent years. All analyses were conducted in Microsoft Excel.

Results

The proportion of young drivers by year and by sex was listed in Table 1 and graphed in Figures 1A, 1B, and 1C. The proportion of drivers has been steady from 2014 to 2019. Due to COVID-19, the proportion dropped sharply in 2020. In 2021, the proportion of drivers recovered slightly, but not to the pre-pandemic level. Age 16 years old having a driver's license declined by 2.3 percentage points, declined by 5.0 percentage points among 17-year-olds, and declined by 4.6 percentage points among 18-year-olds. The rate of decrease from 2019 to 2021 was 17.2%, 16.7%, and 9.3% for ages 16, 17 and 18 respectively. The rate of change was similar in males and females. For males, the rate of decrease was 16.5%, 11.8%, and 2.9% for ages 16,17 and 18 respectively. And for females, the rate of decrease was 17.9%, 21.6%, and 16.2% for ages 16, 17, and 18 respectively. The proportion of drivers among 19-year-olds stayed at the same level over the years, with a slight decrease in males and a slight increase in females.

	Overall					Male					Female			
Year	Age 16	Age 17	Age 18	Age 19		Age 16	Age 17	Age 18	Age 19		Age 16	Age 17	Age 18	Age 19
2014	13.3 %	29.6 %	50.9 %	69.8 %		12.6 %	29.6 %	52.3 %	72.0 %		14.0 %	29.6 %	49.4 %	67.6%
2015	13.1 %	29.4 %	50.5 %	70.4 %		12.5 %	29.0 %	52.9 %	71.7 %		13.8 %	29.8 %	47.9 %	69.0%
2016	13.9 %	30.6 %	51.7 %	72.6 %		12.9 %	30.0 %	53.7 %	75.4 %		14.9 %	31.2 %	49.7 %	69.8%
2017	13.7 %	30.3 %	51.7 %	71.7 %		13.1 %	29.7 %	53.9 %	74.0 %		14.3 %	30.9 %	49.4 %	69.3%
2018	13.5 %	29.9 %	49.6 %	70.6 %		12.7 %	29.3 %	51.5 %	73.1 %		14.3 %	30.6 %	47.6 %	68.1%
2019	13.3 %	30.1 %	49.1 %	69.5 %		12.7 %	29.2 %	50.4 %	71.8 %		13.9 %	31.0 %	47.8 %	67.2%
2020	7.3%	25.9 %	41.9 %	64.8 %		6.6 %	25.5 %	42.3 %	66.6 %		8.0 %	26.3 %	41.4 %	62.9%
2021	11.0 %	25.0 %	44.5 %	69.0 %		10.6 %	25.7 %	48.9 %	66.2 %		11.4 %	24.3 %	40.0 %	71.9%
	Decrease from 2019 to 2021					Decrease from 2019 to 2021					Decrease from 2019 to 2021			
	2.3%	5.0%	4.6 %	0.6 %		2.1 %	3.4 %	1.5 %	5.5 %		2.5 %	6.7 %	7.8 %	-4.7%
	Rate of change 2019 to 2021					Rate of change 2019 to 2021					Rate of change 2019 to 2021			
	17.2 %	16.7 %	9.3 %	0.8 %		16.5 %	11.8 %	2.9 %	7.7 %		17.9 %	21.6 %	16.2 %	-6.9%

Table 1. The proportion of young drivers by year and sex, 2014-2021

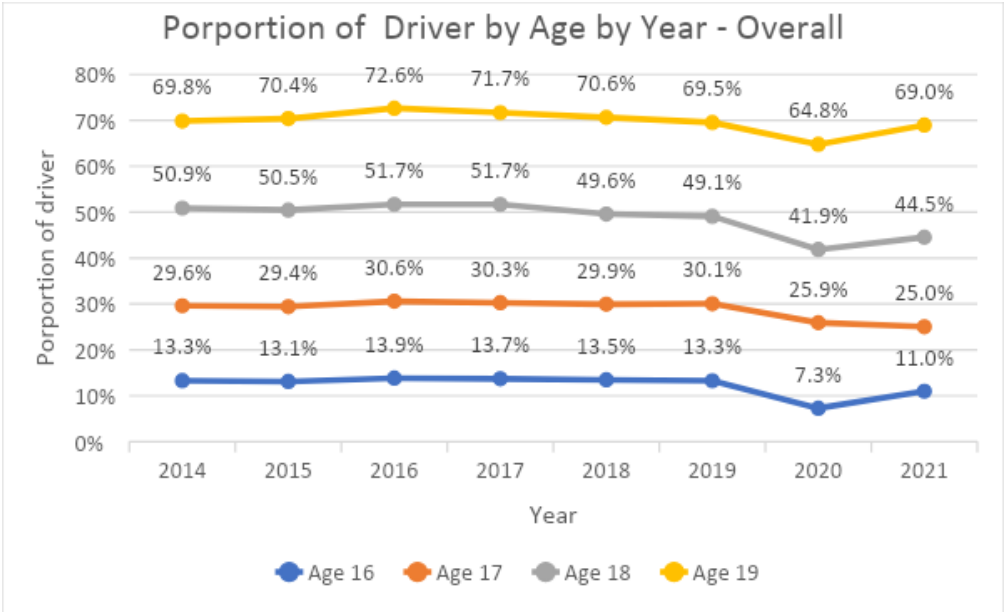

Figure 1A. The proportion of young drivers by age by year, 2014-2021

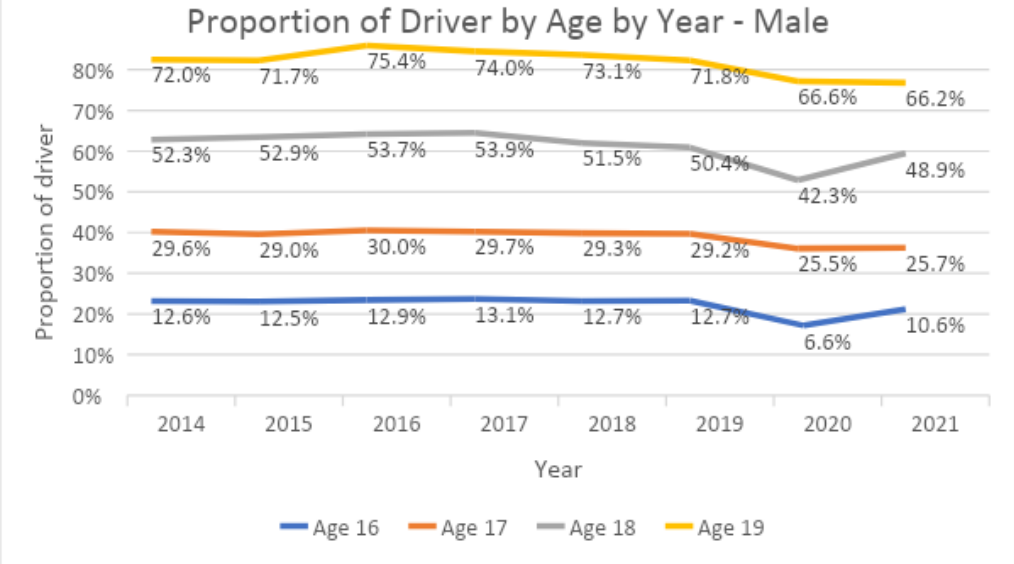

Figure 1B. Proportion of male young drivers by age by year, 2014-2021

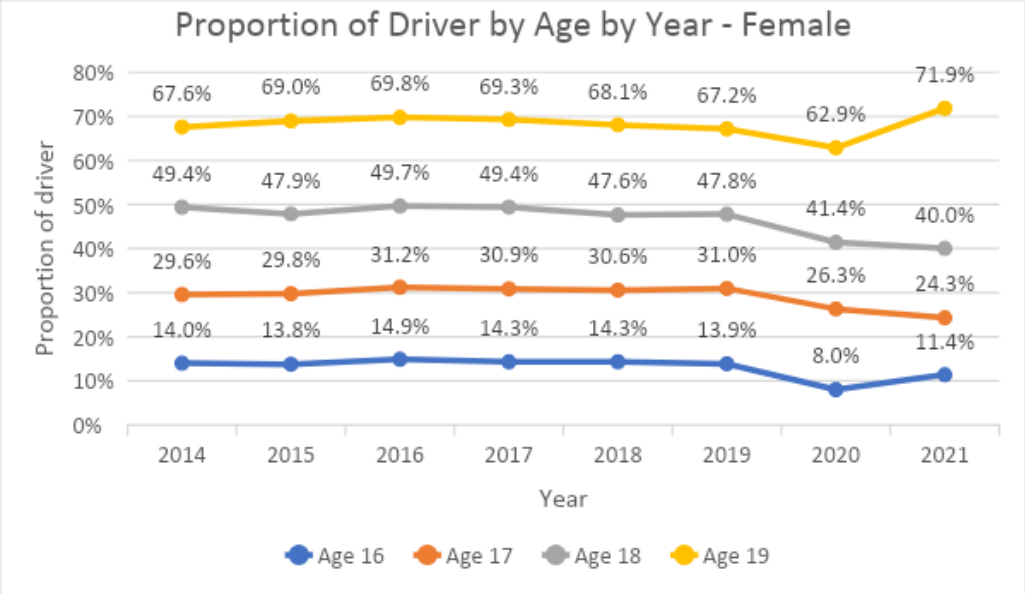

Figure 1C. The proportion of female young drivers by age by year, 2014-2021

Discussion

After the recession in 2008, the proportion of licensed young drivers declined due to economic reasons. And the proportion has been retained at a low level for the years leading up to the year 2020. The outbreak of the COVID-19 pandemic has introduced unprecedented challenges and disruptions, leading to significant changes in various aspects of society. For the year 2020, there was a sharp drop in young drivers trying to get their driver's licenses due to the disruption of driver education and the closure of driving schools and examination centers during the pandemic. In 2021, the proportion of young drivers bounced back slightly, but still not to the levels seen before the pandemic. Interestingly, the decline in 2021 was observed in 16, 17, and 18-year-olds, the proportion of 19-year-old drivers remains stable over the years. The cohort of age 19 in 2021 was age 16 in 2018 and then age 17 in 2019, who were least affected by COVID-19 in the study population. The study also showed that males and females experienced similar trends.

Similar to the observed decline after the recession in 2008, the economic burden could be the key factor in the decline during and after COVID-19. Economic challenges and financial burdens on some families during COVID-19 are tremendous. Financial hardships affect the affordability of car ownership and insurance. Federal Highway Administration (FHWA) study showed that employment status, household income, and other measures of economic status

strongly influence all forms of youth and adult travel behavior, and these factors generally have an even greater influence on the travel of youth than adults (10).

Factors in this decline after COVID-19 that were not common in the last decline are the normalization of remote learning and virtual activities, availability of alternative transportation options, and connectivity on social media. Recent teens and young adults have experienced reduced travel and limited social interactions and increased reliance on remote learning and virtual activities due to the COVID-19 pandemic. The Boston Globe (11) reported that due to technology and the isolated environment this generation of teenagers has been living in, "teens are doing way less of what used to be the activities that bridged the gap between them and adulthood and autonomy." The Washington Post (12) reported that parents have observed that their kids can connect online with their friends, and they believe this has caused this generation of teenagers to be less motivated to drive.

This study examined the most recent eight years of data and identified a declining proportion of teen and young adult drivers during and after the COVID-19 pandemic. As of now, Highway Statistics Series has not published 2022 data. I look forward to examining 2022 and future years of data when they are available to see if the trend will be persistent.

Conclusion

This study examined 2014 to 2021 data and discovered a declining proportion of teen and young adult drivers in recent years during and after the COVID-19 pandemic. The rate of decrease from 2019 to 2021 was 17.2% in 16-year-olds, 16.7% in 17-year-olds, and 9.3% in 18-year-olds. The study also summarized the factors related to this decline. By identifying the underlying factors and understanding the consequences of this phenomenon, stakeholders can develop effective strategies to ensure the safety, independence, and mobility of teens and young adults.

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A Comprehensive Review of Capgras Syndrome By Lucas Angier and Benjamin Bergheim

Abstract

Capgras syndrome, also known as Imposter syndrome or delusion of doubles, is characterized by a false belief that an individual has switched places with someone identical to them. It is a very rare and unique disorder that affects a small percentage of the population. Oftentimes, inaccurate portrayals of this disorder in films have led to false beliefs and unnecessary stigma around the syndrome. This stigma can be combatted by a biological explanation of this disorder. This paper will provide an understanding of symptoms, causes, neural bases for the symptoms, treatment modalities, and future implications.

Introduction

Capgras syndrome (CS) is the most pervasive delusional misidentification syndrome (Shah). It has often been portrayed in the media through films such as Us, Goodnight Mommy, and Invasion of the Body Snatchers. As a result of exaggeration and dramatization in these movies, many individuals have developed faulty or incomplete knowledge of Capgras syndrome. These movies tend to incorrectly portray the disorder and manipulate it to appear more appealing to viewers. Additionally, the obscure nature of this disorder has caused many to believe that it is a fabricated disorder used only to gain attention and recognition. This paper serves to combat the negative stigma surrounding Capgras syndrome by providing a concrete explanation through a biological and anatomical lens.

Understanding

Capgras syndrome, also commonly referred to as Capgras delusion, is a psychiatric disorder that continues to baffle scientists and psychologists alike. The ambiguous nature of this syndrome along with the low number of confirmed cases, has led to Capgras syndrome being a controversial topic for debate in the psychiatric field. In this disorder, an individual will incorrectly believe that a close acquaintance or family member has been switched with a person with an identical appearance to the original person (Shah). In order to aid individuals in formulating a complete and comprehensive understanding of this disorder, this article will also explore the common symptoms, causes, and treatment modalities that are associated with it. It is

also important to distinguish Capgras syndrome from other disorders that may be viewed as similar such as Fregoli syndrome, schizophrenia, and dissociative identity disorder (DID).

First, Capgras syndrome is named after a man named Joseph Capgras, who was a psychiatrist in France. Capgras was employed at several mental health institutions throughout France and came across a woman who believed that a man with an appearance identical to her husband had replaced him. She also believed that there was an individual with an appearance identical to her. Capgras published his thoughts on this phenomenon and christened it "L'Illusion des sosies," a term that translates to an illusion of lookalikes or twins (Enoch).

Secondly, Capgras syndrome is a unique disorder that must be differentiated from disorders with similar attributes or characteristics. One disorder that is commonly mistaken as Capgras syndrome is Fregoli syndrome. Fregoli syndrome is a disorder defined by the "delusional belief that one or more familiar persons, usually persecutors following the patient, repeatedly change their appearance" (Mojtabai). The name of this disorder comes from the Italian actor Leopoldo Fregoli who was known for his quick costume changes and transformations. Fregoli syndrome, though, focuses on the alteration of one's appearance, not an alternative individual with a strikingly similar appearance. Another disorder related to Capgras is schizophrenia. Schizophrenia is a psychiatric disorder that is commonly characterized by symptoms of hallucinations, delusions, confused speech, and dysfunctional movement (Khan). Delusions are an integral part of schizophrenia, meaning Capgras delusion could very well be expressed by an individual with schizophrenia. However, the absence of hallucinations, movement disorders, and speech impediments in Capgras syndrome clearly set it apart from schizophrenia. Dissociative identity disorder also shares certain features with Capgras syndrome. Dissociative identity disorder is characterized by the existence of several personalities, or alters, within an individual. One alter is manifested at each time and each one has unique memories, behaviors, and preferences (Gillespie). Unlike Capgras syndrome, dissociative identity disorder is defined by an individual having multiple alters, not an individual believing a certain person has a singular alter.

Third, it is vital to understand why knowledge of Capgras syndrome is so limited. The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, is the current tool that the American Psychiatric Association utilizes for classifying and diagnosing mental disorders.

Unfortunately, Capgras syndrome is not present in this manual. This is likely due to the extremely small number of confirmed cases or the rare nature of the disorder (Mojtabai).

Causes

There are multiple factors that may cause an individual to develop Capgras syndrome. Damage to the brain in "bifrontal and right limbic and temporal regions" tends to be correlated with Capgras syndrome (Rodríguez). The presence of other ailments, such as dementia and Parkinson's disease, have been associated with Capgras syndrome as well (Davis). In order to remove the stigma surrounding this disorder, viewing it from a biological and anatomical perspective will provide concrete evidence that the disorder is not merely a ploy for attention or a falsified act. Various forms of neuroimaging have proven useful in aiding with the diagnosis of Capgras syndrome. Electroencephalography (EEG) is a brain imaging method that mainly studies the electrical signals found in the brain and does not create physical images of the brain such as other imaging methods (Rayi). EEG performed on individuals with Capgras syndrome often reveals relatively rapid (and characterized as abnormal) rhythmic activity in areas of the frontocentral brain region (Luca). These findings rule out many neurodegenerative diseases, such as schizophrenia, as those diseases are characterized by a decrease in rhythmic activity in these frontal areas of the brain (Chen). Although the findings are considered abnormal, little research has been done to explain the link between Capgras syndrome and this abnormal neural activity, and most neuroanatomical connections to Capgras syndrome have been analyzed with Magnetic Resonance Imaging (Kilcoyne). Magnetic Resonance Imaging is a particular imaging method that makes use of strong magnetic fields, usually around 1.5 Tesla, in order to effectively study soft tissues and is particularly useful for brain neuroimaging (Grover, Rosenbloom). In this application, Magnetic Resonance Imaging (MRI) may indicate lesions in the frontal-subcortical region white matter and semioval centers for individuals presenting with Capgras syndrome (Luca). However, a lack of medically confirmed cases means that the use of neuroimaging to diagnose neurological abnormalities in relation to Capgras syndrome has not been extensively studied (Kilcoyne).

Neural Basis Of Facial Recognition

There are various different neural structures that aid in the process of facial recognition. The fusiform gyrus is an important structure for the perception of visual stimuli and is thought to be related to the process of facial recognition, although this claim has been disputed (Nagai,Weiner). The fusiform gyrus and, more specifically, the fusiform face area (FFA) may be an area generally related to perception and visual recognition and not solely facial recognition (Nagai). Another neural structure that is related to the process of facial recognition is the amygdala which, as the center for emotion expression and processing, can help determine the emotions expressed by other faces (Nagai). Both neural structures referenced above may have some form of impairment in the case of individuals with Capgras syndrome (Young). In these individuals, facial and emotional recognition processes appear to be abnormal in their functioning, and anatomical inconsistencies are thought to be the cause of these impairments (Young). As the fusiform gyrus and amygdala regulate these processes, there is the potential that these structures are damaged or impaired in patients presenting with Capgras syndrome, but further studies involving neuroimaging may be needed to confirm these claims (Nagai, Weiner).

Neural Basis Of Emotional Processing

As mentioned earlier, the amygdala appears to be very important in the recognition and processing of emotions in others (Nagai). The ability of someone to accurately determine the emotions expressed by others also depends on other neurological structures, such as the "ventromedial prefrontal cortex and the anterior insula" (Doré). Activity in these regions in response to external emotional stimuli consequently results in activity in other brain areas, such as the hypothalamus, which helps drive emotional responses as a whole (Doré). Capgras syndrome has often been linked with issues regarding emotional processing and recognition in others related to the individual in question (Shah). This is coupled with difficulties in correctly identifying familiar faces and overall impairment in facial recognition (Shah). In individuals suffering from Capgras syndrome, brain damage primarily in the temporal, frontal, and limbic lobes has been found to cause these symptoms, in addition to other conditions such as dementia and Alzheimer's disease (Shah). Capgras syndrome is very rare compared to these other conditions, so additional studies may be needed to further study the neurological basis of

Capgras syndrome and emotional processing in particular and how it differs from other conditions (Shah).

Treatment

There are several different treatment modalities used to combat the symptoms present in Capgras syndrome. Antipsychotic medications are primarily used to hinder the strong delusions present in the disorder. Antipsychotics such as risperidone, aripiprazole, olanzapine, and pimozide have proven useful in eradicating these delusions (Davis). These medications "diminish dopamine transmission and thereby dampen the salience of the preoccupying symptoms" (Kapur). The effect of these antipsychotics can be heightened with the administration of a selective serotonin reuptake inhibitor (SSRI). A 2012 case study on an 11-year-old girl with Capgras syndrome by Luigi Mazzone et al. revealed that "a combined treatment of an antipsychotic medication plus a SSRI can lead to a good clinical outcome with a remission of the psychotic symptoms" (Mazzone). In another case study from 2014 following an elderly patient with dementia and Capgras syndrome, antipsychotics were used to diminish the symptoms associated with this disorder (Sutton). However, this outcome cannot be generalized due to the singularity of this treatment experiment. Additionally, these medications are merely short-term solutions that may become less effective if the patient undergoes neurodegeneration.

Along with various medications, the usage of therapy has proven to be successful in diminishing the impact of Capgras syndrome. The first type of therapy, psychodynamic therapy, aims to neutralize the impacts of Capgras syndrome by "establishing a therapeutic alliance while negotiating mutually acceptable symptomatic treatment goals" (Shah). This allows the patient to open up about their struggles and gives the therapist the opportunity to see the origin of the patient's suffering. Another form of therapy that has been effective in reducing the symptoms of Capgras syndrome is electroconvulsive therapy. A 2015 case study on a middle-aged woman who developed Capgras syndrome during postpartum. The study proved the effectiveness of this therapy because "after six electroconvulsive therapy sessions, delusions of doubles subsided and other symptoms improved" (Rapinesi). Furthermore, a patient with Parkinson's disease and Capgras syndrome had her symptoms dissolved with electroconvulsive therapy (Chiu). Again, the limited amount of successful cases of treatments reveals that these conclusions cannot be

generalized among all individuals with Capgras syndrome and merit more research on the subject matter.

Future Implications

Although a surplus of research has been done on Capgras syndrome, there are still extensive gaps in the understanding of this complex disorder. One way to improve the comprehension of Capgras syndrome is through the connections between it and other similar disorders that must be investigated and analyzed further. As mentioned earlier, Capgras syndrome shares various similar attributes with disorders like Fregoli syndrome, schizophrenia, and dissociative identity disorder. Doing so will increase the knowledge of these aforementioned disorders as well as Capgras syndrome. It will also pave the way for future treatment approaches with greater success rates. In addition, an improved understanding of Capgras syndrome may allow it to become a part of the Diagnostic and Statistical Manual of Mental Disorders. This would make the process of diagnosing an individual much easier and would lessen the stigma surrounding the reduced clarity of the disorder.

Conclusion

This paper provides an understanding of Capgras syndrome and the potential causes of this disorder. It discusses concrete neurological roots that prove that this disorder is not merely a figment in one's imagination. The paper also describes the different treatment modalities that have proven to be successful in diminishing the symptoms of Capgras syndrome. It is important to raise awareness of disorders like Capgras syndrome in order to lessen the stigma surrounding it. This may lead to individuals affected by this disorder reaching out to get help and assistance.

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The Connection between Exploitative Labor Practices and Sustained Economic Growth

By Yannick Lewy

Introduction

In this paper, I will attempt to determine whether or not there is an inverse causal relationship between the extensiveness of workers' rights and the ability of an economic power, or an emerging economic power, to achieve sustainable economic expansion.

Main Arguments

This paper has two key talking points: how were the current economic powers established, and what were the similarities between the development cases of the United States and China? The second point is: how does a former economic power falter, and what is the reason for its demise? A case study I will analyze to determine whether this is the case of both development and decline in Japan's short history since the 1947 constitution, which included Japan's economic resurgence after the second world war and its subsequent stagnation, which it has not recovered from since its commencement in 1995. Eventually, I will attempt to examine a potential inverse causal relationship between my two variables of interest, limitations on worker's rights, and economic growth. After analyzing former cases and identifying causal factors, I should be able to see if there is an inverse causal relationship between the rate of expansion in economic powers and the extensiveness of their labor force regulations.

Context

The United States of America (US) and the People's Republic of China (PRC) are undoubtedly the two premier economic powers of the present day. Although, amid their economic dominance, both countries have been internationally criticized for their lack of support for the working class and their prioritization of economic growth. For example, the Chinese government has made sizable investments into robotics to replace manual labor, as this would make Chinese manufacturing considerably more efficient and subsequently more lucrative (Lei, 2021). However, one significant issue arises if the Chinese industry-based labor force is replaced with robots, many, if not all, become unemployed. In the PRC, that is around 30% of the

workforce (C.Textor, 2022). The hope of ensuing economic growth instigated such investments which do have a sizable impact on the workforce, which is why this issue matters. We must attempt to understand this connection sufficiently to protect the economy and the labor class, as is the case with any matter because if sovereign nations have to decide between protecting workers' rights and economic expansion, we must understand all the variables involved in this decision.

Research Question

My research question is, "Is there a direct correlation between workers' rights in economic powers/emerging economic powers and that power's ability to achieve economic expansion? If there is a correlation, what is the underlying causation for the correlation, and does it establish a connection?" It is important to note that correlation does not equal causation, they are two very similar, yet very different, concepts. Economist Steven Levitt defines correlation as "two things happening together," he also says that correlation has no value when the causation is unknown as we see a constant correlation in our world between two potentially unrelated factors (Levitt, 2011). Levitt's warnings apply to this project as economic growth has many factors, and incorrectly interpreting the impact of such factors can lead to the wrongful interpretation of the information presented, which would result in the failure of my attempt to answer the research question correctly.

Hypothesis

I believe that my research will show a correlation between the quality of workers' rights and sustainable economic expansion. Furthermore, I believe that I will find an inverse causal relationship between those two factors, which would affirm my research question. I am basing this hypothesis on my pre-existing knowledge of the subject and the applicable transfer of knowledge between the multiple cases of economic expansion I have previously observed and analyzed. The best example of an inverse causal relationship between the extensiveness of workers' rights and economic growth is the growth that occurred in Japan during the second half of the 20th century. The noble laureate economist, Joseph Stiglitz, believes that many factors caused the East Asian miracle, within which Japan was included. However, in a piece he

authored, he was quoted saying, “policies that increase the accumulation of physical and human capital are likely to lead to more rapid growth.” (Stiglitz, 1996). Although various economies grew in various ways, one must remember that Japan’s economic growth was the most noteworthy in the East Asian miracle. If we look at what Stiglitz had to say about Japan specifically, he pointed out that it prioritized the motivation and accumulation of the workforce through amendments to industry policy. Because of the works of economists like Stiglitz, I believe there is a strong connection between labor laws and economic expansion. If we transfer this knowledge to our areas of interest, the PRC originally grew by setting up SEZs and dismantling workers’ protection while enhancing worker productivity and quantity to export low-cost manufactured goods to foreign markets at a competitive price. The US originally grew in the 19th century when it profited from the high demand for cotton, an internationally required product. Nevertheless, like the PRC, the US government had to accumulate its human capital. The US government did this by funding plantation owners by supporting the rubber stamping of loans to plantation owners (Desmond, 2019). Hence, plantation owners had the financial capital to expand their workforce by purchasing enslaved individuals who picked cotton and allowed the US to export cotton to the international market cheaply.

Research Method

The method I have used to evaluate the causation of economic growth in my case studies is a multi-staged plan. The first stage is identifying the periods of economic growth, even identifying the periods of growth has multiple factors; the annual growth rate, policy implementations and implications, interest rates, and many more that all have various effects with various levels of impact. Because global economies are influenced by a plethora of factors it is important to look at peer-reviewed studies by experts because collections of qualified professionals offer a way to receive a consensus from highly capable individuals on the potential reasons for certain occurrences that are presumably the most accurate explanations for events. Furthermore, through such methods, I hope to be able to pinpoint the periods of economic growth and subsequently the reasons for economic growth. Then I can accurately understand the period under which economic growth occurs which will allow me to use historical information and experts’ analysis to find the reasons for economic growth. Finally, I have to determine

whether the reasons given make logical sense and whether there is causality, for example, if the general consensus for economic growth is new legislation but in other cases, this legislation proved ineffective, this would lead to me evaluating the causality of the economic growth and find a reason why this legislation proved ineffective elsewhere while being effective here.

Evaluation of the US's Economic Growth in the 19th Century

To showcase this method I will analyze the economic development of the US in the 19th century below. Using Diane Lindstrom's compilation of historical data I can concur that the period of heightened economic growth in the US occurred before the Civil War, after which the economy struggled to recover until the industrial revolution at the end of the 19th century (Lindstrom, 1983). Now that we have the period of interest we can analyze the historical events at that time for potential reasons for the US's economic growth. According to David S. Heidler and Jeanne T. Heidler, we can pinpoint the main source of economic development at the time to be agriculture as the effects of the industrial revolution would only become apparent later in the century (Heidler, 2004). It is important to note that the US production of Cotton made it indispensable to Britain, the leading world power at that time, as 80% of Britain's raw cotton imports came from the US and 40% of Britain's exports required cotton to be manufactured (Dattel, 2009). Now that we have established the when and the why we need to establish how the US was able to export a sufficient amount of cotton to stimulate the economy to cause rapid growth. The how, according to Dattel, was through slave labor and its governmental support (Dattel, 2009). Slaves were, to the plantation owners, highly efficient tools, the reason for this was that they worked with little to no maintenance cost yet still had the productivity of a regular worker. Because of this slaves were seen how we see robots now, they do not complain, the maintenance costs are comparatively minimal and they have a long life span in which they can work. To summarize, we can identify the reasons for the economic growth in the US to be because they were able to export a valuable commodity with low operating costs to a worldwide market and this was made possible through the oppression of the labor class at the time, slaves.

Main Arguments

As previously outlined, slavery in the US was a driving force for its economic development, economic development in the PRC, although more refined, had similar key characteristics, when compared to the US, which allowed it to build the foundations on which its current economic dominance rests today. If we directly compare the two countries' economic foundations the first apparent similarity is that both the PRC and the US manufactured for developed countries rather than developing countries. In the case of the PRC, their primary trade partner is the US as they are the most economically developed country and subsequently should have the largest group of consumers who possess a sufficient amount of disposable income to be able to purchase goods that are manufactured in the PRC (Workman, 2022). In the case of the US, their primary trade partner was Britain which was the most economically developed country at the time, which, like in the case of the PRC, meant that Britain should have the largest group of consumers who can purchase the product exported by the US (Dattel, 2009). What we can learn from these two cases is that manufacturing for economic powers must have benefits that allow for economic development. I believe that these benefits include stable and reliable consummation and other benefits that are associated with having reliable customers like a continuous income stream. A benefit that is less obvious yet equally important is proximity success, having people around you that are of a high level causes you to raise your own level. In the cases of international trade, if the countries you trade with start attaining more capital, it increases the possibility of FDI into infrastructure which directly benefits you because it allows you to expand your production capacity which allows for more revenue to be generated. Furthermore, both the PRC and the US have implemented pro-expansion policies that flourish at the expense of the labor class. SEZs in the PRC or free-market liberalization in the US are policies that benefit conglomerates and allow them to take advantage of lax regulations which are rarely enforced. For example, Shenzhen is where the majority of Chinese tech companies sit and it was made a SEZ in the 1980s which coincided with the rapid growth of technology companies causing Shenzen to be seen as the Silicon Valley of the PRC, this meant that major tech companies in China could abide by purposefully lax regulations. According to reports of employees of those tech companies, they are made "to work as if you are four people" (Xueqiao, 2019). According to a Financial Times article, "staff at tech companies often cite "996" to

describe their working life", 996 is working from 9 am to 9 pm, 6 days a week. 996 working hours would be significantly above the government-mandated 44 hours in China yet employees must work these hours as employees are expected to work voluntarily (Xueqiao, 2019). Furthermore, the FT article also quotes an unnamed lawyer who says "there is no mechanism to protect employees' rights if they have agreed to "voluntary overwork" and as said this voluntary overwork is expected of workers. Additionally, such policies are not exclusive to the PRC, in the US free-market liberalization allows domestic firms to offer lower prices and push workers towards greater efficiency, which they are required to do as globalization has caused them to compete with the whole world and this subsequently leads to a need for competitive pricing (Banton, 2021). In order to be competitive, the US has to lower or at least limit the growth of wages and other operating costs. In order to do this, the US has maintained a comparatively low minimum wage and promoted automation with one robot replacing around 3 workers in the manufacturing sector (Dizikes, 2020). Such cases are examples of how policies that lack protection for workers are widely accepted and implemented by the economic powers of the world because of the enticing opportunity for economic growth. I would argue that there is a certain level of causality because similar policies yielded similar results in both the PRC and the US. If workers work more then they will be, by default, more productive which means that countries accumulate human capital and as the previously mentioned quote by Stiglitz mentions, accumulation of human capital leads to rapid growth.

The Multi-Decade Economic Stagnation of Japan

As previously mentioned, Japan achieved meteoric growth after the 1950s, it achieved this growth through a highly productive labor force that became focused on hyper exportation. Japan's highly productive labor force was caused by many factors, one of which was increased motivation. This motivation originated in the workforce because workers wanted to receive employment for life status and the protections associated with it. Employment for life was first implemented after World War Two to motivate the labor class with the possibility of job security and guaranteed lifetime employment. In the 1980s, when the Japanese economy experienced a large amount of its growth, many employees were given the opportunity to be employed for life (Inoue, 2020). Subsequently, these workers had extremely strong job security but they would,

over time, become less productive. A report by the New York Times details how a vendor in the Tokyo subway was given a citation for her hard work and success in that job, yet this employee did not have employment for life status and subsequently earned less. But her co-workers, who had employment-for-life status earned more for less work (Inoue, 2020). Employment for life has been upheld in courts multiple times and has become a staple of the Japanese employment system yet I believe that it is causing Japan's economic stagnation, which has persisted for over 20 years. Hypothetically, let us assume that a worker was employed, after the Second World War, at the time when they would have had the highest level of cognitive function, the age of 20 (Trafton, 2015). Now if that worker received employment for life in the 1980s, which was when most employees received lifetime employment (Inoue, 2020), they would reach the age of 65 in the year 1995 having received lifetime employment. It is important to note that cognitive function begins to significantly decline between the ages of 65-75, it is also important to note Japan's economic stagnation began around 1995. I believe that this is evidence of the fact that the workers who caused the economic boom in Japan through their high motivation during their periods of high productivity were the same workers who caused the economic stagnation because they continued to be employed when they became less efficient employees. Essentially, the lifetime employed workers had become liabilities to the economy as they could no longer function at the highest level, nevertheless, these workers could not be replaced because they had a very high level of worker protection in the form of lifetime employment. I believe that this indicates an inverse causal relationship as, in this case, the protection of workers increased and the economic growth decreased as productivity fell and subsequently the accumulation of human capital fell as workers could no longer work as much as they previously had.

Conclusion

Ultimately, there is evidence that economic growth is correlated with how workers are treated, if they are paid lower wages foreign companies can exploit this to cheaply manufacture products which in turn strengthens the infrastructure of the countries which can cheaply manufacture products as they become more attractive opportunities for FDI due to their integration into the global markets. On the other hand, if workers receive strong forms of protection this could limit a country's productivity over time and limit economic growth.

Essentially, what I believe can be concluded is that there is an inverse causal relationship between the extensiveness of workers' rights and economic growth in an economic power in a globalized world. Because this is the case, emerging economic powers may attempt to limit workers' rights so they can grow their exports at a competitive price. I believe that the case of the PRC does exemplify this as they were able to grow by focusing on hyper exportation combined with competitive pricing. The significance of this is that emerging economies have a blueprint as to how they can grow their economy, even if it is at the expense of their workforce. Amid this, I am obligated to mention one significant limitation of my research, the evidence I have collected is from very few case studies, this means that I can not unilaterally say that this causal relationship exists in every country, simply that it exists in economic powers and emerging economic powers as they are the countries in which such infrastructure can be developed. Finally, to answer my research question, I do believe that there is a correlation between economic growth and workers' rights, similarly, I believe that there is a causal relationship between these two factors which would establish a connection.

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Does the Future of Solar Energy Lie in Dye Sensitized Solar Cells?: A Comparative Analysis between Traditional and Dye Sensitized Technologies By Seth Lee

Abstract

The environment is facing formidable challenges due to pollution from burning fossil fuels. Currently, over 70% of the world's energy is produced from fossil fuels, which emit greenhouse gasses like carbon dioxide and methane, leading to environmental degradation and climate change. Transitioning from fossil fuels to sustainable energy production is key in limiting the amount of greenhouse gasses we produce. One of the avenues towards a sustainable future involves generating electricity using solar panels. However, solar technology is nowhere near its maximum potential and suffers economic inefficiencies due to many factors–like poor design, material constraints, and photovoltaic inefficiencies. However, there are several different types of solar cells which could prove to be economically scalable and efficient. Silicon solar cells remain the standard in the photovoltaic industry but require complex fabrication processes, which can be both costly and emission-intensive. The dye sensitized solar cell (DSSC) is a candidate that offers easier, potentially more scalable fabrication procedures and therefore may be more cost effective than silicon. Thus, the focus of this research is to fabricate DSSCs using easily obtainable materials and methods in order to estimate their economic viability through a direct cost comparison with silicon solar cells. An original experiment was conducted and significant findings indicate that DSSCs have a future in the shift to renewable energy.

Introduction

The Earth's environment is at risk for catastrophic climate events as greenhouse gas concentrations continue to rise. For example, carbon dioxide, one of the most influential greenhouse gasses, has seen its concentration rise from 280 ppm in the mid-1700s to levels of 424 ppm in 2023 (Lindsey). This rise in greenhouse gas concentration results in the greenhouse effect, in which heat from the sun is trapped in the Earth's atmosphere. The increase in trapped heat is apparent as the temperature of Earth's atmosphere has been increasing 0.08 degrees Celsius per decade since 1880 (Lindsey & Dahlman). Although this may seem minor, the effects of extreme weather events, such as droughts, floods, and heatwaves, are seen and experienced

today. Catastrophic events in the future, such as food shortages and mass extinctions, could take place and worsen if sufficient action is not taken (Gibbens).

The most common cause of climate change and global warming is fossil fuel burning, which according to the U.N., accounts for nearly 90% of all carbon dioxide emissions. This means that cutting down fossil fuel usage would significantly reduce the rate of environmental degradation and climate change. Likewise, as of February 2023, fossil fuel usage produced 60.2% of the electrical energy in the US while renewable solar energy only produced 3.4%, with 36.4% coming from other sources (EIA). This high reliance on fossil fuel shows that there is immense potential for increasing the usage of renewable energies, specifically solar energy. Switching to renewable energy sources and improving their economic viability is crucial for replacing the unsustainable nature of fossil fuels, which will help prevent and mitigate environmental catastrophes.

For this research, two primary types of solar cells are examined: silicon and dye sensitized (DSSC). Silicon-based solar cells are fabricated through a process known as doping, which involves introducing elements from group III and group V of the periodic table (Aldous & Homer). By introducing these impurities, doping alters the molecular structure of the silicon semiconductor. Doping silicon with group III elements, such as boron, creates p-type silicon, characterized by an abundance of holes (spaces with an absence of electrons). On the other hand, doping silicon with group V elements, such as phosphorus, creates n-type silicon, associated with excess electrons. When p-type and n-type silicon come into contact with each other, they form a p-n junction, which contains an electric field due to uneven charges. This electric field is essential to the function of the solar cell because the field promotes the separation of the electrons from the holes. Thus, whenever a photon–a quantum of light–strikes the solar cell and excites an electron from the silicon semiconductor material, the electric field facilitates the movement of these electrons towards the n-type semiconductor side. The electron from the n side then flows through a circuit, commonly referred to as a load, to power electronic devices as shown in Figure 1.

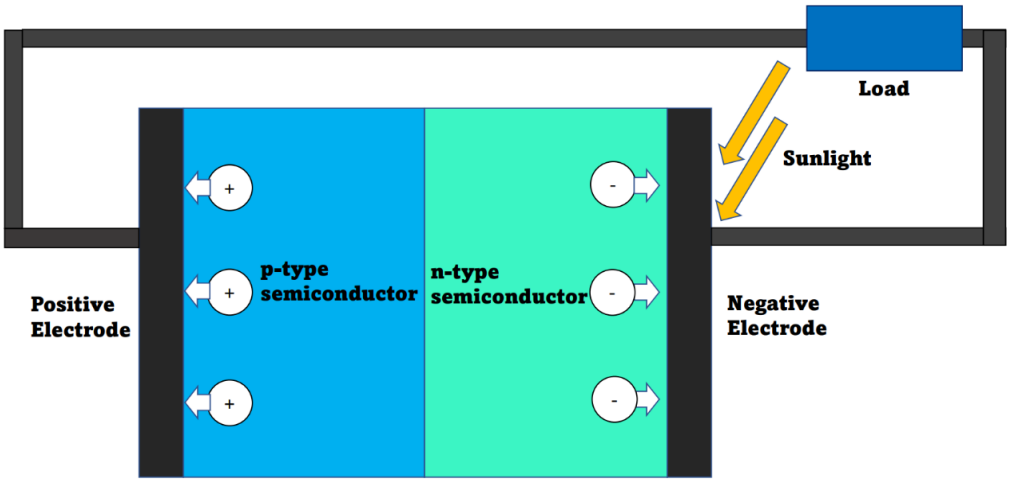

Figure 1. Schematic of a silicon solar cell. Photons from the sunlight strike the solar cell and excite electrons to pass through the n-type semiconductor, which can be used to power a load.

Similarly, in DSSCs, the energy conversion process begins when incoming photons interact with a photosensitive dye, such as raspberry dye (Sharma et al. 1). These photons have enough energy to excite electrons from the dye's valence band, an energy level at which electrons are bound to the atom and to its conduction band, an energy level at which electrons can move freely. The difference in energy levels between the valence and conduction band is commonly referred to as the band gap, which represents the minimum photon energy needed to excite an electron for the production of electrical energy (Sutherland 984). After the excitation of the electrons, often referred to as photoexcitation, the now-mobile electrons are able to migrate onto a semiconductor material, typically titanium dioxide (TiO_2). This initial photochemical reaction from the photosensitive dye to the semiconductor takes place in what is commonly called the working electrode. Within the working electrode, the titanium dioxide semiconductor functions as an electron transport medium, allowing the excited electrons to create an electric current that can be harnessed when they move through an external circuit. After moving through the external load, the electrons accumulate at the counter electrode, which is often coated with a catalyst, such as graphite. This catalyst then facilitates subsequent chemical reactions, acting as a medium for the electron to move from the counter electrode to the electrolyte solution. This electrolyte solution, such as a triiodide/iodide redox couple, functions to regenerate the electron to its original energy state. The electrolyte solution achieves this by undergoing a set of redox

reactions, which refers to the transfer of electrons between an oxidizing substance (losing an electron) and a reducing substance (gaining an electron). These redox reactions help facilitate the transfer of electrons, leading to the restoration of the electron back to the photosensitive dye as shown in Figure 2.

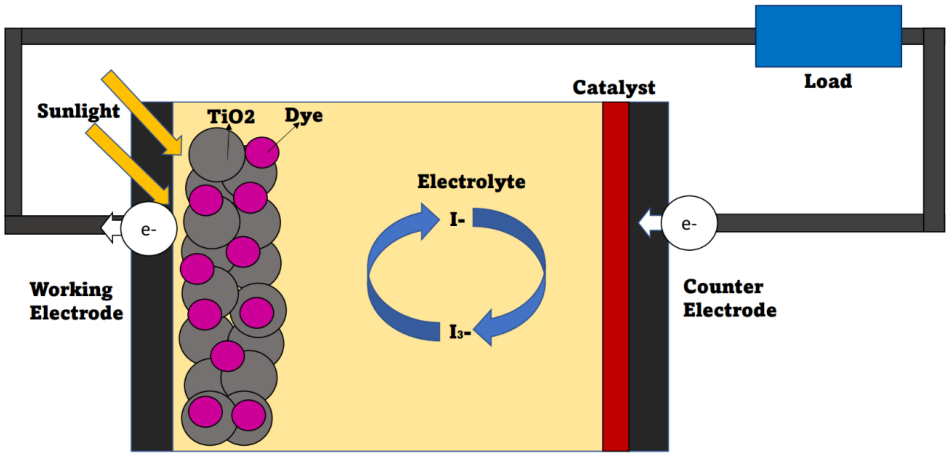

Figure 2. Schematic of a dye sensitized solar cell (DSSC). Photons from the sunlight strike the solar cell and excite electrons that pass through the working electrode, which can be used to power a load.

Given the various ways that solar cells operate, DSSCs could prove useful to the future of solar technology. Currently, DSSCs using Ru(II) dyes can consistently reach up to 12% energy conversion efficiency due to recent advancements in the field of solar technology (Sharma et al. 1). As research and development takes place, new materials used in DSSCs could further increase its efficiency in converting solar energy to usable energy while remaining accessible. Because there are many components that make up the DSSC, everything from the dye to the electrolyte can be optimized to increase solar cell efficiency. For instance, various types of ruthenium dyes are currently undergoing experiments that study their unique ability to harness solar energy from a broad range in the electromagnetic spectrum (17).

According to NASA, the sun produces around 1360 watts per square meter of solar radiation that reaches Earth's upper atmosphere. However, of that amount, 23% of the incoming solar radiation is absorbed by Earth's atmosphere, and another 29% of the solar radiation is

reflected back into space (NASA). This in theory leaves around 707 watts per square meter of solar radiation hitting Earth's surface on a clear day. However, the amount of power that a solar cell produces is nowhere close to this number due to physical limitations of the solar cells and variable weather conditions, such as the ambient temperature, solar irradiance, fog, etc.

To explain, of the external factors, excess heat from high temperatures is generally considered one of the most influential factors in decreasing solar cell efficiency (Gaughan). In traditional solar cells, this decrease in conversion efficiency occurs because higher than optimal temperatures result in the reduction of the band gap within the semiconductor material, decreasing solar cell voltage output. As mentioned above, solar energy is harnessed through the excitation of electrons from the valence band to the conduction band. However, when the gap between the valence and conduction band decreases, the electric potential per each electron diminishes (Weimar). Although this factor affects most types of solar cells, such as silicon, DSSCs are affected minimally by temperature, with efficiency remaining steady when ambient temperature increases from 20 to 60 degrees Celsius (Maçaira et al. 22699). In addition to the physical advantages of DSSCs compared to silicon, assembling DSSCs have the potential to be more scalable than silicon and, therefore, more cost effective. For example, silicon requires complex processing equipment in a pristine environment to produce efficient solar cells, whereas DSSC fabrication is simple enough to be done at home using easily obtainable household materials. This experiment serves to demonstrate the ease of building these cells while also providing a basis to estimate its economic viability by factoring in both raw material costs, as well as analyzing inefficiencies due to heat loss. Therefore, this paper aims to explore the feasibility of homemade solar cells and address the outlook of DSSCs commercially.

Methods–Construction

For this experiment, the silicon solar cells (monocrystalline and polycrystalline) were commercially obtained through Amazon. Monocrystalline and polycrystalline silicon solar cells were chosen due to their widespread availability and common usage. However, due to the lack of commercial DSSCs, the DSSC was constructed using easily obtainable materials as follows: titanium dioxide paste, fluorine doped tin oxide (FTO) conductive glass, triiodide solution, graphite pencil, and raspberry dye.

Construction process for DSSC used in the experiment:

1. Spread titanium dioxide paste on the conductive side of the conductive glass.
2. Heat up the coated glass on a hot plate that's at least 400 degrees Fahrenheit for around 5 minutes.
3. Place the titanium coated glass in raspberry dye and let it soak for 5 minutes. After taking the titanium coated glass out, it should be soaked in raspberry dye as seen in Figure 3.

Figure 3. Image of cell after soaking in raspberry dye.

4. Take another piece of conductive glass and cover the conductive side with graphite using a pencil.
5. Take both conductive glasses, one with the graphite and one with the raspberry dye, and make sure that the two conductive sides are touching.
6. Drip a triiodide solution between the two conductive sides that are touching each other.
7. Clamp down the sides to hold the solar cell in place.

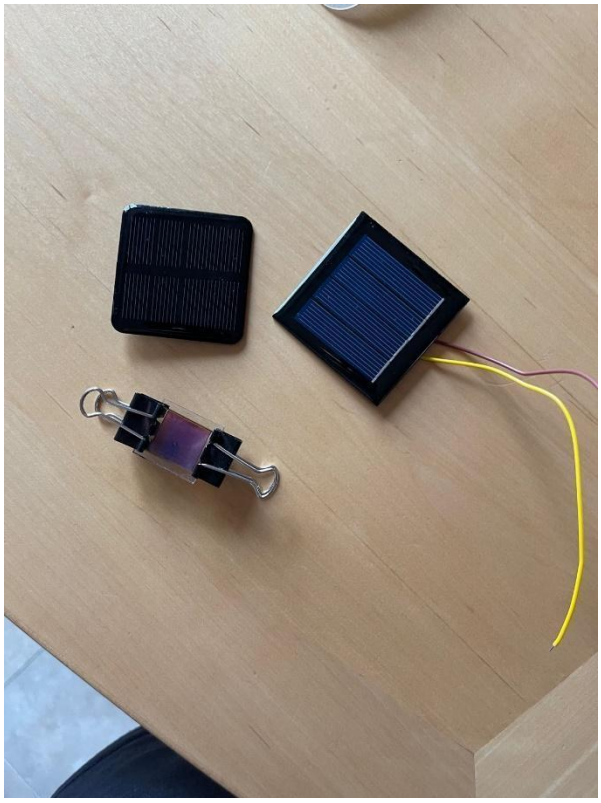

Figure 4. Image of the final result, which includes a finished DSSC (bottom left), a monocrystalline cell (top left), and a polycrystalline cell (top right).

Cost Comparison

To conduct the cost analysis, the price of each solar cell was evaluated. Additionally, the output power of each type of solar cell was measured under direct sunlight using a multimeter. Both the silicon and DSSC were measured at the same time to ensure that there was no variation in weather that may affect the results. Additionally, they were measured under direct sunlight (no clouds, etc.) in order to maximize incident photons. These two factors produced the price per wattage to normalize the comparison. It is important to note that not all of these solar cells are the same size, but the price per watt should not be affected by this as smaller cells proportionally produce less energy whilst also costing less.

To ensure that the data was reliable enough to conduct the cost comparison analysis, the data collection process was conducted 5 times with 5 minute time intervals between each recording. The collected data values from the 5 trials were then averaged to ensure that the

values used in the calculation were reliable. Using the averaged values of the milliamps and millivolts, the equation

$$P = I * V/1000$$

where P is power (milliwatts), I is current (milliamps), and V is voltage (millivolts), can be used to calculate power output. Now that power is calculated, the power per area (mW/mm^2) can be easily obtained by dividing power by area, as seen in Table 1.

Results

The results show that the monocrystalline silicon solar cell was the most efficient in terms of power per area (mW/mm^2) and calculated price rates (USD per watt). Following the monocrystalline solar cell, the polycrystalline solar cell had slightly lower efficiency in both power per area and calculated price rates as indicated in Table 1 and Table 2. Lastly, the dye sensitized solar cell had the lowest efficiency in terms of price rate as visually seen in Figure 5.

Type	Current (milliamps)	Voltage (millivolts)	Power (milliwatts)	Area (mm^2)	Power per Area (mW/mm^2)
DSSC	68.20	412.0	28.10	300.0	0.0936
Monocrystalline (Silicon)	103.2	2287	236.0	2025	0.1165
Polycrystalline (Silicon)	101.1	2304	232.9	2025	0.1150

Table 1. Average power output of different solar cells from 3 iterations of data collection. Rounded to 4 significant figures.

Type of Solar Cell	Calculated Price for Unit (USD)	Calculated Price (USD) per Watt

Monocrystalline	$1.55	$6.57/Watt
Polycrystalline	$1.59	$6.83/Watt
DSSC	$1.46	$51.6/Watt

Table 2. Cost comparison of calculated price (USD) per watt

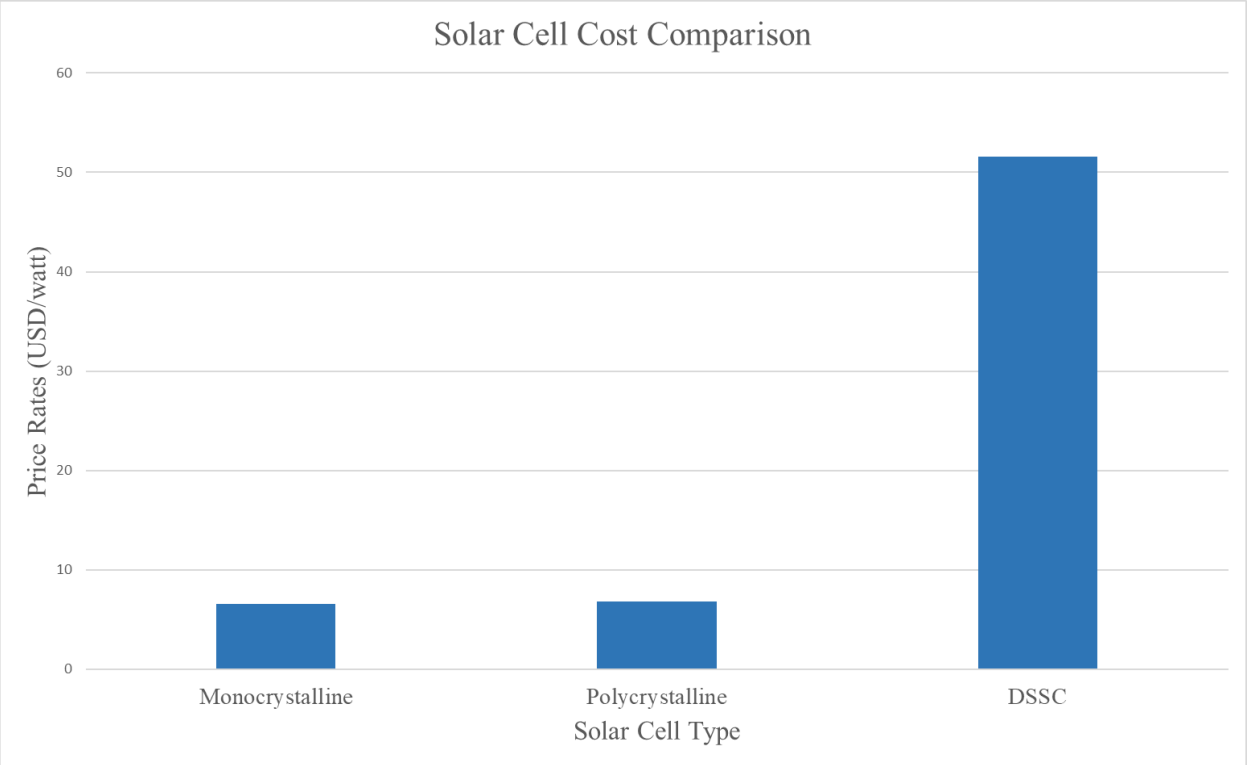

Figure 5. Bar graph comparison of estimated solar cell price per watt.

Discussion

DSSCs, specifically home constructed ones, were significantly less cost effective based on the data measured. DSSCs, monocrystalline, and polycrystalline solar cells were estimated to cost $51.6/W, $6.57/W, and $6.83/W respectively. The cost of the DSSC was nearly 8 times greater than that of their traditional silicon counterparts. This was likely due to the differences in economies of scale. Put simply, economies of scale refer to the proportionate savings in cost from an increase in production. Because silicon solar cells are one of the most popular types of solar cells, researchers and developers have optimized the silicon solar cell production process to

become more economically efficient over time. In a study conducted by Goksin Kavlak, a group of researchers at MIT revealed that the average cost of commercial silicon solar cells dropped just over 99% between 1975 and 2015 (701). Goksin attributed this drop in price primarily to economies of scale and increased investment into silicon solar cell technology (706). Because there has been demand for a shift to cleaner energy, research and development by both the private and public sector has dramatically lowered costs for solar cells. As solar cell factories grow in size, companies are able to develop more efficient production lines for commercialized solar cells, resulting in lower prices. Everything from the extraction of raw materials to the transportation of the solar cells have been more optimized for silicon solar cells compared to DSSCs. Despite this drop in price, however, Goksin notes that there are still technological improvements that need to be made, allowing scientists and engineers to "explore promising opportunities for future improvement" (709).

This presents the question of whether DSSCs still have a future in solar technology even though silicon solar cells are already technologically ahead. Although this experiment used a self-assembled DSSC that proved less efficient, there is still reason to develop DSSC technology because of its massive potential to scale up in production. The ability to self-assemble DSSCs proves that with sufficient research and development, the cost for constructing the DSSC could be substantially cheaper if the materials were properly optimized to function as a solar cell. For example, in this study, the DSSC's glass components were much thicker than they needed to be because they were not initially made with the DSSC in mind. Materials used for DSSC were bought at the consumer-level, possibly allowing for substantially lower costs by buying in bulk and directly from the supplier. Because DSSCs are not easily found in the market, the only real way to get them is to reproduce them using materials not designed for solar cells. This highlights the need to scale-up production as it would likely lead to a massive drop in price akin to that of the silicon solar cell.

On top of the potential to scale-up production, there are also material and physical reasons to prefer DSSCs. As of 2022, a new study found that certain DSSCs have achieved an efficiency beyond 15%, only slightly less efficient than that of their optimal silicon counterparts (Yameng et al. 60). This recent breakthrough in conversion efficiency points towards a future that utilizes solar energy from DSSCs. As mentioned above, there are many physical and material benefits of dye sensitized solar cells, namely that of remaining stable under high

temperatures (Maçaira et al. 22699). Because many parts of the world that would greatly benefit from increased solar energy production often experience high temperatures, it's essential that solar cells retain high conversion efficiency under heat stress. As shown in Figure 6, polycrystalline silicon solar cell conversion efficiency dropped from roughly 16% at -10°C to 10% at 70℃. On the other hand, as per the experimental and normalized DSSC data, DSSC conversion efficiency remained fairly steady from -10℃ to 70℃. Therefore, although DSSCs are currently lagging behind their silicon counterparts in terms of commercialization and economies of scale, DSSCs have a future ahead of them due to their potential scalability and physical advantages.

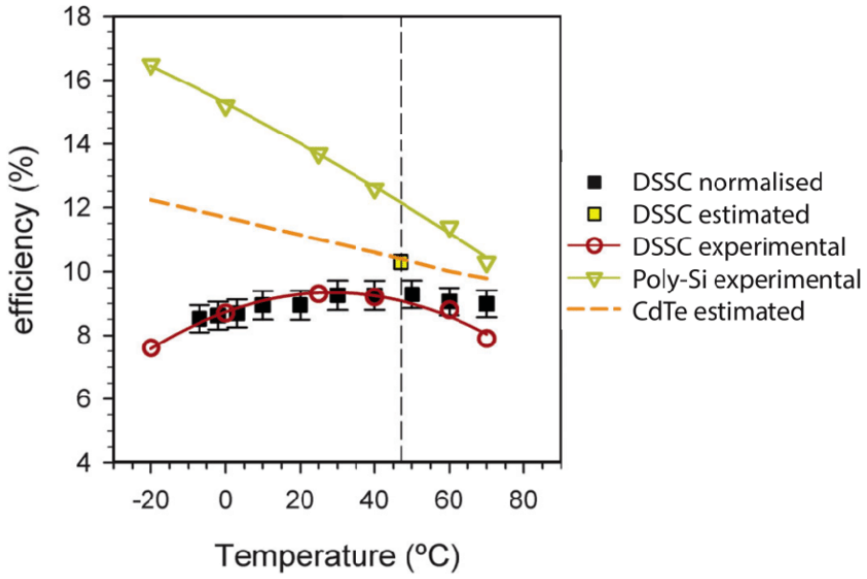

Figure 6. Line graph comparing the efficiencies of a DSSC against a polycrystalline silicon cell at different temperatures (Browne M.C. et al. 764)

Conclusion

To counteract air pollution and mitigate the rising threat of climate change, solar energy is an effective alternative to fossil fuel burning since solar is both renewable and has a low carbon footprint. The DSSC may be a possible competitor to the traditional silicon solar cell given its potential scalability of production and lower sensitivity to ambient heat. This experiment aimed to demonstrate the ease of DSSC production and compare its costs with silicon solar cells. The DSSC used in this experiment used technology that in principle could be readily available for wide-scale usage. However, since DSSC production is not as economically

optimized as that of silicon solar cells, the DSSC proved less cost-effective for home use. Nevertheless, DSSCs could still play a role in future energy production if efforts are made to scale-up DSSC production through research and development.

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Fostering the Informed Citizen: A Comparative Analysis of Two Approaches to Civics Education Amid Institutional Struggles By Devon Jiang

Abstract

Civics education encourages students to embrace the duties of citizenship. This goal is especially potent in the United States, given the developments of polarity among communities. However, the reality is that educators fail to recognize the importance of civics, nor do they have an understanding of its purpose. We assert the case for a modern civics curriculum intended to educate an informed citizen. We develop four standards the informed citizen follows as a member of their society. Using current civics education in America and pre-existing data, we determine that better civics education creates a more informed citizenry. Thus, we recommend several measures to improve the current state of civics standards. Our conclusions indicate that a failure to remediate existing civics education risks the erosion of American democracy.

Introduction

The United States sustains itself with the help of its population. The Founding Fathers envisioned a country with Americans who were competent in advancing its values. Thomas Jefferson stressed the importance of an educated society. His justification was clear: “Wherever the people are well informed they can be trusted with their own government; that whenever things get so far wrong as to attract their notice, they may be relied on to set them to rights” (Jefferson, 1789). Jefferson postulated that education was necessary to uphold the continuance of politically active citizens. He recognized that the system he developed relies on bona fide individuals actively participating in its institutions. Without an informed citizenry, the United States could not have evolved into a successful experiment.

Although the United States has changed for the better, Thomas Jefferson’s vision of civics has not. In the 21st century, many states have put their civics curriculum on the back burner. Until recently, Rhode Island’s Department of Education was one of ten states with no civics courses (Shapiro and Brown). Moreover, students in other states usually learn little over half a year (Jeffrey and Sargrad). As a result, today’s education puts students in a vulnerable position of not knowing enough to become informed citizens.

At the same time, we are facing a knowledge crisis. A 2022 civics survey found that 43% of Americans did not know United States Chief Justice John G. Roberts (American Bar Association). The population continues to know incredibly little about their government. Two faculty members at Johns Hopkins University surveyed 1,500 Americans (Rosen). Almost a third of the sample could not name anyone in their state government, and more than half failed to acknowledge that their state had a constitution—the lack of comprehension of how our state government functions is frighteningly mediocre.

Public officials did not always ignore civics. Contrary to today's efforts to reform civics education, the curriculum after the World War II era had a goal of propelling nationalism. Civics education, though, gained a reputation for being dry (Gould et al.). By the 1960s, Americans began to question their government. The emerging baby boomers criticized the policies of discrimination, student rights, and war in Asia (Johnson and Feinberg). The government could have lessened nationalism in civics education, but STEM sealed any recourse. As the Soviet Union progressed in space exploration, the United States shifted towards STEM education (Neal et al.). The nation spent over a billion dollars on science education which has only increased since the Space Race (Jolly). The shift from civics is present in modern United States education. An organization that promotes civics education estimates that the government spends an estimated 5 cents per student annually on civics compared to $54 for STEM education (Adams).

Today, two issues exist in the systems in America: underfunded civics education and fractures in the nation's institutions. Considering that both problems are complementary, we wondered if better civics education contributed to fewer fractures. Accordingly, we wrote this paper to address three outstanding questions:

1. What is an informed citizen?
2. Does a current state's robust civics education contribute to the existence of more informed citizens?
3. What standards are part of the ideal civics curriculum?

At first glance, the first question may seem unnecessary. We establish the purpose of civics education should be to create informed citizens. That said, without a definition for an "informed citizen," the term is too broad for the second question to answer. As a result, the first

question will attempt to define what standards define an informed citizen. Those qualities will aid in the evaluation of current civics curricula.

From there, we apply the definition to the context of real-life curricula. Although several studies have covered the benefits of experimental civics programs, none of those curricula have been implemented by state Departments of Education. Hence, we answer the second question with a case study of Colorado and Rhode Island's curricula. Although we could use Colorado's 2020 standards, it is too recent to determine its effects, so the comparison is between the state's 2009 requirements and Rhode Island's 2008 curriculum. We look at key provisions of both states' curricula and evaluate their overall quality. Afterward, we analyze seven different statistics that are relevant to an informed citizen. Some aspects of an informed citizen, most notably media literacy, are near impossible to measure with current information. However, we add a caveat that an informed citizen will always analyze as many viewpoints as possible to form a balanced understanding of events. We conclude by addressing how the United States could better civics education and consider the importance of reforming civics education.

Defining the Informed Citizen

In our research of what it means to be an informed citizen, we encountered multiple sources that outlined what the term means (Stephenson). Ultimately, we believe the informed citizen possesses four essential components: basic knowledge, community participation, political participation, and media literacy. We consider these factors as necessary parts of being an informed citizen because of how each pillar contributes to a more democratic society.

Most educators agree that informed citizens with basic knowledge of their government inherently contribute to its preservation. Basic knowledge includes the functions of the federal government, but the informed citizen is also cognizant of what their state and local governments do. The informed citizen should know each agency's jurisdiction because that knowledge serves as the foundation for an informed opinion. Knowing this information comes from understanding the laws of the United States. We concede that the informed citizen could not possibly memorize every single statute, but they should better understand the rules and rights they may encounter in their lives. By reading and respecting the laws, the informed citizen is patriotic to their country because they know whatever community or political action they take is within their rights. The other major part of basic knowledge is the history of the United States government. The

informed citizen should not only know the foundations of the United States but the painful moments that America confronted in its path to becoming a more perfect union. Acknowledging good and bad history helps the informed citizen develop a contextual understanding of today's issues. For example, Americans could learn from the effects of banning immigration from Asian countries to inform themselves of the Central American immigration debate. The informed citizen develops a basic knowledge of the United States to create richer viewpoints while gaining an appreciation for their country.

The informed citizen uses their knowledge of the country as a catalyst for going deeper into the current issues at hand. Thus, they become active in the community for three purposes: to understand how they and others are affected by those issues, to recognize how their elected officials work in principle, and to contribute to a solution. A citizen may help their community by volunteering, donating, and participating in dialogue with neighbors about local or national issues. Volunteering serves both purposes of community engagement: citizens help their neighborhood prosper and develop an understanding of each other's views. The informed citizen understands that they contribute to a tighter-knit community by participating in their town or city's activities. Furthermore, community activities involving problem-solving are times when the informed citizen feels empowered to develop an action plan. Conflicts may form because of opposing views, but an informed community uses the democratic processes learned from basic knowledge to reach a resolution. Community problem solving is a microscopic form of a functioning government. The informed citizen uses these opportunities to build on their understanding of how elected officials with different goals collaborate to make a solution. From community engagement, we turn to how informed citizens apply their actions to established governments.

The public depends on the government to best represent their interests. At the same time, the government relies on the public to hold the system accountable. In an attempt to uphold the country's system, the informed citizen does their best to be politically active. Voting, lobbying, and contributing are three traditional ways the informed citizen uses to put forward a representative they prefer. Many Americans fail to vote because they feel their voices do not matter, yet the informed citizen knows that, regardless of their impact, their vote is the most direct voice in a representative democracy. Meanwhile, demonstrating, contacting officials, and arranging public forums are a few tools the same citizen uses to express the displeasure of a

policy proposal or representative. With basic knowledge, the informed citizen knows their rights, such as the freedom to assemble, are established rights. Political participation is an obligation that citizens should subscribe to because the government, particularly in a democracy, is inherently designed to be a reflection of the majority. If a population does not express their opinions to the government, the informed citizen recognizes that majority or minority rights become too powerful.

Political participation relies on informed citizens who express their opinions, but we are beginning to see more problems developing those views. New sources of unvetted information mean that inaccurate information can spread. If a person has a preexisting view on an issue, social media typically propels stories that affirm those narratives with an extreme lens. Social media, thus, becomes a problem because younger Americans who use their services are susceptible to being trapped in an appealing yet narrow viewpoint. Newspaper reading has its own issues. Readers of an established journal will find factual information, but because humans naturally have biases the language of a report can sway toward one side of an issue (Steinhauser). The presence of bias becomes important because average readers and viewers are more likely to confine themselves in an ecosystem of outlets with similar biases (Broockman and Kalla).

Since biases and misinformation perennially exist, informed citizens exercise media literacy in two ways: perception and diversification. The informed citizen is sensitive towards less regarded sources (Stephenson). They recognize that a mix of primarily fact-based reporting and opinions give them a deeper context to the ramifications of an issue. However, the informed citizen should not stop at a few articles with authors of similar backgrounds. An informed citizen will consult as many sources as possible to reach a balanced opinion.

Media literacy is necessary for civics for two reasons. Legislation in the United States usually comes down to two sides. Informed opinions allow both sides to contribute positively to a discussion about the issues. If one side's view is based on misinformation, the conversation becomes an argument about what is factual rather than the issue itself. Consequently, the democratic processes can unnecessarily stall and suffer. The other aspect is that if all citizens have balanced opinions, they can understand each other, even if their backgrounds differ (Balietti et al.). Polarization comes from misconceptions about the unknown. Diversification minimizes that potential for unfamiliar cultures. We believe that this final standard of an informed citizen

deserves its own category because of how important perception and diversification have become to preserving trust in the country's democratic systems.

A Case Study of Two Existing Civics Curricula

Colorado and Rhode Island represent opposites of aggregate civics education in the United States. Colorado's 2009 approach received commendations from think tanks and awards (Montgomery and Sarché). Meanwhile, the Rhode Island Department of Education, until 2021, only recommended civics education (Caruolo). Regardless of the circumstances, we believe both curricula warrant an examination based upon the four categories of informed citizens.

Civics in America has always included the history and structure of government, which explains why both states have several strands relating to basic knowledge. Rhode Island does a decent job at elaborating the details of American institutions. The 2008 Grade Span Expectations (GSEs) recommend that high school students defend "positions on a current issue regarding the judicial protection of individual or state rights via judicial review" (Rhode Island Department of Education, 2008). The curriculum encourages students to know and interpret existing laws through research and debate. In this context, discussions help expose students to both sides of an issue (Williams-Brown). Unfortunately, Rhode Island furthers misinformation in basic American knowledge. The GSEs asks students to identify "the levels (local, state, national) and three branches of government, as defined by the U.S. Constitution, and the roles and purposes of each (e.g., checks and balances)" (RIDE, 2008). The Constitution never outlines the role of local governments. Perhaps Rhode Island did not mean to link the two and instead asked students only to identify that local governments exist, but the lack of accuracy interprets the GSEs harder for teachers. This error is not a one-off, however. In a recommendation to seventh and eighth-grade students, Rhode Island contrasts democracy and anarchy (RIDE, 2008) to highlight what happens when the public does not accept political structures. Contrary to the beliefs of RIDE, democracy and anarchy are not opposing types of governance. Consequently, the state, knowingly or unknowingly, misinforms its students. Colorado, at the least, is accurate in its information. The Colorado Department of Education expands on civic knowledge by describing why America has a democracy, elaborating why upholding it is crucial, and how citizens in different sectors impact their government (RIDE 2009). For example, high school teachers are expected to enumerate that democracy is a competition of values, including "but not be limited to freedom and security,

individual rights and common good, and rights and responsibilities" (Colorado Department of Education, 2009). This expectation aims to teach students the benefits of being part of representative democracy. At the same time, Colorado gives high schoolers a deeper understanding of how the United States sometimes contradicts its values for national security. Rhode Island does an excellent job at using engaging teaching techniques, but the accuracy and breadth of the Colorado Academic Standards allow students to understand better how America's history shapes the dialogue of contemporary issues.

We find that Rhode Island's curriculum does best at informing students of the process of community engagement. Fifth-grade and sixth-grade Rhode Island students must recognize "potential conflicts within or among groups, brainstorming possible solutions, and reaching compromises (e.g., discrimination, bullying)" (RIDE, 2008). As the GSEs progress, the idea of community is expanded to include engagement. If the state mandated its civics curriculum, every high school student would have to "identify, propose, and carry out a community/civic engagement project/initiative" (RIDE, 2008). With a community project, students could tangibly understand the benefits of being an active citizen. Simultaneously, Rhode Island addresses a common impediment to volunteering by making time for students to participate. We consider RIDE's attention to community engagement the best part of their curriculum. Yet, Rhode Island fails to connect volunteerism to a purpose or obligation. Most students recognize that they should volunteer, but the reliance on students to intrinsically connect their activities to a civic duty prevents RIDE's vision from being realized.

The most direct benefit of civics education in the United States is political participation. Despite that connection, Rhode Island fails to proactively explain why students should participate in the country's democratic system. The curriculum requests that students form opinions on specific issues but does little to convey how to advance their viewpoints in the context of governance. The closest the state's Department of Education gets to the importance of political participation in school elections. Students in the fifth and sixth grades are supposed to be "engaging in the political process (e.g., voting in school elections)" (RIDE, 2008). School-wide elections, though, are rarely a great representation of what happens in American politics. In our experience, student campaigns are more about preexisting popularity than a focus on the issues. Rhode Island addresses how historical movements were used as a force for change. Nonetheless, the more significant problem remains that unless students conduct independent

research, they would have minimal comprehension of how to use their voice. Colorado students, though, learn their role in a democracy. Concepts like rules, voting, and objections are incorporated into a student-approved constitution. Colorado makes this process a requirement because they want students to feel that, "Decisions are made cooperatively. For example, families vote on which movie to see and classes vote to see what project they will do" (CDE, 2009). The curriculum gives the students authority to demonstrate how they can use their power to vote as an adult on various proposals. Subsequently, students gain political socialization by using their influences to develop opinions (Obenchain). When students learn about political participation in high school, they must answer, "Why should you participate in government?" (CDE, 2009). The direct questioning of political participation in Colorado's standards is executed much better than Rhode Island's GSEs because the question focuses on why they specifically should vote, protest, and change the rules. Colorado could have written more specific types of political activity such as lobbying and writing to public officials. Despite the missed opportunities, the state's 2009 academic standards are more direct and insightful than Rhode Island's at making more politically active citizens.

Media literacy is a crucial skill informed citizens use to develop detailed and factual viewpoints, but educators have historically disregarded its importance. Many theories could explain why Colorado and Rhode Island previously paid little attention to media literacy. We believe the lack of ways to quantify media literacy is partly responsible. Educators may recognize the importance of media literacy, but if they cannot justify how it contributes to an informed citizen with direct statistics, they may lack any support to push funding from another subject. In Rhode Island, their GSEs at least raise the idea of determining credibility and biases to foster an informed opinion. The issue, though, is that the burden falls on the teachers to outline the techniques students should use to find reliable sources. The only mention of credibility in the curriculum is a recommendation that students should identify "reliable sources to answer questions about current important issues (e.g., news media, children's news magazines)" (RIDE, 2008). Two examples are used to elaborate on Rhode Island's point, but in the current digital media, students can consider many non-established sites as news media. Rhode Island does not do much better at teaching bias. High schoolers are recommended to analyze "sources (print and non-print discourse/media), by distinguishing fact from opinion, and evaluating possible bias/propaganda or conflicting information within or across sources" (RIDE, 2008). Similar to

the previous standard, RIDE does not give students any resources to determine bias. Colorado, even in its 2009 standards, addresses this issue of bias. Although unintentional, the state teaches students to combat inherent bias by considering multiple perspectives. In the eighth grade, Colorado describes responsible community members as individuals who "read diverse sources to create understanding" (CDE, 2009). The state gets students to recognize that issues are rarely one-sided. As a result, students are expected to use multiple sources of different backgrounds to make themselves well informed. Colorado does introduce the internet in high school as a tool for viewing media (CDE, 2009) but never equips students with skills to combat misinformation on social media. Although the state addresses this issue in its 2020 curriculum (CDE, 2020), thousands of students do not have adequate media literacy skills. The inclusion of diversification in the curriculum, though, means that Colorado's policies, on paper, encourage more complex views than Rhode Island.

The significant differences between Colorado and Rhode Island's curricula come down to the broader context of education policy. Colorado's civics standards need many changes, but the state's Department of Education prioritizes civics more than Rhode Island. There is no particular reason why Colorado chooses to pay attention to civics. However, since one course on civics in high school is the sole graduation requirement in Colorado, the Department of Education recognizes the importance of frequently updating the civics curriculum (CDE, 2022). Rhode Island's civics curriculum woes have a more precise explanation. The Rhode Island Department of Education is experiencing a multitude of issues in the quality of its education. The state's largest school district has noticeable disorganization problems. A report from Johns Hopkins University notes that, after the Providence School District experienced a rise in troublemakers, several teachers segregated them by seating non-engaged students in desks that face the wall (Johns Hopkins Institute for Education Policy). These measures nurture an undemocratic classroom, but there is no visible alternative. The state does not have the freedom to automatically adjust its civics education when its teaching environment is in dysfunction. Because Rhode Island fails to achieve proficiency in english and math, courses that are considered the foundation of education, the state is inclined to focus on improving scores in those subjects before focusing on civics and history (Borg and Parker).

Given the circumstances, we believe many school districts have reasons to turn down RIDE's recommended civics standards. Our suspicion is based on several students who sued

Rhode Island for not having civics classes. Aleita Cook, a former Rhode Island student, said she struggled to become an informed citizen because her school district never taught her the basics of governance (Goldstein). Another student concluded that, in his twelve years of learning, not once was he taught how he could participate in American institutions (McDermott). The fourteen students named in the lawsuit illustrate that many school districts do not provide civics education. In comparison to Colorado, Rhode Island's civics debacle represents a grand failure of RIDE.

Measuring the Effects of a Satisfactory Civics Education

According to our hypothesis, Colorado's acceptable curriculum should result in a more informed citizenry than Rhode Island's. In the following section, we test that claim by examining seven actions an informed citizen would do as an obligation to their nation. Most of the data focus on community engagement and political participation. In our limitations, we explain why basic knowledge and media literacy are not prevalent in this comparison.

One of the principal benefits Americans have is the ability to cast a vote. As a result, informed citizens should know the value of their participation. To best measure the effects of K-12 civics education on voting, we compiled data from the Center for Information and Research on Civic Learning and Engagement on the voter turnout rate among 18-19 year old voters in the 2020 election. Rhode Island had a meager participation rate of 28% (Center for Information and Research on Civic Learning and Engagement, 2020). Meanwhile, 57% of Colorado's 18-19 year olds voted (CIRCLE, 2020), making the state's participation rate better than 35 of the 40 states that reported youth data. If we expand the restriction to voters 18-29 years of age, Rhode Island does better at 43% but still ranks below Colorado (CIRCLE, 2020). Although the 18-19 age restriction did not limit every Colorado and Rhode Island resident who moved to their state after high school, we believe that demographic is not significant. This judgment is based on the freshmen profile of the two largest universities in both states (University of Colorado Boulder; The University of Rhode Island). Considering these facts, along with the number of citizens who do not enroll in university and the prevalence of virtual learning in 2020, there is not enough evidence to conclude that outside forces are the reason for this gap. Ease of voting is also a factor, but because Rhode Island automatically sent mail-in ballot applications and no substantial delays were reported in the mailing process, this factor is

not notable (Rakich et al.). The informed citizen would have enough time in either state to cast a ballot. Regardless of the factors contributing to the 2020 voting pattern, the data strongly indicates that good civics education translates to higher voter turnout.

Another element of the 2020 election is political donations. Colorado and Rhode Island contributed a combined $217,741,063 for the 2020 elections (OpenSecrets). An individual Colorado resident, on average, donated $34.01, while the same person in Rhode Island would have contributed $19.46 (United States Census Bureau, 2021). By that measure, the average Coloradoan donated 74.77% more money to political campaigns than Rhode Island. The difference in average income and cost of living, furthermore, is not significant. The Census recorded that an average Coloradoan makes $39,545 annually compared to Rhode Island's $37,504 (United States Census Bureau, 2022). A contribution sends a message, and Colorado's more substantial contributions indicate that its population is more informed at sending a political statement than Rhode Island.

Understandably, not everyone can afford to voice their opinions using donations, but another action the informed citizen does is protesting. Count Love Organization tallied the number of assemblies from the start of former President Donald Trump's administration until the last day of January 2021. They found that Colorado had 602 protests and 74.3 demonstrators per thousand residents (Leung and Perkins). Meanwhile, there were 27.7 demonstrators per thousand residents in Rhode Island and a total of 123 protests. The additional number of protestors in Colorado suggests that the state's civics education is working.

The other standard of the informed citizen we measure is community participation. The informed citizen will volunteer in their community to contribute to others and learn more about current events. We used a report from the University of Maryland to compare the states. Their institute found that Colorado ranks in the top 15 nationwide, with 34.1% of Colorado's high school students volunteering between 2012-2015 (Grimm and Dietz). Concurrently, only 24% of Rhode Island's high school students participated in the same period. Rhode Island peculiarly performs better when we only look at college students. 32.8% of the state's college students volunteered compared with Colorado's 24.9% rate. Some individuals could hypothesize that Colorado's rural geography lends well to volunteerism, yet prior inquiries dispelled that theory (Paarlberg et al.). The likeliest justification is that Rhode Island's universities provide a better environment for volunteering, but we do not know for sure. Regardless, because high schoolers

in Colorado disproportionally contribute to the state's overall volunteer rate, the extensive participation validates that Colorado's 2009 civics education produces a notable increase in community engagement.

Informed citizens always find ways to contribute to their community on a micro and macro scale. Donations to charities reflect the contributor's understanding of people's or nature's struggles. When the University of Maryland conducted its report on volunteering, it also compiled data on donation rates. Among high schoolers, 24.7% of Colorado students donated between 2012 and 2015, while 11.8% did the same in Rhode Island (Grimm and Dietz). A basic explanation for the disparity should be the poverty rate. In this case, though, poverty is not a substantial factor. In 2020, Colorado had 1.6% fewer people in poverty than Rhode Island (United States Census Bureau, 2022). Compared to the national average, Rhode Island had 0.8% fewer people in what the Census defines as poverty (Shrider et al.). The best rationale, therefore, is influence. In the report, The Do Good Institute believes education is one meaningful way to influence community engagement (Grimm and Dietz). RIDE could have mandated volunteerism and charity, but Rhode Island's absence of required civics education is a significant reason for low donation rates.

We looked at many different statistics between Colorado and Rhode Island to understand how civics education contributes to the informed citizen's various actions. However, most of them are not included because of insurmountable limitations. Although the following metric–the rate of Americans contacting a public official–falls under that category, we felt the data was important to note. Census survey in 2017 observed that, nationally, only 11.2% of 16-29 year old Americans expressed their opinion to a public official within the previous twelve months (CIRCLE, 2020). Colorado had a lackluster 3% of youth residents who talked to a public servant. Rhode Island did marginally better at 5.1%. The dismal result is not surprising, however. In our comparison of the two curricula, only Rhode Island's GSEs mentioned emailing members of Congress (RIDE, 2008). Considering the previous positive attribution of civics education and informed citizenry, we can reasonably conclude that the current state of civics education is not strong enough to establish exceptionally informed citizens.

The results are primarily positive signs that having a holistic civics education creates more informed citizens. Many factors and side notes contribute to the results that we compiled. Despite the elements, one difference stood out in every statistic: the availability of good civics

education. When we look at actions that have been well established in civics, namely voting and volunteering, Colorado achieves better results than Rhode Island. The 28% voting rate among 18-19 year olds in the 2020 election suggests that the statements that Aleita Cook made are valid across the state (CIRCLE, 2021). Simultaneously, although we intended to find the effects of an excellent civics curriculum on an informed citizenry, we are absorbed by the anti-climatic reality of Colorado's lauded civics education. Colorado succeeds in the metrics that they focus on in their curriculum. The Center for American Progress, though, lacks the basis to consider Colorado a bright spot for civics education (Shapiro and Brown). When we emailed a local state Senator about why Colorado had an outstanding civics curriculum, she described her state's education as abysmal (Terri Carver, 2022, personal communication). The lawyer of Rhode Island's civics lawsuit affirmed her assessment by writing that "the fact is that no state is doing an adequate job on preparing students for capable citizenship in the 21st century" (Michael Rebell, 2022, personal communication). We establish that civics education makes a meaningful difference to the democratic systems of the United States, but to know what a robust civics curriculum does to its students, we conclude that state Departments of Education must do more.

Recommendations

Reforms to civics education are achievable. Having examined two existing state civics education, we recommend a few actions to create the ideal curriculum. An exemplary civics education does more than teach basic knowledge with textbooks. Civics learning should feel engaging, not dry. Some states will have operational differences that impact how curricula are taught to students. Regardless of the differences, we use this opportunity to present what the ideal civics standards–free from the realities of current policy–would resemble.

The ideal civics curriculum must have a genuine purpose. Rhode Island provides an example of why creating a civics curriculum is insufficient. Because the justification for their GSEs was to offer a big picture for local school districts, RIDE wrote an incoherent curriculum (Lamiell). Since the Rhode Island civics lawsuit, RIDE established a task force with specific goals for improving its curriculum. Curricula reflect the purpose of the writers, so any standard must recognize that civics is necessary to create informed citizens.

The foundation of civics relies on basic knowledge. A mandated assessment based on the United States citizenship exam efficiently provokes students to learn about their country. Many

teachers and advocates have opposed adding a civics test as a graduation requirement (Colias). Their arguments partly rest on the notion that students will learn the content before ignoring it after the assessment. Prior research indicates, though, that tests increase knowledge. A sample group of students who took a high-stakes evaluation scored 0.2 points higher on a six-point civic knowledge index than students with no test requirement (Campbell). These effects are most pronounced on students of color and immigrant children (Campbell and Niemi). However, we agree with advocates that a required test should not become the sole method of instruction. The ideal curriculum uses a mandated test as part of a broader set of tools to have students comprehend American history.

The addition of service learning can address issues with volunteerism in America. We recommend service learning to be at least 20% of the curriculum because it addresses the importance of engagement. Students should actively research issues, participate in organizations that remedy the problem, and reflect on their overall work. Those who engage in mandatory volunteer service at high-quality organizations are more likely to contribute as adults (Gallant et al.). The shift from learning local issues to participating in the solution has a meaningful effect on how students view their role in the community. Service learning gives students the time to realize how their actions cause positive change. As a result, students begin to recognize the importance of research and participation despite all the work they may have.

Before researching issues in the community, students must learn how to find factual information. The ideal civics education combats the rising problem of misinformation by creating criteria for evaluating information. Teachers convey tools such as the credentials of the author, the changeability of the event, and confirmation of the news by other sites. Students also determine which source is a scholarly article, an established outlet, a magazine, and a tabloid. Afterward, the informed middle school student applies these two exercises to a research project on a current issue. There is not enough data to judge the effects of media literacy, but we believe a well-crafted program helps inform students because they give different lenses to look at what an article says and why the author writes a piece in a specific tone.

The most integral part of executing a good civics curriculum is the teachers. Although it may seem obvious, teachers ought to have the necessary resources to inform their students. School districts must use professional development days as a significant opportunity to tell the teachers. Teachers should collaborate to have a rich comprehension of the material. In an idyllic

setting, teachers can report any instruction issue to their administration. Vigorous teacher training naturally means better education. Students with teachers who receive more engaging professional development day training gain more knowledge than students whose teachers teach without the treatment (Taylor et al.). Teachers are messengers who send information from the curriculum writers to the students. Consequently, the ideal civics curriculum comes with funding for schools to implement more professional training days and a diverse portfolio of programs that help teachers better understand the content.

Civics education in the United States should prepare the next generation to become informed citizens, but achieving that ideal goal with our recommendations comes after confronting the current state of education. Outside factors often prohibit curricula from being successful. For example, although additional professional development days would benefit civics education instruction, educators may not have enough funding. Therefore, these measures that we believe are best for civics education are idyllic, not realistic. Ultimately, local, state, and national policymakers are the stakeholders who dictate what belongs in the ideal curriculum.

Conclusion

The issues of divisions among Americans about their government strengthens the argument for adequate civics education. As the relevant government agencies continue to ignore civics, Americans are becoming incapable or unwilling to exercise the duties of citizenship. We contribute to this connection by comparing two vastly different curricula that have been implemented statewide. We analyze how a satisfactory civics education results in more informed Americans. As importantly, we assert the purpose of civics in the 21st century by defining the informed citizen.

With the help of previous studies, we developed four categories of the informed citizen. First, informed citizens know how their government works and the history that led the United States to today. Second, the informed citizen recognizes that community engagement fosters important local connections. The perspectives that informed citizens gather will allow them to develop stronger viewpoints in local, state, and federal government. At the same time, the informed citizen conducts good research. In tandem, the informed citizen knows how to cherish and maintain the American democracy.

Next, our case study of Colorado and Rhode Island presents major ramifications for how governments should treat their civics curriculum. We discovered that Colorado invests more in PreK-12 civics education than Rhode Island. Though Rhode Island's curriculum had a few bright spots, we attributed the state's lack of informed citizens to the fact that a civics course is only recommended. Young adults in Colorado consistently performed better than their Rhode Island counterparts in all the significant ways to be an informed citizen. As a result, we can confidently affirm that a good civics curriculum contributes to more informed citizens. Despite that conclusion, we discovered numerous examples of Colorado failing to specify multiple standards. As a result, we concluded that every state needs to evaluate its civics standards.

Colorado and Rhode Island, along with the rest of the United States, need to invest time and money into civics education. We noted several standards and graduation requirements that could better fulfill the purpose of civics than the status quo. Most of our focus centered around increasing engagement among students. More importantly, we established that the ideal civics curriculum not only requires detailed standards but informed teachers. Without adequate professional development days, teachers cannot actively captivate students.

Education is becoming increasingly politicized during this polarizing period in the United States. In an effort to push their agenda, politicians are trying to make curricula that fits within their social agenda. Educators, thus, should recognize the harmful effects of promulgating uninformed and misinformed citizens. Rhode Island is a demoralizing case study of what happens when students are not taught the ways of the informed citizen. Although the debate on implementing civics is controversial, states should invite politics into the classroom to teach students how to handle controversial discussions, how to use their voice while abiding by the rule of law, and how to develop informed opinions. We hope that our contributions can provide insight to educators about the risks of ignoring civics education so that future curricula can raise an informed society.

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Exploiting Intestinal Microbiota and Bacterial Metabolites to Combat Breast Cancer

By Sophie D. Tanenbaum

Abstract

Breast cancer is a complex disease that affects millions of women worldwide. Although prognosis is generally favorable in the early stages of the disease, outcomes worsen significantly as the disease advances. In a disease where every mitigating factor counts, it is important not to overlook any possible targets for therapy. Hence, many researchers have recently shifted their focus toward the gut and breast microbiomes. This paper delves into four major bacterial metabolites—lithocholic acid, short chain fatty acids, cadaverine, and estrogen—and analyzes how they impact carcinogenesis. Overall, this literature review aims to examine the current understanding of the microbiome changes in breast cancer patients, provide insights into the potential of dietary modifications as a complementary therapy, and identify the major gaps in the literature.

Keywords: breast cancer, microbiome, cancer metabolism, microbiome dysbiosis, bacterial metabolites, lithocholic acid, short chain fatty acids, cadaverine, estrogen deconjugation

Introduction

Breast cancer is a leading cause of death among women worldwide. The American Cancer Society estimates that in the United States of America, 353,310 women will be diagnosed with cancer and around 43,700 women will die from breast cancer in 2023 [1].This is categorized into subtypes based on which markers the tumor cells present, including estrogen receptor (ER), progesterone receptor (PR), and the human epidermal growth factor receptor 2 (HER2). Current methods to treat breast cancer include chemotherapy, immunotherapy, and radiotherapy.

The gut microbiome plays a critical role in the development and treatment of breast cancer. Gut microbiota are the microorganisms, including bacteria, archaea, fungi, and viruses, that live in the digestive tract of animals. Because gut microbiota coevolved to be symbiotic with human cells, disruptions in the gut microbiome are also associated with changes in the immune response and metabolism. Dysbiosis, or functional alterations to the gut microbiome, can

increase the risk of developing breast cancer [2]. The breasts also have their own microbiome, which impacts breast cancer tumorigenesis and treatment. Bacterial metabolites from the gut microbiome also influence breast cancer cell metabolism [4]. Bacterial metabolism produces metabolites such as short chain fatty acids and vitamins that are not produced by human cells. This literature review aims to examine how the gut microbiome can be manipulated to increase the efficacy of anti-cancer treatments for breast cancer patients.

Dysregulation of the Metabolism in Breast Cancer

Like other solid tumors, breast cancer cells show characteristic pathological changes in metabolism. All subtypes of breast cancer cells were shown to upregulate glycolysis even in the presence of oxygen, a phenomenon known as the Warburg effect (Figure 1) [5]. The increased uptake of glucose and production of lactate facilitates the synthesis of more biomaterials to support rapid proliferation. The pentose-phosphate pathway (PPP), glutaminolysis, lipid and cholesterol metabolism, and protein translation are also upregulated in breast cancer (Figure 1) [6, 7, 8, 9]. These metabolic changes are instrumental for supporting proliferation and the epithelial-to-mesenchymal transition of breast cancer cells. The reconstruction of tumor metabolism can also promote angiogenesis and metastasis [3]. Hence, the metabolism of breast cancer has become an attractive target for cancer treatments. Through observing the inner workings of metabolites in breast cancer, researchers can design promising and targeted treatments for patients.

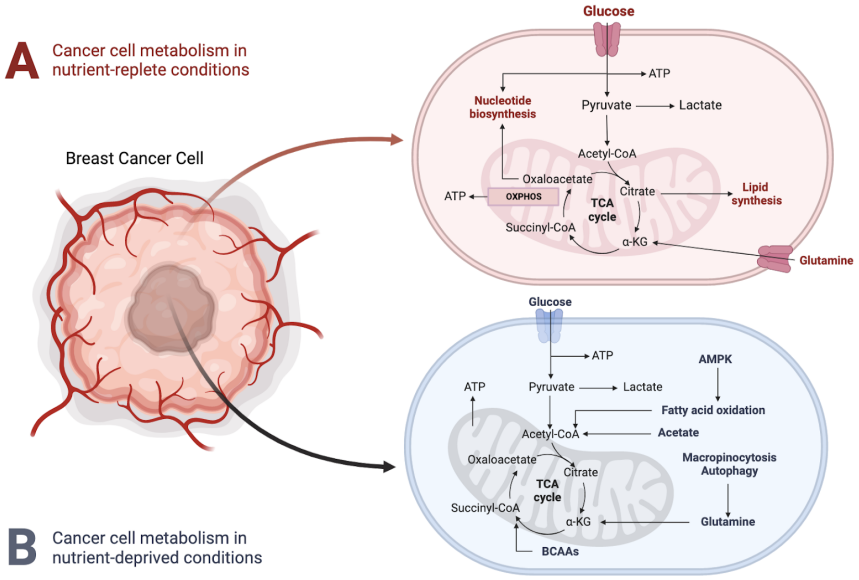

Figure 1. Simplified schematic review of breast cancer cell metabolism in nutrient-replete and nutrient-deprived conditions to support survival and proliferation. In nutrient-replete conditions, the cell promotes nucleotide biosynthesis and lipid synthesis. Oxidative phosphorylation (OXPHOS) is also more present in nutrient-abundant conditions. Glutamine uptake is increased, consequently promoting the TCA cycle. In nutrient-deprived conditions, the cell undergoes autophagy to produce glutamate. Branched chain amino acids (BCAAs) promote the TCA cycle. AMP-Activated Protein Kinase (AMPK) oxidizes fatty acids. Nucleotide biosynthesis and lipid synthesis are downregulated in nutrient-deprived conditions.

Microbiome Dysbiosis in Breast Cancer

Interruptions in the symbiotic relationships of the microbial community are known as dysbiosis [10]. In breast cancer, both the gut microbiome and the breast microbiome—which resides in the milk ducts of the breast—experience dysbiosis as the diversity of these microbe populations decrease in patients [11, 12, 13, 14]. In most cases, the biodiversity of the gut microbiome is decreased in breast cancer patients compared to healthy patients [14, 15].

To analyze the breast microbiome, researchers use next-generation sequencing on nipple aspirate fluid or sterile biopsy. Oftentimes, the physiological change in the breast as a tumor develops causes these microbiome changes [11]. Each subtype of breast cancer has its own unique microbial markers [12]. The microbial communities in the breast and gut microbiomes of triple-negative breast cancer patients typically differ more greatly from other types [16]. As shown by Meng et al., the breast microbiome composition can change drastically as a result of the histological grade of the disease [17]. These changes alter the function of the breast microbiome. Using next-generation sequencing, Meng et al. observed that as the grade of the tumor increases, breast microbiome glycerophospholipid synthesis and ribosome synthesis processes are upregulated and flavonoid synthesis is downregulated [17]. In this experiment, the researchers also discovered that as grade increased, the relative abundance of *Agrococcus* increased and bacterium from the family Bacteroidaceae decreased [17]. Despite these observations, it is still unclear whether these differences have any functional significance in the promotion of carcinogenesis. Moreover, all the subjects in this study were Chinese. Because dietary, lifestyle, and environmental factors have been known to influence microbial

composition, the uniform sample size does not provide a full scope of the metabolic changes in breast cancer patients.

The gut microbiome undergoes significant changes in breast cancer patients. The group of James J. Goedert published a series of studies that compared the fecal biodiversity of breast cancer patients to that of healthy participants. They found that the biodiversity of the gut microbiome was significantly lower in breast cancer patients compared to healthy controls. From their results, they also hypothesized that the gut microbiota may influence breast cancer risk by altering the host's metabolism, estrogen recycling, and immune system [18, 19, 20, 21]. In 2018, Miko et al. discovered that the most drastic changes to the gut microbiome occurred in the early stages of breast cancer tumorigenesis [22]. These observations were confirmed in Luu et al., as the relative abundance of *Bacteroidetes, Clostridium coccoides, Clostridium leptum, Faecalibacterium prausnitzii*, and the *Blautia* species had the greatest increase between stages 0 to 1 [23]. Because antibiotics upset the balance of the microbiomes, antibiotics consumption has been identified as a possible risk factor for developing breast cancer [24, 25, 26, 27, 28]. The effect on breast cancer risk varies between various antibiotic classes, with penicillins, tetracyclines, and nitrofurans showing the strongest increased risks [28]. While most of the literature identifies a possible causal relationship between antibiotic consumption and tumorigenesis, over half of those findings are not statistically significant. Among the studies that did find a significant relationship, the subjects were actively taking more antibiotics than necessary. In a 2019 study on breast cancer mice models, researchers found that the antibiotic Cephalexin reduced the abundance of *Odoribacter* and *Anaeotruncus*—two butyrate-producing bacterial groups—and increased the abundance of *Bacteroides*, a microbe that supplies polysaccharides and vitamins to the host [27]. Essentially, the antibiotic accentuated the decrease in microbe diversity that the tumor induced and facilitated tumorigenesis, suggesting a causative relationship between antibiotic usage and breast cancer progression [27]. These results were consistent with the hypothesis that reduced bacterial diversity is associated with breast cancer.

Metabolic Interactions Between Microbes and Breast Cancer Cells

Just as the host regulates the composition of its microbiome through its innate immune system and diet, microbes can also calibrate the pathophysiology of the host [23, 29, 30]. Many microbes secrete bacterial metabolites. The bacterial metabolites that travel through the circulatory system are a fundamental part of microbe-to-host signaling [31, 32]. These

free-floating metabolites—including lithocholic acid (LCA), short chain fatty acids (SCFAs), cadaverine, and deconjugated estrogens—impact various metabolic pathways, thereby modulating the progression of breast cancer (Figure 2) [22, 33, 34, 35, 36].

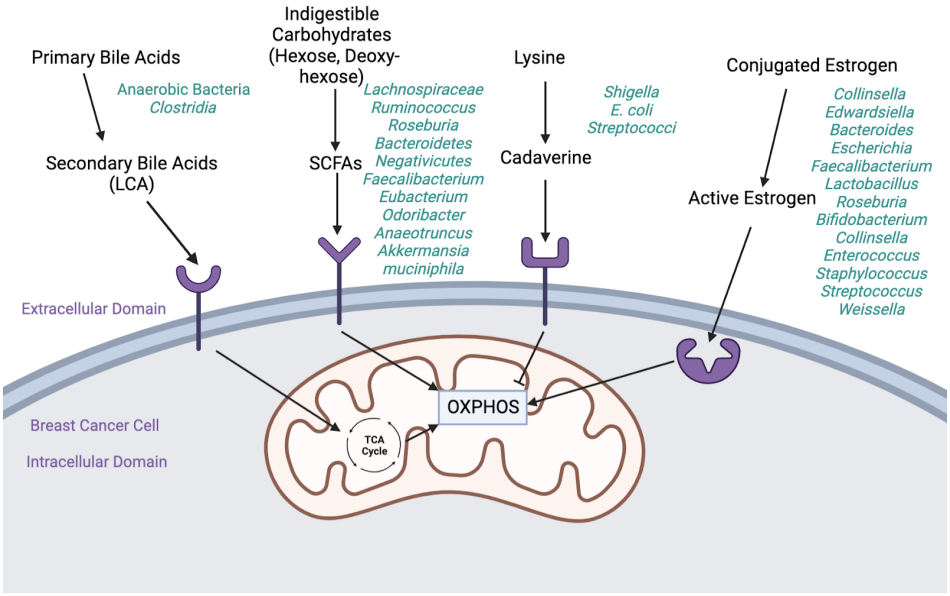

Figure 2. Schematic of the bacterial metabolites that modulate breast cancer cell mitochondrial metabolism. Adapted from Mikó et al. [55]. Secondary bile acids induce the TCA cycle. Short chain fatty acids (SCFAs) and active estrogen induce oxidative phosphorylation (OXPHOS). Cadaverine inhibits OXPHOS.

Lithocholic Acid

Secondary bile acids result from bacterial metabolism in the colon. LCA is a secondary bile acid created when anaerobic bacteria, mostly *Clostridiales* and *Eubacterium*, convert a primary bile acid produced by the host (Figure 3) [37]. This primary bile acid is known as chenodeoxycholic acid (CDCA) [37]. The capacity of the human body to synthesize LCA is largely reduced in breast cancer patients [22].

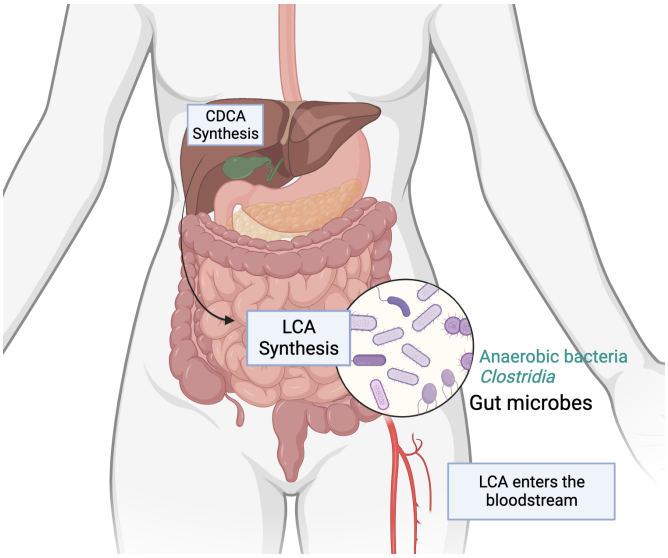

Figure 3. The pathway of LCA synthesis in the human body. Chenodeoxycholic acid (CDCA) is produced in the liver and travels through the gastrointestinal tract. Anaerobic bacteria, such as *Clostridia*, convert CDCA into lithocholic acid (LCA) in the intestines. Finally, LCA enters the bloodstream and can enter cells.

Miko et al. established that LCA has a partially cytostatic effect on breast cancer cells, in that it induces oxidative phosphorylation (OXPHOS) and the TCA cycle, inhibits epithelial-to-mesenchymal transition (EMT) and vascular endothelial growth factor (VEGF) expression, and boosts antitumor immunity (Figure 4). In total, higher concentrations of LCA reduced cancer cell proliferation by 10-20%. It exerts these effects through the G protein-coupled bile acid receptor 1 (TRG5) [22]. LCA induces TGR5 expression. As a metabolic regulator, TRG5 is involved in energy homeostasis, bile acid homeostasis, and glucose metabolism [39]. The TRG5 pathway has been shown to antagonize cancer-cell proliferation [40]. LCA-induced activation of TRG5 was shown to induce OXPHOS in metastatic breast cancer animal models, thereby eliciting an anti-Warburg effect in the cells [41].

EMT, the process in which epithelial cells convert into a mesenchymal phenotype, is involved in tumor progression. EMT is typically incomplete in breast cancer, as tumor cells express mixed epithelial and mesenchymal genes. It is associated with metastasis and migration because hybrid cells tend to be more aggressive [42]. VEGF is a potent angiogenic factor that is upregulated in many cancer cells [43]. Miko et al. observed that LCA reversed EMT and

decreased VEGF production by 37% [22], suggesting that LCA is a strong anti-tumor bacterial metabolite.

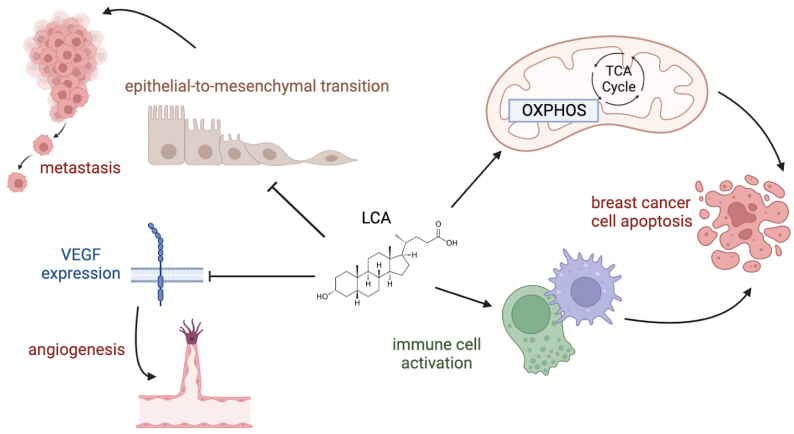

Figure 4. Simplified review of lithocholic acid's (LCA's) anticarcinogenic effects. LCA can inhibit epithelial-to-mesenchymal transition and vascular endothelial growth factor (VEGF) expression. By extension, this inhibition limits breast cancer cells' ability to metastasize and form new blood vessels. LCA promotes aerobic respiration and mitochondrial metabolism and immune cell activation—both of which can induce apoptosis.

Other secondary bile acids, such as deoxycholic acid (DCA) and ursodeoxycholic acid (UDCA) had no effect on breast cancer cells in the same models [22]. In Miko et al., LCA did not directly induce cell death; however, Luu et al. demonstrated that LCA could induce apoptosis [22, 38]. These conflicting findings highlight the need for more investigation.

Many questions about LCA are still unanswered, and the possibility of utilizing a LCA supplement as a cancer treatment is largely unexplored. As of now, there are very few studies that track lithocholic acid levels alongside gut microflora markers and tumor progression.

Short Chain Fatty Acids

Short chain fatty acids (SCFAs) are released after microbes ferment non-digestible carbohydrates (Figure 5). Acetate, butyrate, and propionate are all examples of microbial metabolic SCFAs [44]. They represent the flow of carbon from the diet, through the microbiome, and to the host. Depending on the context, SCFAs can have either a positive or negative effect on breast cancer. Cancer cells have been shown to selectively use SCFAs for proliferation.

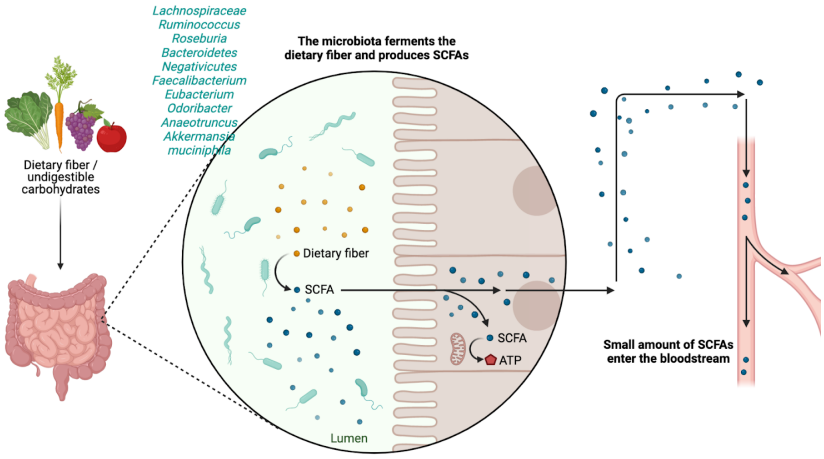

Figure 5. Short chain fatty acids metabolism entering the bloodstream. When indigestible carbohydrates enter the digestive tract, microbes ferment the dietary fibers to produce short chain fatty acids (SCFAs). Some SCFAs are used to produce adenosine triphosphate (ATP), and a smaller proportion of SCFAs enter the bloodstream.

Faecalibacterium prausnitzii, Eubacterium rectale, Roseburia faecis, Eubacterium hallii, Odoribacter, and *Anaerotruncus* are the main producers of butyrate [27]. Butyrate synthesis is diminished in postmenopausal women with breast cancer [36] and can activate T cells and macrophages (Figure 6) [56].

Butyrate can induce apoptosis through inducing mitochondrial reactive oxygen species (ROS) generation (Figure 6) [47]. Some SCFAs, including butyrate, are histone deacetylase inhibitors. Histone deacetylases are a class of enzymes that remove acetyl groups from histones, allowing them to wrap around DNA more tightly [48]. Inhibiting these enzymes can thwart the proliferation of cancer cells by inducing cell cycle arrest or apoptosis (Figure 6) [49]. However, compared to other histone deacetylase inhibitors (such as suberoylanilide hydroxamic acid), butyrate is a relatively weak histone deacetylase inhibitor [73]. Hence, butyrate is not an attractive target for tumor suppression.

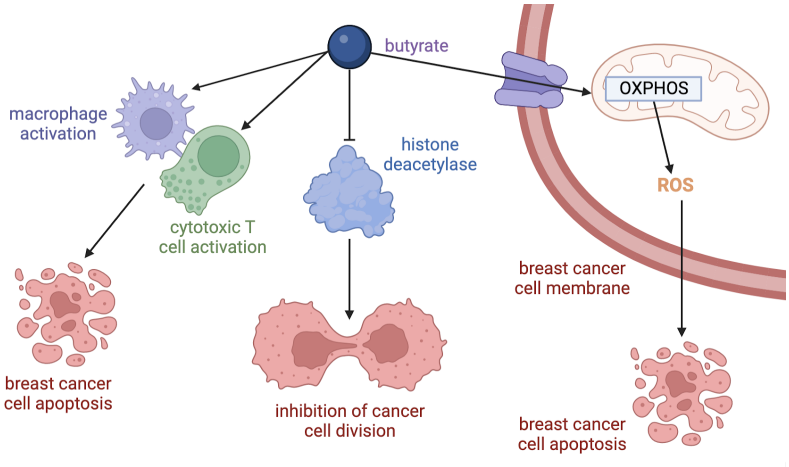

Figure 6. Simplified review of the anticarcinogenic effects of butyrate. Butyrate activates immune cells, including macrophages and T cells. These immune cells induce breast cancer cell apoptosis. Additionally, butyrate inhibits histone deacetylase, which prevents cancer cells from further dividing by preventing DNA replication. Butyrate can also induce oxidative phosphorylation (OXPHOS), a process that produces reactive oxidative species (ROS). ROS contributes to breast cancer cell apoptosis.

The capacity for acetate production is widespread among various bacterial species. Acetate is a source of carbon for histone acetylation. It forms acetyl-CoA, a compound that attaches to the histone, allowing it to unwind. High expressions of ACSS2—the enzyme that transforms acetate into acetyl-CoA—are found in triple-negative and hormone-positive breast cancer [74]. Some aggressive forms of breast cancer upregulate acetate consumption for lipogenesis [74]. However, the research surrounding the presence of acetate-producing bacteria in breast cancer patients is scarce, so the full scope of acetate's effects on tumorigenesis remains ambiguous. Moreover, the transport mechanisms involved in the uptake of acetate are highly debated and largely unexplored.

Although lactic acid—also known as lactate—is not technically an SCFA, it is often grouped together with acetate and butyrate. Two of the most common bacteria that catalyze lactate production are *Lactococcus* and *Streptococcus.* In the breast tissue microbiome, *Lactococcus* and *Streptococcus* are more abundant in healthy women than in breast cancer patients, suggesting that lactate production is decreased in breast cancer patients [11].

Cadaverine

The bacterial enzymes LdcC and CadA synthesize cadaverine from the amino acid lysine [50]. Humans are able to produce cadaverine on their own, but the bulk of cadaverine is created by bacteria. *Shigella flexneri, Shigella sonnei, Escherichia coli,* and *Streptococci* all express cadaverine biosynthetic enzymes [51]. At certain concentrations, Kovacs et al. showed that cadaverine reverted the epithelial-to-mesenchymal transition, inhibited proliferation, and prevented tumor infiltration to the surrounding tissue [51]. Cadaverine has been shown to lower glycolytic flux, although the molecular mechanisms for how this occurs are unclear. The microbiome's capacity to produce cadaverine is stunted in breast cancer [51]. Higher expressions of lysine decarboxylase—the enzyme that converts lysine to cadaverine—are associated with an increased survival rate among early-stage breast cancer patients, underscoring cadaverine's importance in enhancing anti-cancer effects. Kovacs et al. discovered low protein expression of *E. coli* LdcC in the feces of stage 1 breast cancer patients [51]. This observation implies that cadaverine biosynthesis is suppressed in breast cancer. Moreover, cadaverine exerts its effects through the trace amine-associated receptors-1, 2, 3, 5, 8, 9 (TAAR1, 2, 3, 5, 8, 9). Vattai et al. showed that an increased expression of TAAR1 correlates with an increased chance of survival in breast cancer patients [52]. Since then, it has been confirmed that higher expression of TAAR1, TAAR2, TAAR4, TAAR5, TAAR8, and TAAR9 correlated with better survival for breast cancer patients whose tumor cells are ER- [51]. However, the current literature on cadaverine fails to address how cadaverine levels differ between different grades of breast cancer.

Estrogen Reuptake

Estrogen levels have long been recognized as a prime risk factor for developing breast cancer, as 70% of breast cancers belong to the ER+ subtype [53]. The microbiome plays a key role in estrogen reuptake and deconjugation. The liver inactivates estrogens by conjugation, including sulfonation, methylation, and glucuronidation reactions (Figure 7). Bile acids are excreted with the conjugated estrogens into the intestinal lumen (Figure 7). Once they are in the lumen, the composition of the gastrointestinal microbiota determines whether the estrogens will be deconjugated and reabsorbed into the bloodstream or excreted in feces [55]. The collective bacterial genes in the gastrointestinal tract capable of metabolizing estrogens are referred to as

the estrobolome [54]. Goedert et al. showed that in men and postmenopausal women, the gut microbiome was a key determinant of estrogen metabolism [18, 19].

Bacterial β-glucuronidases encoded by the *gus* and *BG* genes are responsible for the deconjugation of conjugated estrogens [36]. *BG* genes are more common in *Bacteroidetes* and *Firmicutes* [57]. The following genuses were shown to express the enzyme β-glucuronidases: *Collinsella, Edwardsiella, Alistipes, Bacteroides, Bifidobacterium, Citrobacter, Clostridium, Dermabacter, Escherichia, Faecalibacterium, Lactobacillus, Marvinbryantia, Propionibacterium, Roseburia,* and *Tannerella* [58]. In 2015, Goedert and colleagues presented strong evidence for the role of *Clostridiales* in estrogen reactivation and showed that the relative abundance of *Clostridiales* increases in breast cancer patients [18, 19, 20]. As reactivated estrogens are absorbed into breast stromal cells, estrogen-evoked changes in the mitochondria were suggested to facilitate carcinogenesis [59]. However, these studies compared postmenopausal women with untreated breast cancer to healthy women. Therefore, they fail to address how estrogen reuptake may fluctuate depending on what treatments the patient is receiving. Estrogen production varies greatly amongst different age groups, so more studies highlighting breast cancer in a wide range of age groups is needed.

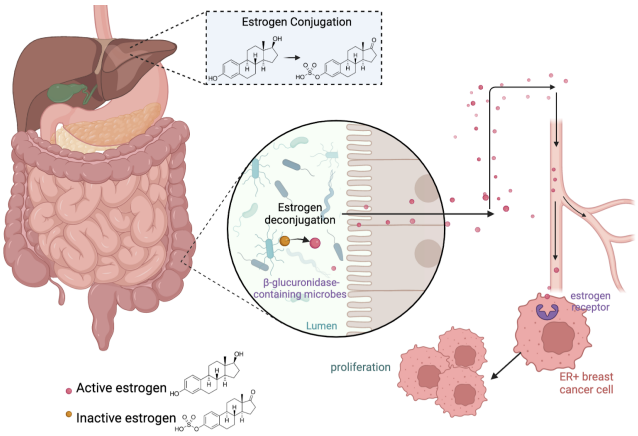

Figure 7. Bacterial enzymes facilitate estrogen deconjugation and enable reuptake for ER+ breast cancer cells. First, estrogen is conjugated in the liver. Then, beta-glucuronidase-containing microbes deconjugate the estrogen molecules. Estrogen is released into the bloodstream. Breast cancer cells take up activated estrogen in order to support proliferation.

Dietary Modifications

The compositions of human microbiomes are attributable to the dietary, environmental, and hygienic behaviors of the host. Despite the immense impact microbes have on breast cancer metabolism, little research has been conducted on harnessing dietary modifications to further enhance breast cancer treatment.

Limiting the intake of ß-glucuronidases with feeding regimens is crucial to maintaining a proper balance of estrogen. Shapira estimated that the increased estrogen bioactivity spurred on by a high-fat diet may result in a 20% increased risk of developing breast cancer [60].

Many studies have extensively reported that a decrease in gut microbiota diversity leads to an increased risk of breast cancer [11, 12, 13, 14, 18]. Regular consumption of fermented foods may present a potential avenue to balancing the dysbiosis causing and caused by breast cancer [62]. Increased consumption of fermented foods that are abundant in probiotics is likely to reduce carcinogenesis risk and improve disease prognosis. Prebiotics promote the growth of microbes, whereas probiotics are live, beneficial microorganisms [61].

One food that is rich in probiotics is kimchi. Kimchi has been observed to have cancer-preventative potential. Chinese cabbage—the main ingredient of kimchi—is considered to have anti-carcinogenic effects due to its abundance of dietary fiber [63]. *Weisella cibaria*, *Lactobacillus plantarum*, and *Pseudomonas aeruginosa* play a large role in kimchi fermentation. *Weisella c.* and *Lactobacillus p.* both produce lactic acid; moreover, *Weisella c.* also produces acetate [63]. Acetic acid is an SCFA that can inhibit breast cancer cell proliferation. Rahimi et al. observed that *Pseudomonas a.* displayed strong cytotoxicity against breast cancer cells [66]. In particular, *Pseudomonas a.* induced p53 gene expression and apoptosis [67].

Another easily-accessible probiotic food is kefir. Kefir is fermented milk with a unique mixture of different microbes, such as *Lactobacillus parakefir, Lactobacillus kefiri, Lactobacillus kefiranofaciens, Lactobacillus kefirgranum,* and *Lactococcus lactis* [68]. In 2006 and 2007, de Moreno de Leblanc et al. published two articles detailing kefir's cytotoxic effects on tumor cells in breast cancer mouse models [69, 70]. Compared to the mice in the control group, the mice that were fed kefir every two days showed a significant decrease in tumor volume. Mice with the two-day cyclic diet supplemented with whole kefir showed increased cellular apoptosis in the tumor twenty days after injection [70]. However, in these breast cancer mouse models, the subjects were immunodeficient. Therefore, these results do not consider how

lactic acid-producing bacteria impact cancer cells in the presence of immune cells. Avoiding unnecessary consumption of antibiotics is also imperative, as decreased diversity in the microbiota has been linked to increased risks of breast cancer [24, 25, 26, 27, 71].

Applications and Future Directions

Breast cancer is a major global health concern. The disease is characterized by microbial dysbiosis in both the gastrointestinal tract and the breast tissue [2, 11, 12, 13, 14]. The nuances and complexities of bacterial metabolites should not be underestimated. Butyrate, acetate, and lactate are all SCFAs, yet butyrate inhibits cancer progression, acetate promotes tumorigenesis, and lactate can accomplish both. Further research into this field in order to clear up misconceptions and contradictions about bacterial metabolites. Scientists have yet to determine to what extent dysbiosis causes breast cancer and to what extent the disease causes dysbiosis. What comes into clear focus are the communications and interactions between gut microflora and metabolites associated with breast cancer.

Dietary modifications are most influential in the early stages of the disease; however, they can improve a patient's outlook no matter the state of their treatment or prognosis [55]. Consuming more fermented foods can populate the host's microbiomes with more lactic acid bacteria, which has been shown to have cytotoxic effects against breast cancer. Maintaining a cytotoxic microbiome is vital to successfully completing chemotherapy [72]. Considering the accessibility and widespread cultural importance of fermented foods, dietary modifications have huge potential in the field of preventing and defeating breast cancer.

Further research into this field is critical. A large portion of the current literature does not single-out specific foods and supplements and their effects on cancer. The mercurial characteristic of the gastrointestinal and breast microbiomes makes this an especially difficult field to study. However, the benefits outweigh the downsides. Understanding the metabolism of breast cancer can contribute to the understanding of breast cancer onset and can propel the development of targeted therapeutic strategies. More researchers should establish both *in vitro* and *in vivo* controlled systems to study the responses of breast cancer cells to microbes and bacterial metabolites. The novel organ-on-a-chip technology has a lot of potential for researchers to design three-dimensional, high-throughput, and controlled systems to track microbiome changes in breast cancer [75]. The gastrointestinal tract, tumor, breast, and liver would be the key organs modeled in such a system. Of course, a lot of research is limited by cost and specialized

skills. Most of the current literature focuses on breast cancer subtypes that are ER+ or HER2+, but only a handful elucidate the relationship between triple-negative breast cancer and microbiota. Moreover, the molecular mechanics of bacterial metabolites (such as butyrate and LCA) anti-cancer effects have yet to be interpreted in detail.

Researchers have only scratched the surface of the connection between dysbiosis and breast cancer metabolism. Through untangling and unmasking this deep, convoluted network, oncologists can exploit this relationship to benefit patients battling breast cancer.

Acknowledgements

I am grateful to all of those with whom I have had the pleasure to work during this project. Without the guidance of Dr. Naama Kanarek and Dr. Sam Barrit, this research would not have been possible. They have provided me with extensive personal and professional guidance and taught me a great deal about scientific research. I greatly appreciate the Cambridge Centre for International Research for cultivating my development as a researcher.

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Using Machine Learning and Crop Simulation Models to Find a Sustainable Alternative to Common Industrial Farming Practice By Arpan Agarwal

Abstract

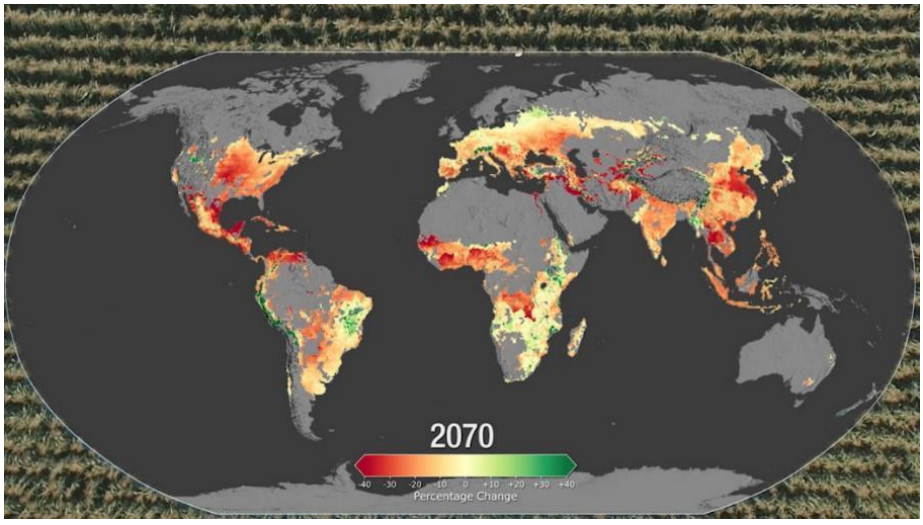
Under modern-day agricultural practices, climate change will reduce corn production in the Midwest USA by more than 20% over the next 30 years leading to devastating economic and social impacts. Therefore, farming must become more resilient towards climate change, and one approach is to abandon the monoculture cropping systems in favor of a sustainable alternative cropping system that preserves land, soil moisture content, and uses fewer nonrenewable resources. This study aims to develop a sustainable alternative cropping system for growing corn in the Midwest, USA by analyzing and comparing previously proposed practices. The study examined and compared the effects of 10 cropping sequences, 2-row spacings, and 5 nitrogen rates, resulting in the analysis of 100 distinct cropping systems. Data was collected from the Agricultural Production Systems sIMulator (APSIM), which simulated 35 years of data on variables measuring the impact on soil quality and crop yield for each cropping system. The data was then analyzed using principal component analysis and data aggregation techniques. The results revealed that the most resilient cropping system was planting corn in a Maize-Winter Wheat cover cropping sequence, with a nitrogen rate of 225 kilograms/hectare, and a row space of either 37.5 or 75 centimeters. This cropping system helped the soil retain more moisture, while also having higher crop yields on average compared to the monoculture cropping system. The findings of this study should provide farmers with more clarity on how to make corn production more resilient towards climate change, a goal that must be achieved.

Introduction

This project seeks to find the best cropping sequence and management techniques to maximize the resiliency of corn production towards global warming impacts and to maximize the sustainability of corn production. According to NASA projections, annual corn production in the Midwest, USA – the highest corn-producing region in the world – could decrease by 30-40% within the next 50 years, due to the effects of global warming [1]. This is because global warming will increase the frequency of extreme weather causing a lot of the land in the Midwest, USA to become very dry and have a lack of moisture, which will significantly impact the

production of corn [1]. This reduction in corn production will have serious implications both economically and on the well-being of people as corn production is a $72 billion industry (USDA) in the United States and is relied upon for a multitude of other food and industrial products such as starch, sweeteners, corn oil, beverages, and alcohol [2]. Ultimately the US economy will lose billions of dollars and many people will lose their jobs and occupations such as farmers and factory workers if corn production decreases according to NASA projections. Therefore, to prevent this there must be a change to many current farming practices for corn production. In addition to not being resilient towards global warming impacts, current farming practices for corn production are also highly unsustainable as according to Cornell University, 140 gallons of fossil fuels are required to grow and produce just one acre of corn [3]. As fossil fuels are a nonrenewable resource that exists in finite supply, this rate of consumption will lead to fossil fuels being fully depleted before they can be replenished. As agriculture as a whole greatly relies on fossil fuels, if fossil fuels are to be fully depleted then overall annual agricultural production will significantly drop, which will send the world into a worldwide famine crisis due to the exponential population growth, which will lead to millions of people dying. Therefore, farming practices for corn production must change to make corn production more sustainable.

Figure 1: This is a map highlighting how climate change will reduce corn production in different parts of the world by 2070. For the Midwest, USA it is 30-40%

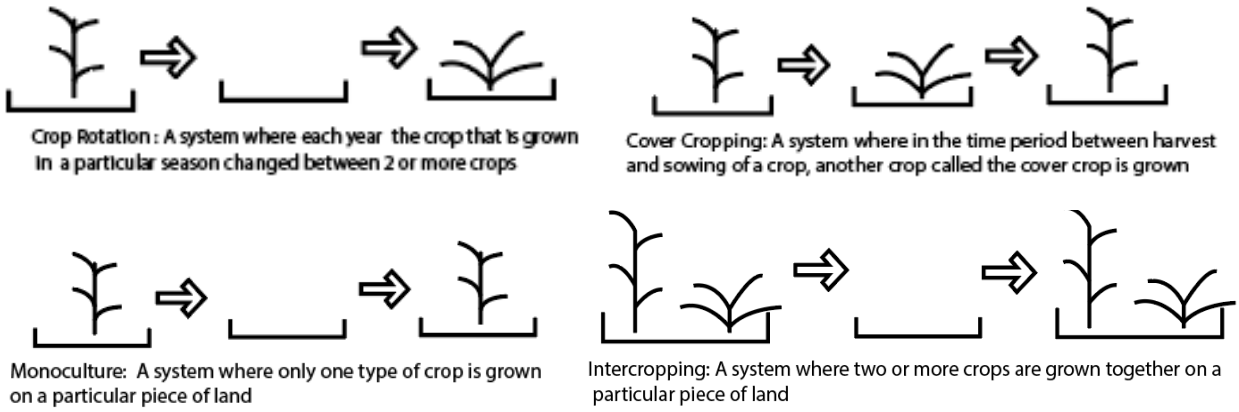


Finding an alternative cropping sequence to the continuous corn (monoculture) cropping sequence would be a potential solution to make corn production more sustainable and resilient towards global warming impacts. The continuous corn cropping sequence is one that grows corn year after year on the same piece of land. The main problem with it is that it consumes a large amount of nitrogen fertilizer, which leads to a large amount of N2O emissions being emitted [4]. Synthetic fertilizer also requires fossil fuels to be made, so consuming large amounts of nitrogen fertilizers leads to more fossil fuels being consumed in the production of corn. Another big problem with continuous corn cropping is that it significantly depletes the quality of soil since corn takes more nutrients and moisture out of the soil than it replenishes the soil with [4]. This makes corn production more susceptible to the impact of global warming because global warming will increase the frequency of extreme weather, and if the soil has a lack of moisture and nutrients it won't be able to withstand the impacts. Farmers also can't rely on continuously finding new farmland as land is a nonrenewable resource with 38.6% of worldwide land already being consumed in agriculture, according to National Geographic [5]. The Earth can't afford to keep creating more land for agriculture. Therefore, to make corn production more sustainable and more resilient towards climate change it is imperative for farmers to stop using the continuous corn cropping sequence and for them to switch to a more sustainable alternative cropping sequence – one that preserves soil quality and reduces fossil fuel consumption.

Encouragingly, there has been a lot of research into finding sustainably alternative cropping sequences for producing corn in the Midwest, USA. The first main alternative cropping sequence is intercropping, which is the practice of simultaneity growing 2 or more crops with a synergic relationship are grown together, and it is practiced because it can help reduce demand for synthetic fertilizers and better preserve the soil quality (Fig. 2). The corn-soybean intercropping sequence, in particular, was found to emit significantly lower N2O emissions than the continuous corn cropping sequence [6]. Other common intercropping sequences for corn are corn-lablab intercropping and corn-perennial grass intercropping. Next, there is crop rotation, which is the practice of sequentially planting crops of a specific growing season in a particular plot, and it is practiced because it can also help significantly preserve the soil quality and demand use of fertilizer (Fig. 2). Common corn crop rotation systems are corn-soybean and corn-oat crop rotation. Next, there is cover cropping, which is like crop rotation, where except for sequentially alternating crops every specific growing season, a cover crop is planted in

between every growing season for corn, which is practiced to prevent soil erosion and preserve soil quality (Fig. 2). Field peas are a common cover crop for growing corn, and it was found that using field peas as a cover crop helps the soil have a higher nitrogen content and carbon content [7]. Other common cover crops for corn are vetch, barley, faba beans, and winter wheat. Lastly, there is the fallow system, where a specific plot of land is left arable every other year so it can recover, store organic matter, retain moisture, and disrupt the life cycle of pests. For management techniques, the first main one is nitrogen rate, which is the amount of nitrogen fertilizer applied on a field. It has been found that higher nitrogen rates such as 300 and 225 kilograms/hectare (Kg/Ha) can be better for getting high crop yields, but lower nitrogen rates such as 0 Kg/Ha and 65 Kg/Ha can be better for maintain the soil quality. There has also been research done into row spacings, which is the distance between rows of crops on a field. For example, Raeann Lyn Huffman from Illinois State University has stated that, "in narrow-planted rows, the rate of photosynthesis can increase due to majority of the sunlight being utilized by the canopy…assisting in an increase in yield potential" [8]. However, he has also stated that "when the row spacing is too narrow it can cause too much competition" [8].

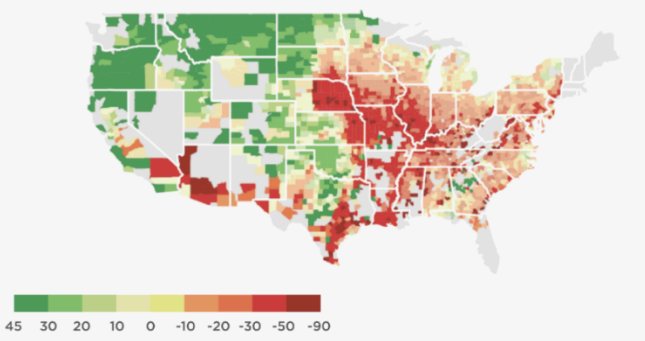
Figure 2: This is a diagram describing all the specific cropping sequences



Despite all this research there has been hardly any research into comparing each of these specific cropping sequences and management techniques and developing/finding one clear specific cropping system – the specific cropping sequence and management techniques used on a piece of land – that is the best for growing corn in the Midwest, USA, considering factors such as growth productivity, environmental friendliness, and sustainability. Due to this, it is hard for

farmers to maximize the sustainability and global warming resilience of corn production since there is a lack of clarity over what cropping sequences and management techniques are the best for this purpose. This project sought to change this by evaluating 10 different cropping sequences, 5 specific nitrogen rates, and 2 row spacings commonly used for producing corn in the Midwest, USA, in order to develop one clear best alternative cropping system through using crop simulation models and machine learning. The findings for this project aim present Midwest farmers with a clear best alternative cropping system for producing corn and help make more farmers switch away from continuous cropping and maximize the sustainability and global warming resilience of corn production. Overall, this project could be a big step forward towards the big goal of sustainable and resilient food production, which is a goal that the United States must achieve for the future of the economy, environment, and society in general.

Figure 8: Map showing how each area in the United States is going to be agriculturally impacted by climate change.



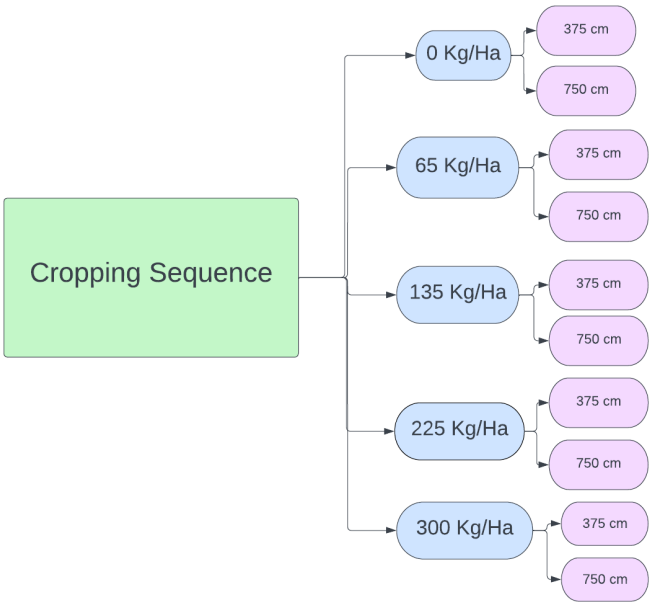
Hsiang, Kopp, Jina, Rising, et al./Science

Methodology

As discussed in the introduction there were 10 cropping sequences, 5 nitrogen rates, and 2 row spacings that were evaluated in this project. Each cropping system was composed of 1 cropping sequence, 1 nitrogen rate, and 1-row space put together. Figure 3, down below shows that for 1 cropping sequence, 5 nitrogen rates, and 2 row spacings there are 10 possible cropping systems. Since there are 10 cropping sequences evaluated, there were therefore 100 distinct cropping systems that this project analyzed. To account for the confounding variable of weather, each cropping system was simulated 3 times per crop model, each time under a different weather

data file. To simulate each scenario and collect data the APSIM (Agriculture Production Systems sIMulator) was used, an internationally recognized platform for modeling and simulating agricultural systems [9]. The model simulates biophysical processes in agricultural systems and accurately predicts crop production knowing climate, genotype, and soil. For this project, the APISM710-r4420 version of the software was used. The DSSAT (Decision Support System for Agrotechnology Transfer) model was also used in this project, which is a model that simulated agricultural systems and collected data on the greenhouse gas emissions emitted throughout each system's simulation [10-12]. For this project, DSSAT Version 4.8 was used.

Figure 3: Diagram showing all the possible cropping systems for one cropping sequence.



For each cropping system, before they could be run and simulated, the models had to be parameterized accordingly. For parametrization, the models had to be parametrized on data about the weather, the soil, and management rules – sowing rules, harvesting rules, fertilizer application, manure application, and tillage – imposed for the specific cropping system being simulated. To parametrize the model DAYMET weather data files) was used where each file contained data about the daily weather in a specific region for the past 30 years. In this study, data about Ames, Iowa weather, northwest Iowa Data, and Southeast Iowa data were used. For the soil data, the USDA WBB Clarion Soil data file was used which contains data about initial

water, soil organic matter, and initial nitrogen contained in the soil. Both the specific DAYMET weather files and USDA WBB Clarion Soil data were found inside the APSIM model software. For management rules literature analysis was conducted to find information about each of the management rules imposed for each specific cropping system being tested [13-21]. Once the models were parametrized accordingly, variables that the model had to collect data on were specified based on the data variables shown in Table 1. The model was then run, and data was collected. These set of steps were repeated for each cropping system being simulated.

Table 1: Table showing all the variables that data was collected on in this investigation.

Variables	Units
Cropping System	No units
Carbon Dioxide (CO2)	Million Metric Tons
Biomass Carbon	Kg/Ha
Biomass Nitrogen	Kg/Ha
Biomass Phosphorus	Kg/Ha
Total Carbon	Kg/Ha
Net Biomass Nitrogen Mineralized	Kg/Ha
Extractable Soil Water	mm
Total Nitrogen	Kg/Ha
Organic Carbon	%
Soil Water Storage	mm
Soil Temperature	Degrees Celsius
Yield	Kg/Ha
Biomass	Kg/Ha
Soil Water	Mm
N2O Emissions	Kg/Ha
CH4 Emissions	Kg/Ha
CO2 Emissions	Kg/Ha

Once the data was collected, data analysis occurred to find out which sustainable cropping system was the best. First, the data was preprocessed and columns that had many missing values were removed. Additionally, labels were added to the dataset that described the cropping sequence, row spacing, and nitrogen rate used by each cropping system. Table 2 shows part of the final preprocessed dataset. Once the data was preprocessed, the data was then aggregated. For data aggregation, the GroupBy function in Pandas library was used where the data was split into groups based on the cropping sequences each cropping system used. Therefore, the data was split into 10 separate groups since there were 10 cropping sequences

evaluated. Each variable in each group was then aggregated down to just one value describing the whole group, by taking either the mean or median value of the variable column. The groups of data were then merged back together in one data frame. Table 3 shows the data aggregation table. After that a bar graph for each variable in the data aggregation table was made, to visually see how each variable's values differed for each cropping sequence (Fig. 6). This data aggregation process was then repeated for both row spacing and nitrogen rates, where the GroupBy function split and aggregated the data based on these 2 parameters just like it did for cropping sequence. Lastly, PCA (Principal Component Analysis) an unsupervised machine learning model was used. This model is a dimensionality reduction algorithm that is useful for clustering and visualizing high-dimensional data such as soil quality since the impacts of each cropping system on the soil was represented by multiple data variables. The PCA model basically states, how similar cropping systems were in terms of their impacts on the soil quality. Cropping systems plotted close together were more similar in terms of their impacts on soil quality, whereas cropping systems plotted farther away from each other were less similar (Fig. 5). Each cropping system was color coded on the PCA plot based on the cropping sequence used in the cropping system. This made it easier to specifically compare the effects of each cropping sequence on soil quality.

Figure 4: Flow Chart summarizing the whole experimental procedure.

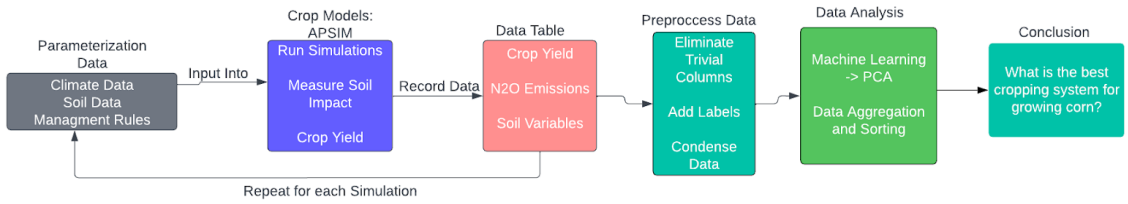


Table 2: Table showing how part of the data looked after preprocessing

	Cropping System	year	Biomass Carbon	Biomass Nitrogen	Total carbon	Total nitrogen	Organic Carbon	Soil Water Storage	Soil Water	N2O emissions	Cropping Sequence	Nitrogen rate	row spacing
0	Continuous Maize (375cm) 0kg fertilizer.csv	1979	1234.4	154.3	132691.1	9235.9	5.634	1.246	1.245	0.000	Monoculture	0 kg/ha	375cm
1	Continuous Maize (375cm) 0kg fertilizer.csv	1980	1728.7	216.1	134063.1	9270.4	5.632	1.239	1.239	0.000	Monoculture	0 kg/ha	375cm
2	Continuous Maize (375cm) 0kg fertilizer.csv	1981	1776.5	222.1	132481.7	9229.7	5.610	1.259	1.259	0.000	Monoculture	0 kg/ha	375cm
3	Continuous Maize (375cm) 0kg fertilizer.csv	1982	2148.4	268.5	132766.2	9260.9	5.610	1.193	1.193	0.000	Monoculture	0 kg/ha	375cm
4	Continuous Maize (375cm) 0kg fertilizer.csv	1983	1866.2	233.3	131664.7	9200.1	5.578	1.218	1.218	0.000	Monoculture	0 kg/ha	375cm
...	...	...	...	...	...	...	...	...	...	...	...	...	...
4668	Maize-Wheat Cover Crop 65kg.csv	2011	2067.8	258.5	122553.7	9523.4	5.164	1.119	0.539	0.488	Maize-Wheat Cover Crop	65 kg/ha	750cm
4669	Maize-Wheat Cover Crop 65kg.csv	2012	1921.8	240.3	122255.7	9488.9	5.149	1.123	3210.858	0.476	Maize-Wheat Cover Crop	65 kg/ha	750cm
4670	Maize-Wheat Cover Crop 65kg.csv	2012	2000.5	250.1	121963.4	9513.3	5.142	1.091	0.527	0.420	Maize-Wheat Cover Crop	65 kg/ha	750cm
4671	Maize-Wheat Cover Crop 65kg.csv	2013	2066.7	258.3	122234.1	9485.2	5.139	0.858	2434.984	0.470	Maize-Wheat Cover Crop	65 kg/ha	750cm
4672	Maize-Wheat Cover Crop 65kg.csv	2013	2217.0	277.1	122061.0	9509.6	5.139	1.227	0.606	0.442	Maize-Wheat Cover Crop	65 kg/ha	750cm

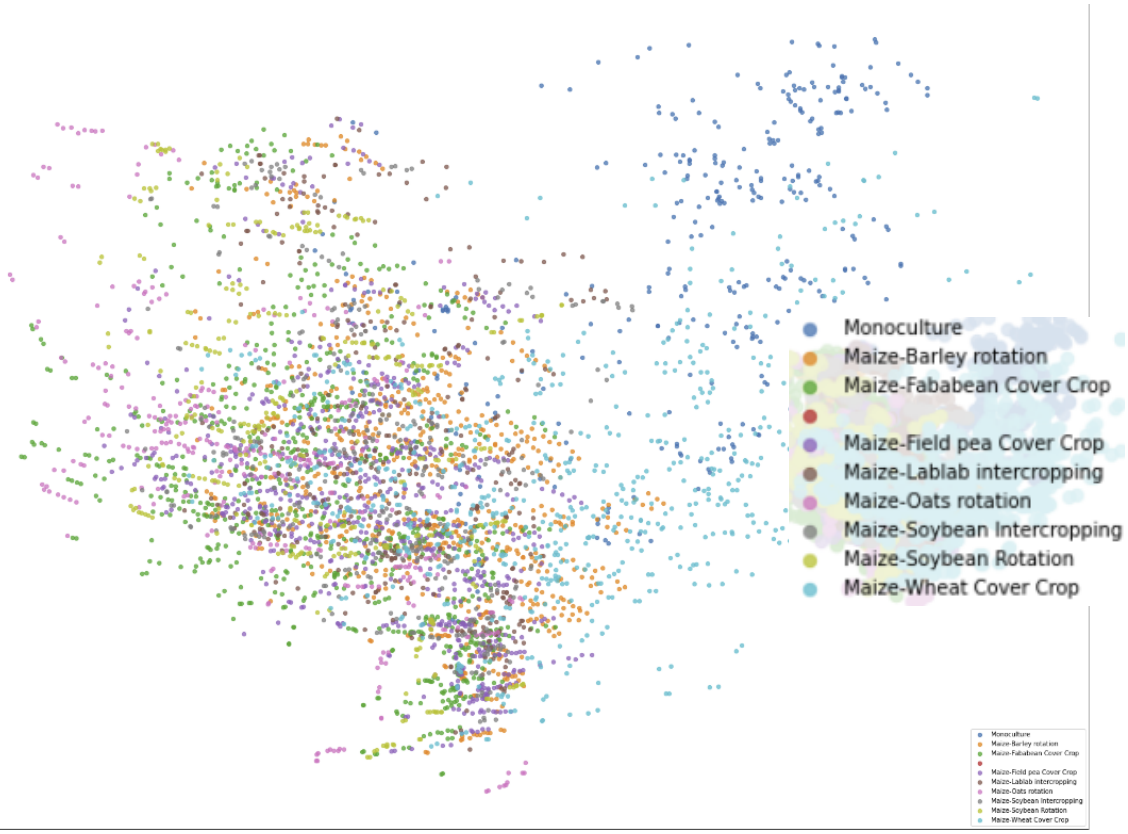
Table 3: Table Showing the combined data after aggregation.

	Biomass Carbon		Biomass Nitrogen		Total carbon		Total nitrogen		Organic Carbon		...	
	nanmean	nanmedian	nanmean	nanmedian	nanmean	nanmedian	nanmean	nanmedian	nanmean	nanmedian	...	nanmean
Cropping Sequence												
Maize fallow	900.881111	885.15	112.611111	110.60	123461.987222	122940.25	9562.361667	9522.60	5.232644	5.2100	...	0.722367
Maize-Barley rotation	1905.312705	1891.20	238.163527	236.40	126755.300676	126969.15	9924.613092	9942.35	5.355482	5.3625	...	0.446078
Maize-Fababean Cover Crop	1418.326352	1439.25	177.290815	179.90	125053.520000	125014.65	9687.578584	9696.30	5.280695	5.2800	...	0.402580
Maize-Field pea Cover Crop	1665.946995	1685.70	208.243399	210.70	126266.558030	126223.45	9784.081478	9790.55	5.318341	5.3160	...	0.408388
Maize-Lablab intercropping	1751.752095	1702.50	218.972857	212.80	127050.151905	127129.30	9829.668190	9837.50	5.360779	5.3630	...	0.756730
Maize-Oats rotation	1107.735645	1093.30	138.469171	136.70	123882.739499	123696.05	9592.743642	9573.60	5.244319	5.2360	...	0.878365
Maize-Soybean Intercropping	1643.576571	1670.45	205.446857	208.90	126143.126714	126154.75	9799.485000	9813.85	5.330659	5.3280	...	0.810756
Maize-Soybean Rotation	1362.022929	1305.50	170.253214	163.15	125393.971429	125298.10	9718.860000	9717.20	5.302671	5.3005	...	0.801662
Maize-Wheat Cover Crop	2637.072837	2485.30	329.636684	310.60	129372.599468	130591.40	10093.968004	10175.40	5.455340	5.5040	...	0.465136
Monoculture	3637.399237	3762.40	454.672545	470.30	133846.337274	133857.40	9498.658341	9490.10	5.625163	5.6370	...	0.002955

Results

Figure 5 shows the Principal Component Analysis (PCA) plot down below for the data, where each dot represents one cropping system impact on soil quality. PCA is an unsupervised machine learning algorithm, used to cluster and visualize high-dimensional data. For this research, it was used to cluster cropping systems based on their impact on soil quality. On the PCA plot, each cropping system is color-coded based on the cropping sequence it implemented. The PCA plot shows that most of the cropping sequences had similar impacts on the soil quality compared to one another since a lot of the cropping sequences are tightly clustered together, especially in the middle-left section of the plot. The only cropping sequences that had somewhat unique impacts on the soil quality are corn-wheat cover cropping and monoculture (continuous corn cropping) cropping sequences since they are further apart and separated from the other cropping sequences. These results were very helpful for simplifying the whole final analysis process as discussed later.

Figure 5: PCA plot of the Northwest Iowa Weather Aggregated Data. PCA plots for other weather data followed a similar pattern



For my final analysis of cropping sequences, only 3 cropping sequences of Monoculture (continuous-cropping), Maize-Wheat Cover Cropping, and Maize-Faba Bean Cover Cropping were analyzed. The Monoculture and Maize-Wheat Cover Cropping were analyzed since they both made somewhat unique impacts on the soil quality as shown by the PCA plot. The Maize-Faba Bean Cover Cropping was analyzed since it had the highest crop yield. All the other cropping sequences had similar impacts on the soil that Corn-Faba beans cover cropping had (shown by PCA plot), but less crop yield as well as higher N2O emissions, so there wasn't a need to analyze them in depth. To find the best cropping sequence, bar graphs were made for each variable in the data aggregation table (table 2), which is shown in Figure 6 and a table that listed the pros and cons of each of the 3 cropping sequences was also made which is shown below. Based on the pros and cons of each cropping sequence, it was concluded that the Maize-Wheat Cover Cropping system is the best cropping sequence for growing corn since it allows the soil to retain high moisture, allows the soil to retain decently rich content of carbon and nitrogen, emitted small amounts of N2O, and lead to decent production in crop yields. The other 2 cropping sequences have major flaws, such as the Monoculture cropping sequence making the soil have bad water retaining efficiency and moisture as well as high N2O emissions, and the Corn-Faba Bean cover cropping sequence leading the soil to not be rich in nutrients.

Figure 6: Figure showing the bar graphs made based on each variable in Table 2. Yellow is Maize-Faba bean cover cropping, blue is Maize-Wheat cover cropping, and green is monoculture

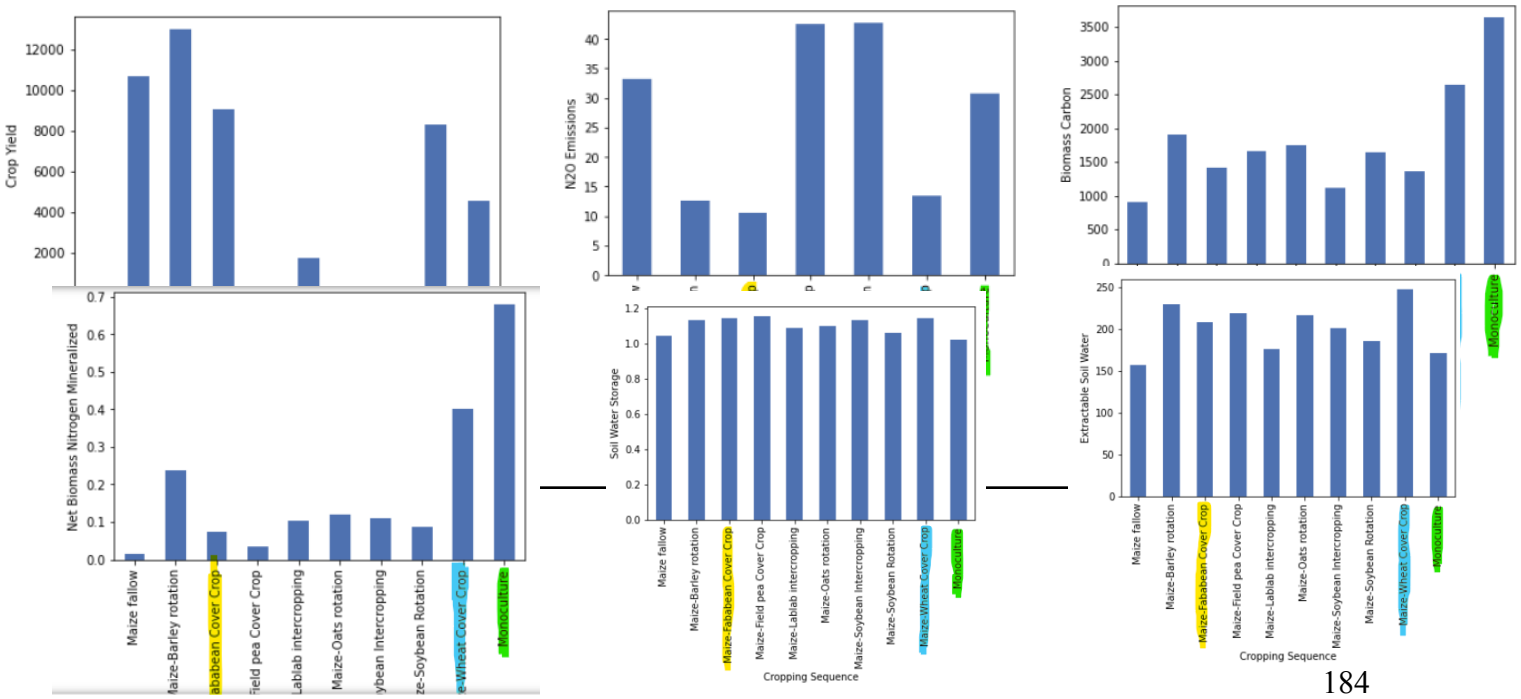


Table 4: Table showing the pros and cons for each of the 3 cropping sequences.

Summary	Monoculture	Maize-Winter Wheat Cover Crop	Maize-Faba Bean Cover Crop
Pros	• High carbon quantity in soil • High nitrogen quantity in soil • Low N2O emissions	• Decent carbon quantity in soil • Decent nitrogen quantity in soil • High soil moisture • High water retaining efficiency • Relatively low N2O emissions	• Highest Crop Yield • Average/Low N2O Emissions • Decent soil moisture • Decent water retaining efficiency
Cons	• Low soil moisture • Low water retaining efficiency. • Mediocre crop yields • High N2O emissions	• Relatively high CO2 emissions	• Low carbon quantity in soil • Low nitrogen quantity in soil •

Next the different nitrogen rates were analyzed, where bar graphs were made for each variable in the nitrogen rate data aggregation table. Looking at the bar graphs there was a general trend that as the nitrogen rate increased, crop yield, soil carbon content, and soil nitrogen content increased. However, as the nitrogen rate increased soil moisture and soil water holding capacity, tended to decrease and N2O emissions tended to increase. Therefore, it was concluded that a nitrogen rate of 135 Kg/Ha is the best since it is the balance of all the extremes that allows farmers to have decent crop yield, soil nitrogen content, soil carbon content, soil moil moisture,

water holding capacity, and not too high N2O emissions. However, if the crop yield is very important to keep high, then 225 Kg/Ha is also an acceptable nitrogen rate. Lastly, the 2 different row spacings were analyzed. It was concluded that there was no significant difference between either row spacing and that either is acceptable.

Figure 7: Figure showing all the bar graphs made based on each variable in the data aggregation table of nitrogen rate.

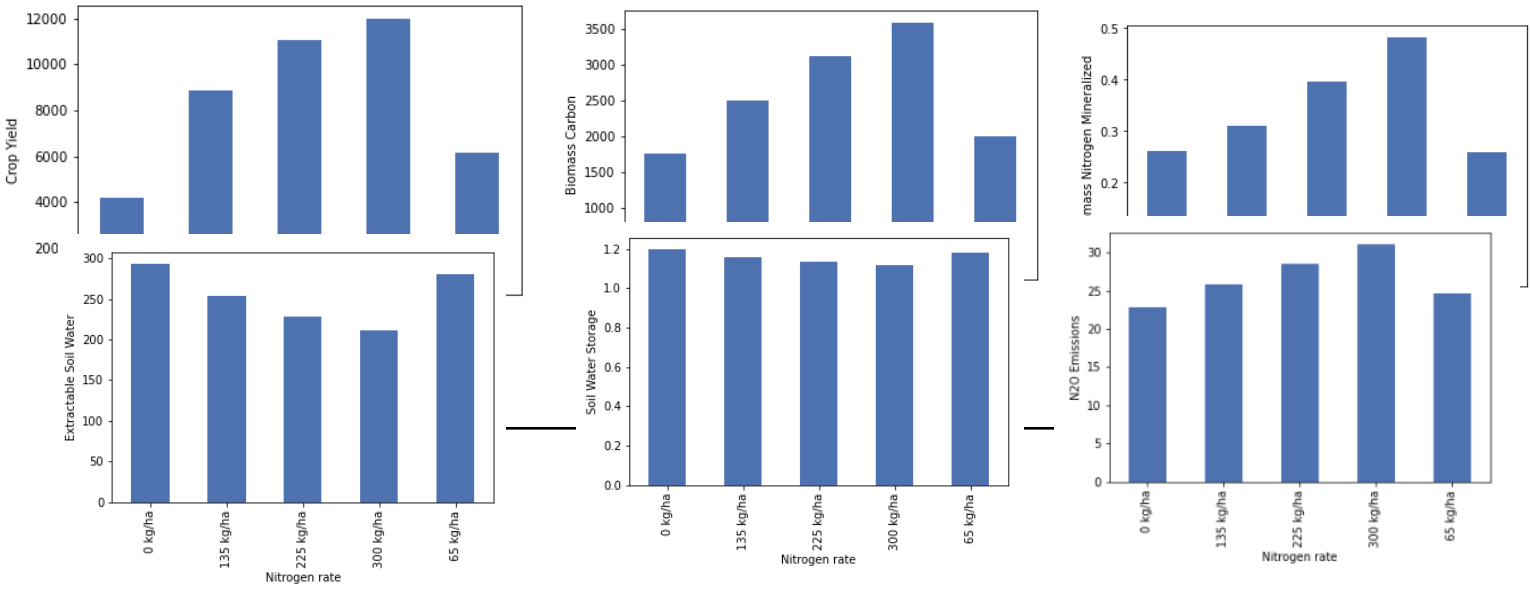


Table 4: Table Showing the pros and cons of the nitrogen rates of 0, 135, and 300 Kg/Ha

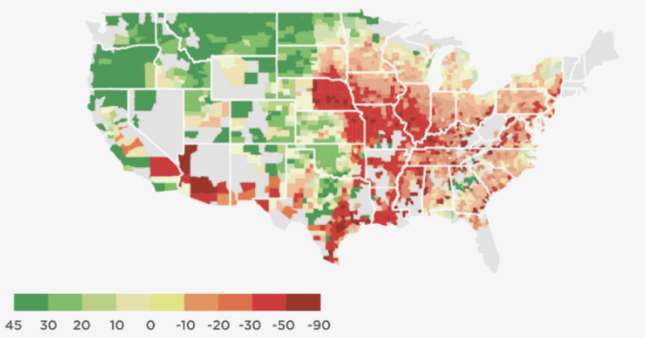
Summary	0 Kg/Ha	135 Kg/Ha	300 Kg/Ha
Pros	• High soil moisture • High water retaining efficiency • Low N2O emissions	• Decent soil moisture • Decent water retaining efficiency	• High carbon quaintly in soil • High nitrogen quaintly in soil • High Crop yield • High N2O emissions

		• Moderate N2O emissions	
Cons	• Low carbon quantity in soil • Low nitrogen quantity in soil • Low crop yield	• Moderate carbon quantity in soil • Moderate nitrogen quantity in soil • Moderate crop yield	• Low soil moisture • Moderate/low water retaining efficiency

Conclusion/Discussion

After conducting the final research and analysis, it can be concluded that the best sustainable and global warming resilient cropping system for growing corn in the Midwest, USA was a cropping system that implements a corn-winter wheat cover cropping sequence, uses a nitrogen rate of 135 kg/ha or 225 kg/ha, and either a row spacing of 37.5cm or 75cm. This cropping system is significantly more resilient to the impacts of global warming as it is significantly better for retaining the long-term moisture of the soil. This is demonstrated by the fact that this system had an extractable soil water content that was 90mm higher than the mean extractable soil water for fields that implemented a continuous cropping sequence. As shown by the map below, the land in the Midwest is going to be extremely dried out and therefore it is essential for farmers to implement a cropping system that allows the soil to retain high moisture [22]. This system is also highly more sustainable as its crop yield is 1900 kg/ha higher than the mean crop yield of fields that implanted a continuous cropping sequence, and its N2O emissions were 17.28 Kg/Ha lower than the mean N2O emissions of fields that implemented a continuous corn cropping sequence. The future for this project is to verify these results on the field and spread the message to farmers.

Figure 8: Map showing how each area in the United States is going to be agriculturally impacted by climate change.



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Acknowledgments

I would like to express a special thanks to my mentor, Deirdre Griffin Lahue, who helped me a lot during the duration of this research project. She really helped me complete this project and learn a lot which I am very thankful for. I would also like to express gratitude towards Dr. Kyungdahm, who provided me with valuable resources and advice about crop modeling. I would lastly like to express great appreciation to my high school research teacher, Mrs. Allender, who provided me with valuable guidance, feedback, and support throughout the whole process.

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Introduction to Game Theory By Amudhan Gurumoorthy

Abstract

From cards to stocks, game theory continues to be a huge aspect of the world today. However, game theory continues to be neglected today. Lots of people believe that game theory has no applications to real life, even though it is the complete opposite. Many people do not even have a good understanding of what game theory is.

This review paper will correct that, providing a basic explanation of the complexities behind game theory. First, I will introduce game theory and talk about some important definitions. Then, I will provide an example of an interesting game within game theory (Nim), with some winning strategies, and finally, I will talk about some of the many applications of game theory.

1. What is Game Theory?

Game theory is the analysis of strategies for reacting to different scenarios. It allows for analyzing the best possible way of solving a problem, or the best way to deal with something huge. It can be both in a small little game, or an implication in the real world.

Game theory has constantly been a major topic in mathematics, as it allows for very interesting problems to be made. Some of these problems have extreme real life implications, especially with predicting human behavior. Although that may seem unpredictable, a part of human behavior that can be predicted is the extent to which an individual will focus on themselves, rather than a group. We will talk about this later. Game theory also has economical applications, especially when identifying when to do a specific interaction. It can be crucial to predict a stock's movement, which helps determine whether to buy it or not. We will also talk about economical applications later. For now, let us briefly look at the different aspects of a game: the things necessary to make a game function well.

Aspects of a Game

There are many different things that are necessary in a game. Let us take a look at a few of those aspects.

Players

Obviously, players are key to a game. Without people to actually play a game, the game wouldn't be played.

A game could be played with one player. There are plenty of games where it is just one player vs. everyone else. A good example of that is Solitaire. Only one person plays it, but they have a goal that they must achieve; they must order each of the suits from Ace to King.

Two player games are usually the most common games studied by game theorists. They are usually 1v1s, where each player takes turns until one of them wins. A good example of this is checkers, where one player plays black, and the other plays against them with red.

Three or more player games are also quite common. These games may involve a few people targeting one player, two different teams of equal players, or every man for themselves.

The different players in a game can often be seen as a set (1,2,3,4...n), with n many players playing the game (Mycielski 1992). If there is a specific order, then player 1 goes first, followed by player 2, and so on up until player n.

Players are a very important aspect of different types of games. However, they need something to make themselves useful: actions.

Actions

Obviously, actions are extremely important in games. Players are important, but without anything for a player to do, a game cannot really occur.

Similar to players, actions can also be seen as set $A = (a_1,a_2...a_n)$, but it changes every turn, based on the action the other player(s) did on the previous turn. For example, in a game such as chess, if White plays a check, Black cannot play whatever they want. They have to play a move to stop the check, by either moving the king, taking the piece that is checking, or blocking the check (Mycielski 1992).

There may be many actions, which the player must choose from, one forced action, or no actions at all, which is called a dead end. For example, a checkmate in chess is a dead end, because the player cannot do anything to stop the king from being taken next turn.

Outcomes

Other than actions, another thing that occurs in games are outcomes. Every action ends with a specific result, but depending on the game, the results may be different.

For example, in chess, there are three different outcomes: White wins, Black wins, or they both draw. Every single possible set of actions will always end up with one of these three scenarios happening. Of course, there are different ways to reach these scenarios. For example, when drawing, it could either be an agreed draw, a stalemate, insufficient material, etc, and for one of the sides winning, it could either be resignation, checkmate, time running out, etc.

Outcomes can also be written as a set $B = (b_1, b_2 ... b_n)$, with n possible different outcomes. Each of these elements in the set is a way by which a game can end, not necessarily who wins or if they draw (Mycielski 1992).

Now that we have finished talking about outcomes, there is one more thing that we have to talk about: strategy.

Strategy

Finally, every single player must have some sort of strategy in a game. The strategy may just be picking up random cards or moving random;y, but usually, there is something much better than that.

Each and every person should have a strategy. There is also one person who may have a winning strategy, which means that no matter what the other players do, that player will always be able to win.

Again, strategy can be written as a set $S = (s_1, s_2 ... s_n)$, where each s is a strategy for a single player (Mycielski 1992).

Together, players, actions, outcomes, and strategy define a game. These things are all crucial to make a game functional, and without one of these things, the game would not exist anymore. Now that we have given a brief introduction on game theory, let us talk about some

different aspects of game theory, and, more specifically, the topic of perfect information games.

2. Game Theory in Perfect Information Games

Perfect information games are one of the more basic but very important concepts of game theory. It is basically defined as a game where both people know everything that is going on and every possible move they can make. In other words, it basically means that every move made is done while knowing everything that the other player has done up until then (Muskalla 2019).

For example, chess or Go are good examples of a perfect information game, because each player knows all the moves that have happened before their move. There are no things that are unclear about the game, so making a move is fully based on strategy. Meanwhile, Poker is not a perfect information game, because you do not know for sure what cards other players have, meaning you do not know all of the information in the game.

There are a few things that are important with perfect information games. Let's take a look at them.

Nash Equilibrium

In perfect information games, since each player knows what is happening in the game, more interesting strategies can be developed. Nash Equilibrium occurs when one player cannot change their strategy to benefit themselves. This does occur quite commonly. If one player plays a certain move, the other person cannot do anything but just do the same strategy.

For example, take a game of tic-tac-toe. If the first person takes the center, the second takes the bottom right corner, and the first takes the top right corner, player 2 must take the bottom left. No other strategy will work. This forced player 1 to take the bottom middle, then player 2 to take the top middle, and so on. Each move is forced in this scenario, which makes this a Nash equilibrium, as no player can use multiple strategies. In the end, this game will end in a draw, as no player will be able to make three in a row.

Nash Equilibrium occurs in quite a lot of games. Now, let us look at another game type that is common as well, which is a zero-sum game.

Zero-Sum Game

A zero-sum game is a game where when one person gains something, another person must lose the same amount as well. There is no joint winning, and no joint losing. It all balances out, ending up at zero.

An example of a zero-sum game is rock paper scissors, where the winner gets a dollar from the loser. If they draw, no one gets anything, so it stays the same. If one person wins, however, the loser is forced to give the winner a dollar, so while one person gains a dollar, the other player loses a dollar, balancing the amount of money out.

Zero-sum games are very common. It's very rare for a person to gain without another person losing something, because otherwise, that game has an external source players should give and take money from. That doesn't happen too commonly.

Nonetheless, zero-sum games are important to game theory, as they are the most basic way to represent what occurs when a player wins and loses. They can help identify what the winning strategy is for a person in a scenario.

These definitions are important when it comes to perfect information games. Now that we have the basics of perfect information games, we will look at an example game that utilizes important aspects of game theory. This game is none other than the game of Nim, one of the most interesting games in game theory whose strategy has been determined.

3. The Game of Nim

Nim is one of the very first games to be implemented on a computer. It is a very famous two-player perfect information game. This game was first solved by Charles Bouton in 1901, who ended up determining when Player 1 and Player 2 can win the game, and their strategy to do so (Friedman and Landsberg 2022). Let us start by talking about the game itself, and then we shall talk about the winning strategy.

The Rules of the Game

There are different piles, each with a random amount of coins in them. Player 1 chooses a pile, and takes however many coins they want to. Player 2 then chooses a pile, and

takes however many coins they want to as well. This process keeps on repeating, until all of the piles have no coins in them. Then, the person who took the last coin wins the game.

Example

For example, let there be three coins in the first pile, two coins in the second pile, and five coins in the last pile. This can be written as (3,2,2,5), where each comma separates a pile of coins.

Player 1 takes two coins from the first pile, turning the amount of coins (3,2,2,5) → (1,2,2,5). Then, player 2 takes all the coins from the third pile, and player 1 takes two from the last pile, player 2 takes all the coins from the second pile, and player 1 takes one from the last pile, turning the piles into:

(1,2,2,5) → (1,2,0,5) → (1,2,0,3) → (0,2,0,3) → (0,2,0,2)

Player 2 takes two from the last pile, allowing player 1 to take the last two from the second pile. Since player 1 took the last coin, they have won the game.

Now that we have seen an example, let us talk about one of the basic concepts of Nim: the concept of symmetry.

Symmetry

Obviously, symmetry is bad for a player. If left with a symmetrical board, whatever one player does, the other player can just match, and the first player will lose every time.

Example

Let the number of coins be (3,5,5,3). If player 1 takes two from the first pile, player 2 can just match and take two from the last pile, turning it to (1,5,5,1). If player 1 then takes one from the third pile, player 2 can take one from the second pile, making it (1,4,4,1). Player 2 can continue doing this, matching player 1, until the very end, where player 2 will be left with one pile with coins, which will give them the win.

So, symmetry is a bad thing, and should be avoided at all times. However, a strategy a player can take is to force the other player into symmetry.

Forcing Into Symmetry

First, let us think about two different piles: (c_1,c_2), with $c_1 > c_2$. Player 1 can take $c_1 - c_2$ coins from player 2, which forces the piles into symmetry: (b, b). This inevitably forces player 2 to lose, and thus, player 1 to win.

Now, let us look at three different piles. When two of the piles have the same amount of coins, player 1 should take all of the coins from the third pile. This creates symmetry that player 2 wants to avoid, and gives player 1 the win.

This symmetry is not just true for two or three different piles: it works for n many piles. If all the piles except one or two can be paired to have unique pairs of piles with the same amount of coins in them, Player 1 will always be able to win. If there is one pile remaining without a pair, the player can just take everything in that pile. If there are two piles left that do not have the same number of coins, the player can take just enough to make those two equal.

Now that we have gone over the basics with symmetry, we will now focus on something else entirely: how to develop the strategy of winning for each player.

Nim Sum

First, before any proof, we need to talk about Nim Sums, also represented as NimΣ. Let (c_1,c_2,c_3,...c_n) be the n many piles in the grid (this is called a *state*). Find the binary representation of each pile. For example, If c_1 was 5, its binary representation is 101. Then, define c_{ij} to be the j-th bit in the binary representation of i. Take the $\sum_{n=1}^{i} c_{ij}$ for all j.

Example

Let the coins be arranged in the order (5, 6, 2, 9). The binary representation of each of these is (101, 110, 10, 1001)

$$\begin{array}{r} 0\ 1\ 0\ 1 \\ 0\ 1\ 1\ 0 \\ 0\ 0\ 1\ 0 \\ +\ \underline{1\ 0\ 0\ 1} \\ 1\ 2\ 2\ 2 \end{array}$$

Therefore, the Nim sums of this sequence, also represented by NimΣ(c_1,c_2,c_3,...c_n), are (1, 2, 2, 2), for j = 1,2,3, and 4, respectively.

A state of coins is considered *balanced* if all of the Nim Sums are even, and *unbalanced*. So, the sequence above is unbalanced, because although three of the sums are even, the fourth one is odd.

Why does this matter? It will help to create a strategy for each player's path to win, and when they can win. However, before doing this, we will need to prove three different lemmas that will be critical to seeing when each player can win.

Three Useful Lemmas

Lemma 3.1: *Let* $(c_1,c_2,c_3,...c_n)$ *be a balanced state. There is no possible move that will turn this state into (0, 0, 0, ... 0).*

Proof: Since the state (0, 0, 0, ... 0) is already in its final position, there is no move that will turn it into (0, 0, 0, ... 0). Therefore, we do not need to focus on that case.

The only way the state $(c_1,c_2,c_3,...c_n)$ can go to (0, 0, 0, ... 0) on one move is if there exists only one number $i \leq n$, such that $c_i \neq 0$. Therefore, we only need to prove that there exists another number $j \neq i$ such that $c_i \neq 0$ as well.

If $c_i \neq 0$, then its binary **must** contain a 1 in at least one position (ie. at least one bit (call it m) must be 1). However, since every other pile is 0, the sum of the m-th bit in each stash is 1. The definition of a balanced set is that every Nim sum is even, but since the m-th bit is 1, which is odd, this is not a balanced set. There must be another coin stash that isn't zero in order to make this balanced, which proves that in a single turn, a balanced set cannot go to (0,0,0,... 0). □

Lemma 3.2: *Let* $(c_1,c_2,c_3,...c_n)$ *be a balanced state. Any single move from this state will turn it into an unbalanced state.*

Proof: Every binary value is different. No string of 0s and 1s will produce two different outputs. Call c_i the pile which a move will be done upon. Since this pile changes, at least one digit will change from 0 to 1, or 1 to 0. Call that digit the j-th bit.

The state before was balanced, which means $\text{Nim}\Sigma(c_1,c_2,c_3,...c_n)_j$ was even for the j-th bit. Call that sum $2k$, where k is a natural number. However, since c_{ij} (the j-th bit of c_i) changes by 1, and no other j-th bits change, $\text{Nim}\Sigma(c_1,c_2,c_3,...c_n)_j$ turns to either $2k - 1$ and $2k + 1$, which is odd. This means this is no longer balanced, proving our lemma. □

Lemma 3.3: *Let* $(c_1,c_2,c_3,...c_n)$ *be an unbalanced state. It is always possible to turn it into a balanced state.*

Proof: Since this state is unbalanced, the Nim sum of at least one bit is odd. Call all of the odd bits $(j_1,j_2,...j_m)$, and call the furthest bit to the left that is odd (the highest place value bit) j_{max}.

Since j_{max} is odd, there exists at least one i such that $c_{i\,j\,max}$ is 1. Take that c_i, and change $c_{i\,j}$ to 0. Then, for all j_k where k is a natural number such that $k < m$, change the bit $c_{i\,jk}$. If it is 1, change it to 0, and vice versa. That means that all of the odd bits will either be added or subtracted by 1, which turns it to even. This new value is smaller than c_i, since the biggest digit that was changed ($c_{i\,j\,max}$) went from 1 to 0, so everything under it, even if they all changed from 0 to 1, would be insignificant compared to that. Thus, all of the Nim sums are even, making it balanced. □

This may be a bit confusing, so let's look at an example.

Example: (6,7,11,12)

The binary representations of these numbers are (110,111,1011,1100). Then, taking the Nim sums result in (2,3,3,2) The greatest bit that is odd is the 4s digit (third from the right), so that is our j_{max}. We can take any of the c_i's that have $(c_{i\,j\,max}) = 1$, but without loss of generality, take 1100. We change the second 1 to 0, as that bit is odd (3), and then we change the first 0 to 1, as that bit is odd as well (3). This turns 1100 → 1010, and turns the Nim sums to (2,2,4,2), all of which are even, making it balanced. Therefore, the move that will change it to balanced is taking the 2 coins from the pile with 12 in it.

Now that we have proven these three lemmas, it's time to prove when the first player has a winning strategy, and when the second player has a winning strategy.

Solving Nim

Theorem 3.4: *The first player will win in a game* $(c_1,c_2,c_3,...c_n)$ *if and only if it is in an unbalanced state.*

Proof: By Lemma 3.3, the first player will be able to change it to a balanced state. By Lemma 3.1, there is no way to change it to (0, 0, 0, ... 0). In other words, there is no way to take the last coin if it is in a balanced state. Therefore, the second player will not win the game on this turn. By Lemma 3.2, they will be forced to change the game to unbalanced.

Then, player 1 can change it back to balanced, by Lemma 3.3. This process will continue happening. The second player will never be able to change it to (0, 0, 0, ... 0), meaning that the first player will always win if it is unbalanced.

Now, let us prove the converse. If the game is balanced to start, by Lemma 3.3, the first player is forced to change it to unbalanced, and the second player can just follow the same strategy that the first player did. They will then be able to win. Therefore, player 1 only wins when the game starts in an unbalanced state, which proves our claim. □

That is all of Nim's strategy in a nutshell. We have shown when each player wins, and their strategy to do so. Now, let's look at some real-life applications of game theory.

4. Game Theory in the Field of Economics

Now that we have talked about a few important examples of games, let us now move on to some examples in real life. Game theory may seem like something useless, but in reality, it is extremely important in a lot of aspects of life.

One of the most important ways that game theory is implemented in real life is through economics. There are so many different ways that game theory is used in the field of economics. Let's take a look at a few of those.

Negotiations

When negotiating, game theory is constantly used to arrive at the perfect solution that pleases both sides.

For example, during a strike, unions and management can try to work together to reach the optimal solution. Wages can be raised by enough to support the workers, but not too much to where the higher people aren't satisfied as well.

Products

Certain products can be very important to a company, depending whether or not they do really well in the market. However, the timing of the product release is very important. Game theory can be very important in determining when a product should go into the market. It can be incredibly useful to send the product into the market if interest in the product is high, while not sending it in if interest in the product is low. Being wise about when to send a product into the market could be the difference between failure and success (Upjourney 2021).

Stocks

Managing stocks involves a lot of game theory. Although stocks rise and fall somewhat randomly, predicting stocks can be achieved. Using these stock predictions, a person can wisely decide where to spend their stocks (Upjourney 2021).

Also, in options trading, game theory can be used wisely. An options writer must be wise when determining how much they want to buy the stock for. If they believe that the stock value will go up, or stay high enough for them to earn a profit, then they can go through with it. Otherwise, they either raise the price of buying the stocks, or just fold entirely.

The same applies to the person who is selling their stock. If they believe that the stock value is going down, then they should buy ”insurance” by selling it to an options writer. Otherwise, they can keep the stock, to sell it for a profit.

Game theory is crucial when it comes to saving money in the stock market. To make a profit, people must carefully find the stocks that would rise the most, while keeping careful in case of a stock crash.

As you can see, game theory is incredibly important when it comes to the economy. There are certainly way more examples than the three I talked about right here, showing how important it truly is. Now, let us talk about some more applications of game theory, but through some interesting problems.

5. Different Game Theory Problems and Their Application to the Real World

The games in game theory may seem like they have no real value in the real world. However, in explaining different scenarios, and what rises due to choices in these scenarios, game theory suddenly becomes critical. Let’s take a look at some of the most famous problems involving game theory in real life.

The Prisoner’s Dilemma

While The Prisoner’s Dilemma is not a perfect information game, it is one of the, if not the, most complicated and interesting scenarios in the real world involving game theory. Although the story itself may sound basic, this is something that is constantly seen in the real world.

What is the Prisoner's Dilemma?

While the Prisoner's Dilemma has different scenarios, this is the most common one:

Two criminals have been convicted of murder. It has been decided that they should each spend 15 years in prison. The judge, rather than just putting them both in jail, plays a cruel and interesting game with them. The two criminals will each be put in a box, with two buttons facing them saying "Split" or "Steal". Without talking to the other person, they must each select one of the buttons.

If they both select Split, they will each spend 15 years in prison. If one person selects Split and the other selects Steal, the person who selects Split will have to take on both criminals' prison sentences, and stay for 30 years. On the other hand, the person that selected Steal will walk away rent-free, and not have to spend any time in prison. However, if they both select Steal, their prison sentences will be extended to 25 years each. What do each of them decide to do?

Strategy

It may seem obvious for both of them to split; after all, it would only be 15 years in prison, which, compared to something like 25 or 30 years, is alright.

However, it is not as simple as that. Both of these people are criminals, which means that they are greedy. They are okay with putting the other person in jail for longer, if it means that they don't have to spend any time in prison. So, in that case, they should pick to steal. So, what does game theory say for them to do?

This is where it gets very interesting. Without loss of generality, look at it from prisoner 1's point of view. If prisoner 2 decided to split, then if prisoner 1 split, they would get 15 years, but if prisoner 1 steals, they get no years. Therefore, it would be ideal to steal in this case.

However, what happens if prisoner 2 steals? If prisoner 1 splits, they have to stay for 30 years, but if they decide to steal, they only have to stay for 25 years. That means that the ideal for them in this case is to steal as well.

Since it is better for prisoner 1 to steal in both cases, they would choose to steal. However, prisoner 2 has been thinking the same things as prisoner 1 and chooses to steal as well. That means that both criminals have decided to steal, which means an extra ten years in prison for them. They have to stay for 25 years each.

Not only that, but if they had some sort of friendship or good relationship, it may have soured if they have both decided to steal. One of them would be shocked that the other would have chosen to steal and forced them to stay for longer in prison, and vice versa.

It may seem strange that the ideal strategy is for both of them to steal and spend 25 years in prison, when there is an option that betters it for both of them (both splitting and only spending 15 years in prison). However, if one of them were to choose to steal rather than to split, they would benefit, spending no time in prison compared to 15 years. That is why they would choose to steal, even though in the long run, it negatively impacts them.

Applicability in Real Life

This prisoner's dilemma may sound very niche, and it might not seem applicable to real life, but in reality, it shows something that has been seen for a very long time: people choosing for their individual gain rather than a group gain. Both of these prisoners are looking out for themselves, which is why they both chose to steal. However, if they were looking out for the good of the group, then they would both choose to split.

This is something interesting that was proposed by a man named John Nash. He realized that if everyone were to look out only for themselves, it would not benefit the good of the group. However, if everyone was looking out for the best interests of the group, rather than themselves, then it would be better for everyone, including the individual.

Individual selfishness occurs a lot of the time. Whether it be something as small as taking the last candy bar rather than splitting it with their sibling, or something as big as forgery, people choosing themselves over others has become predictable. Choosing for the group can benefit an individual much more than choosing for themselves, and this problem is a great example of that. Now, let us look briefly at another problem: The Fair-Division Problem.

The Fair-Division Problem

This problem is very easy to understand. It is just a simple question: How do you divide resources fairly across different people?

What is ”Fair”?

While this problem may seem easy to understand, it is certainly more complicated than that. This is because each person has a different idea of ”Fair”. Similar to the last problem, people want to try and get as much as possible. They believe that they contributed a lot, so in return, they should get a lot as well. The type of ”fairness” shown here is called ”subjective fairness”, because it is different for each person (Inigo et al 2022).

This creates a problem, because every single person wants their ideal share of the resources gained. This leads to arguments on who gets to keep the most, and that is why this problem is so hard to solve. Negotiations are complex, because people value things at different rates. Let us take a look at that.

Valuing Certain Items

If it is the same item, then the only thing that matters is magnitude. For example, if people were looking to split up money, then each person would try to just make the most money. There would be no other complications, and they could just figure out how to divide the money. These types of sets of items are called ”heterogeneous”.

However, there are a bunch of different items, certain people will value certain items at a higher rate, and certain ones at a lower rate. This is called ”homogeneous”: the value of each item varies based on each person. So, how do we model that?

Well, create a function $V_i(C)$, which is the value function. For each person, this function will take in every possible subset of the objects given, and give out a value. Usually, the empty set would give out zero, and the actual full set of the objects given would give out one. Each value specifies how much that specific person wants that subset of items (Inigo et al 2022). This can be for specific items, or for a range of items. Let us take a look at a few examples.

Example 1

Suppose there are three items, a computer, a mouse, and a TV. Each of these items cannot be split up, so they must each be taken by a single person. Therefore, the set of these items is {computer, mouse, TV}.

Amy takes the value function, and labels the subsets computer, mouse, and TV each at 1/3. This means that she values each of these items equally, and no one item is more important than the others.

Now, suppose another person, Barry, labels the subset computer, mouse at 1, but labels every other subset 0. This means that Barry only cares about getting the computer AND the mouse. He does not want just the computer, nor does he want just the mouse. He also does not care about the TV; it has no ”value” to him, since he ranked every subset with the TV in it equal to 0.

Finally, let us look at another person, Carrie, who labels the TV at 1/3, the computer at 1/2, the mouse at 1/5, and the TV and computer at 1. This means that Carrie really wants both the TV and the computer, but if she could only have one, she would have just the computer. She still would be somewhat fine with getting just the TV or just the mouse, but the thing she really wants is both the TV and the computer.

Example 2

Suppose that there is a cake. The cake has to be distributed between three people: Alex, Bob, and Caroline. How do we use the value function for this scenario?

Well, we can call this cake an interval of the form [0,1], and the value function takes in all possible subsets of this interval, and values each one. For example, if Alex ranks the values of each interval based on the length (how long the interval is), it shows that she does not care about what is on the cake, but only about how much of the cake she gets. If she ranks every interval of length n with a value of n, this means that the bigger the slice of cake, the more she wants it.

Suppose Bob ranks any interval which has a subset of the interval [0,4, 0.6] as 1, and every other subset equal to 0, This means that Bob really wants the slice of cake with that interval on it. This may be because that part of the cake has frosting that he really loves, or because it has cherries while the rest of the cake does not. He really likes that portion of the cake, and the rest of the cake has no value to him.

Now, suppose Caroline ranks any interval of length n based partially on the length of the subset [0.3, 0.5], which we can call m. She values each slice as the formula $(10n/8) - m$.

This means that she really does not want the subset [0.3, 0.5], but if she gets a lot of the other parts of the cake, she wouldn't mind it that much. However, it would be best if she had all parts of the cake that didn't contain the interval [0.3, 0.5], because that would be $(10(0.8))/8 - 0$, which is equal to 1.

The value function does work for a case even like this one. There is always a way to value items, even if it may seem difficult.

Does it Have Real-Life Applications?

The value function will be used a ton in the future, because it creates a great way to take in every person's opinion. Each person wants different things, and if every person can understand what the others want, they can negotiate much, much better.

Some people may not be able to get their first wish, but that's fine, because they can always get one of the things they want. The value function is key for negotiations like this one, which proves the Fair-Division problem has real-life applications.

6. Conclusion

In conclusion, there are many problems in game theory, and many of them have their own application in the real world. Game theory is incredibly helpful when looking at human irrationality and predicting human behavior. These problems above can help immensely throughout the world. Game theory will continue to be a huge aspect of mathematics. It will help to make logical choices based on the options given, and in the future, it could be used for even bigger things. For example, game theory is being used to make more advances in AI, because it is useful for making logical and rational decisions. Game theory is a very interesting topic that is helpful in many ways, and as we continue on, its role will be more and more critical.

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The Importance of Marketing Sustainability in Building a Positive Brand Image for Fast Fashion Companies By Runxin Li

Abstract

While fast fashion has been increasing in popularity for the past few decades, there is a recent shift towards sustainable fashion. Especially for Gen Z female consumers, who are going to make up the majority of fashion consumption in the near future, the emphasis on awareness of sustainability is rapidly pulling customers away from mass-produced fast fashion, while second-hand and handmade clothes are rising in popularity. In order to address this change, many companies are starting to advertise themselves as sustainable and environmentally responsible. This paper seeks to understand if and how marketing sustainability within fast fashion increases perception of brands as environmentally aware amongst Gen Z females. In this paper, I explore whether marketing sustainability is the most important contributor to a positive brand perception for Gen Z females. I use quantitative data to compare the value of sustainability to other marketing tactics to measure its effect on positive brand image. I conduct follow-up interviews to find out why respondents value sustainability. The results present that marketing sustainability is the most effective marketing tactic, which supports the fast fashion industry intentionally changing their business model and marketing towards sustainability. Future research can be conducted on other age and gender demographics to expand the implications of these results.

Introduction

Over the past 10 years, there has been increased attention towards climate change. While fast fashion has dominated the market since the 1990s, consumers are demanding more from brands, whether it's environmental or ethical, among other brand values. This is, among many other factors, leading to fast fashion's decreasing popularity among young consumers, bolstered by an increase in the pursuit of individuality. Fast fashion companies are constantly evolving to combat these changes in their consumer base. One of the ways companies seek to attract new customers is by improving their brand image. For Gen Z consumers specifically, sustainability has become increasingly important as young people become more aware of environmental issues and their contributions to climate change. Due to the fast turn-around of fashion trends and increased productivity, 92 million tons of textile waste end up in landfills each year (Forbes

2018). This number proves to be shocking for many young consumers, and increased news coverage on this issue contributed to their concern over sustainability. While fast fashion can have a negative environmental impact, changing these business models often come at a cost for companies, driving some towards greenwashing, which is misleading advertisement of a company on its environmental conduct in order to protect its public image. In order to achieve change, we should understand the relationship between sustainability and marketing in business models. As fast fashion companies change their advertising strategies to face these changes, I hypothesize that marketing sustainability is the most important factor contributing to a positive brand image.

Brand Image

Brand image, defined as the impression of a product held by real or potential consumers by Oxford Languages, is a key component of sales. Consumers are becoming increasingly conscious of the values the brands they support represent, rather than merely being concerned with the products themselves. The brand image promoted by advertisements is the understanding consumers derive from the total set of brand-related activities (Park, 1986). Brands offer both functional and symbolic concepts that are perpetrated through positioning strategies that separate a brand from its competitors. Marketing through brand image communicates to consumers to motivate them to overcome purchase barriers, such as budgets (Park, 1986). This gives meaning to and elaborates on products beyond their initial impressions. Brand identification, similar to brand image, is proven to be positively correlated to brand performance, both for personal use and non-usage-oriented behaviors, such as brand support, eventually contributing to the brand's competitiveness in the market (Hughes, 2010). For example, in the late 2010s, Victoria's Secret sales were largely replaced by brands such as Aerie that place an emphasis on body positivity. Victoria's Secret experienced around a 7% decline over the past few years as consumers considered the brand to be women's garments made for the male gaze, which stood against the increase in feminism depicted in the media. In addition, the company's executive stated that they won't include transgender or plus-size models in their shows because "their show is a fantasy," signifying the misogyny of the brand's executive board. On the other hand, American Eagle's daughter brand Aerie also specializes in intimates and loungewear and was one of the first brands to heavily market on body positivity by including plus-size models in their campaigns and

eliminating retouching photos to avoid portraying a false perception of perfection. As a result, sales rose 8% in 2022, namely due to the brand's popularity among conscious young consumers. Gen Z is a generation known for activism, with 38% concerned about global warming (Forbes 2018), the highest across all generations. It makes sense that many young consumers want their clothing brands to reflect their personal values.

Sustainability/Greenwashing in Fast Fashion

In fashion, sustainability refers to creating, producing, and consuming clothing in a way that minimizes negative impacts on the environment. It considers the entire life cycle of the garment from design and production to use and disposal, ultimately ensuring that the company operates in a responsible manner. Efforts to increase sustainability include using sustainable materials, reducing waste, and expanding product lifespan. Sustainability in materials refers to the usage of recycled materials, such as recycled nylon, and materials that are sustainably sourced with lower environmental impacts than their traditional alternatives. Sustainable fabrics include organic cotton and more innovative options such as vegan leather made from mushrooms produced by Mylo Leather. Waste reduction is applied to the production and transportation of garments to reduce pollution and carbon footprint. Technology is highly involved in this process as it's used to reduce water usage and adopt renewable energy resources. It's also essential for companies to have a transparent production chain that keeps consumers informed on the carbon footprint of their garments through production and transportation. Lastly, fashion can achieve sustainability by increasing its quality and promoting durability and timelessness in pieces to avoid landfill wastes. Sustainability efforts, if put into practice, would result in a culture shift away from fast fashion, especially among Gen Z consumers who are eager to make the change. In recent years, the sustainable fashion movement has responded to the sharp incline of fast fashion from the 1990s to the present day. Younger generations recognize the negative effect industrialization has had on the environment and more importantly, the reality that they and future generations will have to live with that effect. As Gen Z enters the employment field, they will have more purchasing power and their spending can help determine the future of the fast fashion industry.

In order to face this shift in consumers' values, fast fashion companies are instituting fundamental changes in their production chains. Fast fashion companies can market themselves

as environmentally responsible towards their consumers, which combats the degradation of the ecosystem due to garment manufacturing. Zara's Life program, which strives towards sustainability, claims that the company has used 100% renewable electric energy in proprietary operations in 2022 and promises to use 100% sustainable fibers, redesigned packaging, eliminate single-use plastic for customers, and reuse or recycle waste in proprietary operations in 2023.

However, these claims made by companies are not always accurate or reliable, such as greenwashing strategies, through which companies advertise misleading environmental benefits of the brands' goods or services to consumers (Lane, 2012). Even with these claims, the fashion industry still consumes 79 trillion liters of water annually. Fast fashion company SHEIN claims to support the ten principles listed by the United Nations Global Compact focusing on human rights, labor, environment, and anti-corruption. But, according to the Times Magazine, the company emits 6.3 million tons of carbon dioxide each year. A positive correlation exists between brand equity and green brand image, satisfaction, and trust, which all promote high levels of consumption-related fulfillment to satisfy consumers' sustainability desires (Chen, 2010). Promoting a green brand image leads to higher levels of brand dependency and loyalty based on the belief that the brand is environmentally conscious and therefore benevolent and credible (Chen, 2010). Gen Z values action on environmental issues, as they are highly influenced by direct exposure to climate change impacts (Strazdin and Skeat, 2011). The topic of sustainability is important because Gen Z's purchase power holds a significant place in the fashion market as they currently hold purchasing power of over 300 billion dollars and counting according to Lexington Law, and their brand loyalty is valuable to fast fashion companies.

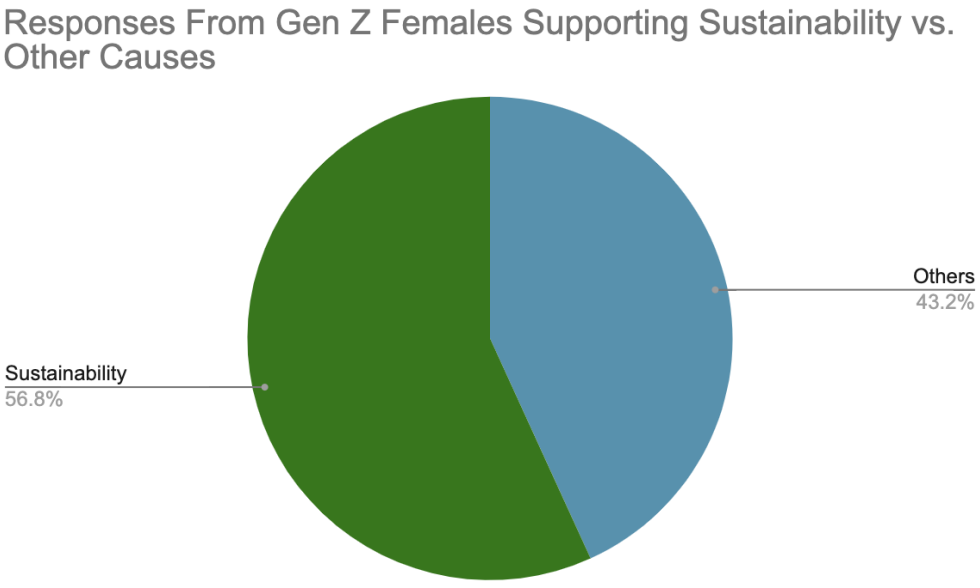
Research Methodology

I seek to validate my hypothesis by conducting research through surveys and interviews. Surveys can provide quantitative data that is easy to collect and interpret. I created one survey with two sets of respondents: one answered by 36 Gen Z females only and another by 10 participants of all ages and genders in order to understand if Gen Z has a different perspective than older generations. Females were the target demographic of this research because women are 59% more likely to consume fashion than men, according to Charge Retail. Therefore, they are important actors in the fashion market. All consenting subjects of the survey were asked to choose between two advertisements based on which one provides a more positive perception of

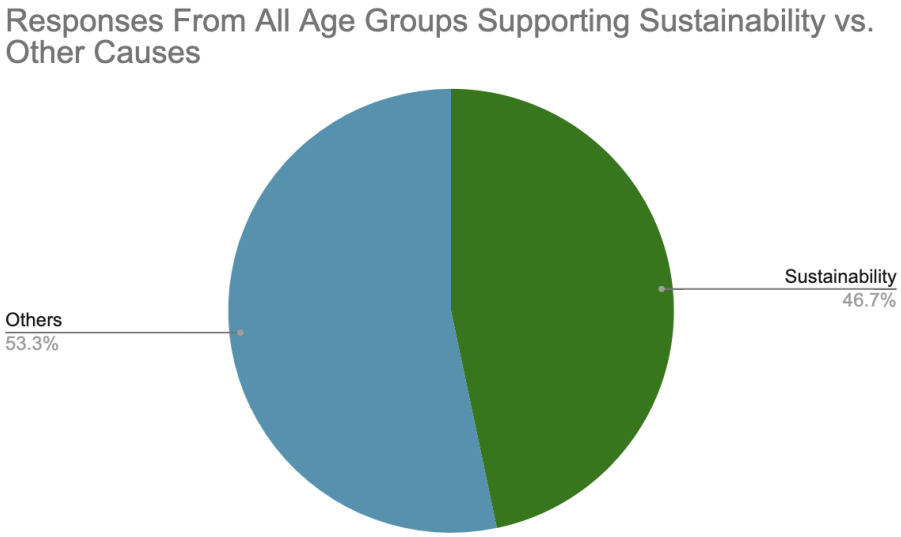
the clothing brand. Each question had two options, one advertising for environmental sustainability and another for various other social impacts, such as support towards Black Lives Matter movements and body positivity. I held fast fashion advertisements that were image-based against each other, while text-based advertisements were compared to each other to create parallel visual impacts to ensure that respondents are not merely drawn in by images. This strategy aimed to limit the impact of confounding factors, including the placement and sequence of advertisement presentation. In addition, I conducted interviews to inform case studies to provide more insights into why participants chose the answer they did during the survey and their understanding of sustainability in fast fashion. This data aimed to answer the hypothesis of whether sustainability is the most effective aspect to market to consumers to create a more positive brand image.

Survey Results

As seen in the survey created for 36 Gen Z students, 176 responses are in support of environmental sustainability in the advertisements across all 6 questions while 122 are in support of other social causes. This means that 56.8% of the responses consider environmental sustainability the more effective method to market towards a positive brand perception while 43.2% of responses prefer other positive social impacts.



In comparison, responses collected from participants of all ages and genders show that 28 responses are in support of advertising sustainability, and 32 responses lean towards other social causes. This corresponds to 46.7% of responses for sustainability and 53.3% for other causes among 10 respondents' answers.



Data Analysis

The data presented above shows that Gen Z female consumers value environmental sustainability over other positive impacts marketed by fast fashion companies while this statement is not true for other age groups. This data suggests that marketing sustainability may indeed be highly impactful for brand image among Gen Z consumers, if not the most impactful.

Interview Results

To provide more insight into the reasoning behind these answers, I conducted interviews with individual respondents. When asked about their choices, participants gave the following answers: "Sustainability is a company's responsibility towards our planet. It shouldn't just be something they claim; it should be based on action. I chose some advertisements revolving around sustainability because they're the most tangible ones. The advertisement on body positivity, for example, represents diverse bodies but doesn't state any real impacts the company has made. While it's still a step in the right direction, I think fashion companies need to

stop making these empty claims just to check off a box and appeal to consumers." This respondent chose sustainability over other social causes 71.4% of the time. This statement directly correlates with greenwashing and how consumers are able to recognize these tokenism marketing strategies rather than the company's effort to achieve genuine change.

Another respondent answered that "the advertisement on ethical labor did state actions the company has taken, and because it was something that affects workers directly, it was a compelling choice. As a woman myself, Lululemon's donations towards abortion was something that really spoke to me on a personal level, so for that question I felt that it was more appealing [than sustainability]." She chose the advertisement with sustainability 42.8% of the time. Overall, many participants mentioned the impact the environment has on everyone, whereas many social causes may only apply to a particular group: "Although these causes are undeniably important, we are actively running out of time to save our planet before the damage we have done becomes irreversible; so for that reason, I think sustainability should be prioritized." Specifically, programs that focus on recycling existing items seem to be popular. One respondent who was in favor of these programs explained, "I think clothing in landfills is one of the primary issues that we need to address. The recycling program is giving consumers the opportunity to make a change proactively as opposed to companies making claims on being carbon zero, which has many loopholes. Landfills also have a negative impact on the living conditions of people in developing countries, so these programs are important because they can address both environmental and social issues."

An interview with Ms. Tanya Lerch, teacher and faculty at Sage Hill School, brings more insights into the importance of sustainability and what changes can be made to address these issues. Ms. Lerch is the advisor of student-led fashion magazine *Flare*, which published an issue on sustainability in their Fall-Winter 2022 edition. The magazine focused on how the Sage Hill community can implement changes towards sustainability, including shopping consciously. She also gave a presentation on fashion sustainability to the Sage Hill faculty to bring awareness to the issue and call for action. As someone who works with students, Ms. Lerch suggests that sustainability is important to Gen Z largely because they are the generation most affected by it. She also mentions the use of social media and how quickly information on environmental activism spreads. The reason why fast fashion has become popular is because "people desire affordable versions of fast fashion, which is how these rapid prototypes come into existence."

She suggests that the drive behind it is consumer demand and therefore waste is produced because people have so many affordable options in the modern age. To address this issue, people should start with changing consumer culture to drive change on the corporate level. Consumers have the power to vote with their purchases and indirectly influence practices of fast fashion giants. She has noticed that Gen Z has taken actions such as shopping second hand or upcycling clothing. In addition, she recommended mobile applications such as "Good On You," which rates fashion companies on various scales such as carbon emission, recyclable materials, and working conditions. Their measurements of sustainability and ethics help consumers decide if they support a brand from the convenience of their phones.

Peer interviews authentically reflect values of Gen Z consumers through a personal perspective, while an educator and subject matter expert's perspective analyzes the trends present among students from an outsider's point of view. The perspective of an educator in addition to Gen Z females provides a comprehensive understanding of consumers' values regarding sustainability and how their beliefs affect their choices.

Error Analysis

While the survey provided tangible results and a trend, there are some flaws to note. Due to the fact that respondents were participating on a voluntary basis, the sample size is not large enough to be completely representative. All participants were also from the same school in the same region, introducing bias into the data sample. In addition, the specific advertisement examples the researcher chose in each category can also influence the accuracy of results. In the interview portion, people may have been more likely to voice their support towards social issues due to the pressure of wanting to be seen as ethical by the interviewer and researcher, especially because these were peers and not strangers. The interview format can introduce bias on the participants' answers and portray skewed results. This bias can be partially eliminated if I conducted a written survey instead of spoken interviews as it would partially remove the presence of the researcher.

Conclusion and Implications

As consumers become increasingly aware of the negative impacts of fast fashion, it is important to observe the future implications for marketing in the fast fashion industry.

Sustainability is arguably the most important aspect of building a positive brand image as seen across multiple surveys and interviews. Specifically, Gen Z is more concerned with sustainability because they are the most affected of any age group. In addition to a brand's environmental impact, its ethics and other social impacts are also important factors for consumers. As consumer values change, traditional fast fashion brands are using advertisements to market sustainability towards positive consumer perceptions. However, many companies will not see the necessity to make measurable changes as long as consumer demand for fast fashion is present. Therefore, this research can be implemented by both consumers in driving change and by companies in making these changes towards sustainability. Corporations can change their business models as well as marketing strategies to address the shift in Gen Z consumer values towards environmental sustainability. As Gen Z shifts into a demographic with deeply-rooted values and high purchase power, companies need to market on their candid efforts towards sustainability.

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Mental health and Sexual Identity in Adolescents: Analysis of 2021 Youth Risk Behavior Study Data By Nathaniel J. Choi

Abstract

Through analyzing 2021 Youth Risk Behavior Survey (YRBS) data, LGBT youth were more likely to be impacted by mental health during Covid than heterosexual youth. [1] The latest YRBS data was analyzed to explores association between mental health and sexual identity. Twenty nine percent of youth reported mental health was most of the time or always not good. Highest reports of poor mental health among American Indians/Alaskan Natives. There was no statistically significant difference by high school grade. The prevalence of poor mental health was 29.3%. The results demonstrate an association between poor mental health and sexual identity. 44% percent of gay or lesbian youth reported poor mental health. Compared to heterosexual youth, gay or lesbian, bisexual, other/questioning youth reported poor mental health. Sixty four percent of youth who seriously considered attempting suicide reported that their mental health most of the time or always not good. Ten percent of youth report actually attempted suicide one or more times during the 12 months before the survey. Twenty five percent of bisexual youth reported actually attempted suicide. Gay or lesbian youth were more likely than heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

Statistically significant groups were who were found to have an association between reports of suicidal ideation and poor mental health were gay, lesbian, bisexual youth or other/questioning yout . In addition, LGBT youth were at increased risk of reporting poor mental health and suicidal ideation during Covid pandemic among those. These findings point for the need for improved school–based services for mental health and the need for schools to provide mental health services or referral systems to community resources. These findings of association between mental health and sexual identity are consistent with previous studies.

Key words: Mental Health , Sexual Identity

[1] Centers for Disease Control and Prevention. (2021). Youth Risk Behavior Survey Data. Available at: www.cdc.gov/yrbs. Accessed on 6/26/2023.

Introduction

A significant percentage (37%) of youth reported poor mental health during Covid. Poor mental health includes stress, anxiety, and depression. Results of community surveys in regions of the United States have shown one in every four children experiences a mental disorder with few affected youth receiving adequate mental health care. However, there has been a lack of data on the prevalence and distribution of a wide range of mental disorders from a nationally representative sample of children or adolescents. This information is necessary to establish resource allocation priorities for prevention and treatment.[2345]

Results

The analysis included 17,232 high school students from the YRBS. 36.9% of youth reported mental health was poor during the Covid-19 pandemic. Compared with heterosexual youth, gay, lesbian, or bisexual youth were more likely to report mental health was most of the time or always not good. Sexual minority youth were comprised of bay or lesbian or bisexual and other/questioning. In all tables below the group of (gay, lesbian, or bisexual) is a combination of (gay or lesbian) and (bisexual) into a larger subgroup.

Twenty nine percent of youth reported mental health was most of the time or always not good. Forty percent of female youth and 18 % of male youth reported mental health was most of the time or always not good.

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Heterosexual females 32% and male youth 15.6% reported lower incidence of poor mental health when compared to gay or lesbian, bisexual, gay, lesbian, or bisexual, or other youth.

Table 3. Comparison of gay or lesbian youth with heterosexual youth for poor mental health

Sexual Identity Sex	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
Total	22.2 (20.8–23.6) 9,239†	44.3 (39.1–49.7) 414	0.00	Yes
Female	32.0 (29.6–34.6) 3,697	49.7 (41.0–58.4) 245	0.00	Yes
Male	15.6 (14.3–17.0) 5,482	36.0 (26.3–46.9) 148	0.00	Yes

Regardless of sex, gay or lesbian youth were more likely than heterosexual youth to report that their mental health was most of time or always not good. P=0.00

Table 4. Mental health and bisexual compared to heterosexual youth

Sexual Identity Sex	Heterosexual (straight)	Bisexual	p-value	Bisexual More Likely Than Heterosexual (straight)
Total	22.2 (20.8–23.6) 9,239†	53.2 (49.4–57.0) 1,402	0.00	Yes
Female	32.0 (29.6–34.6) 3,697	56.5 (52.9–60.2) 1,121	0.00	Yes
Male	15.6 (14.3–17.0) 5,482	38.1 (30.8–45.9) 249	0.00	Yes

Bisexual youth were more likely than heterosexual youth to report that their mental health was most of time or always not good. P=0.00

Table 5. Mental health and sexual identity by race

Sexual Identity Race	Total	Heterosexual (straight)	Gay or lesbian	Bisexual	Gay, lesbian, or bisexual	Other/Questioning
Total	29.3 (27.8–30.8) 12,795†	22.2 (20.8–23.6) 9,239	44.3 (39.1–49.7) 414	53.2 (49.4–57.0) 1,402	51.3 (48.0–54.6) 1,816	52.2 (47.9–56.4) 1,106
American Indian or Alaska Native‡	31.1 (23.1–40.3) 114	20.2 (11.9–32.3) 81	N/A 3	N/A 12	N/A 15	N/A 8
Asian§	22.8 (18.3–28.2) 609	17.0 (12.7–22.4) 421	N/A 26	51.7 (36.6–66.4) 60	44.8 (32.3–57.9) 86	34.9 (21.8–50.7) 79
Black or African American§	26.5 (24.0–29.1) 2,084	21.5 (18.8–24.4) 1,534	22.4 (12.3–37.3) 93	44.7 (36.5–53.3) 205	38.5 (32.3–45.1) 298	48.2 (41.0–55.5) 172
Hispanic or Latino	29.7 (27.7–31.9) 2,703	22.9 (20.5–25.3) 2,016	39.2 (26.8–53.3) 60	58.7 (52.7–64.3) 283	55.2 (50.2–60.0) 343	53.3 (46.8–59.6) 212
Native Hawaiian or Other Pacific Islander‖	20.1 (7.8–42.8) 50	3.4 (1.1–10.3) 35	N/A 3	N/A 6	N/A 9	N/A 3

Sexual Identity Race	Total	Heterosexual (straight)	Gay or lesbian	Bisexual	Gay, lesbian, or bisexual	Other/Questioning
White[§]	30.2 (27.8–32.7) 6,150	22.4 (20.7–24.2) 4,467	57.8 (47.7–67.3) 190	53.3 (48.2–58.2) 695	54.2 (49.4–58.9) 885	55.9 (50.0–61.7) 499
Multiple race[§]	33.0 (29.4–36.8) 769	24.5 (19.6–30.2) 493	26.2 (12.5–46.9) 32	46.9 (34.6–59.5) 107	42.2 (31.9–53.2) 139	55.5 (44.9–65.6) 101

Thirty three percent of multiple race and 30% of white youth reported that their mental health was most of the time or always not good. Hispanic bisexual youth 58.7% and white gay or lesbian youth 57.8% reported highest rates of poor mental health.

Table 6. Mental health among gay or lesbian compared to heterosexual youth by race

Sexual Identity Race	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
Total	22.2 (20.8–23.6) 9,239[†]	44.3 (39.1–49.7) 414	0.00	Yes
American Indian or Alaska Native[‡]	20.2 (11.9–32.3) 81	N/A 3	~	No
Asian[§]	17.0 (12.7–22.4) 421	N/A 26	~	No
Black or African American[§]	21.5 (18.8–24.4) 1,534	22.4 (12.3–37.3) 93	0.88	No

Sexual Identity Race	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
Hispanic or Latino	22.9 (20.5–25.3) 2,016	39.2 (26.8–53.3) 60	0.03	Yes
Native Hawaiian or Other Pacific Islander‖	3.4 (1.1–10.3) 35	N/A 3	~	No
White§	22.4 (20.7–24.2) 4,467	57.8 (47.7–67.3) 190	0.00	Yes
Multiple race§	24.5 (19.6–30.2) 493	26.2 (12.5–46.9) 32	0.86	No

Statistically significant differences were found. For Hispanic and White gay or lesbian youth p=0.00, they were more likely than heterosexual youth to report poor mental health.

Reported Mental Health was most of the time or always not good during the Covid-19 Pandemic

	Percentage	95% Confidence Interval
Sex		
Total	36.93	35.15-38.75
Females	51.00	48.42-53.57
Males	23.71	21.89-25.63

Higher percentage of females reported poor mental health during Covid-19 compared to males.

Table 7. Reported That Their Mental Health Was Most Of The Time Or Always Not Good During The Covid-19 Pandemic (poor mental health includes stress, anxiety, and depression) by sexual identity

Sexual Identity Year	Total	Heterosexual (straight)	Gay or lesbian	Bisexual	Gay, lesbian, or bisexual	Other/Questioning
2021	36.9 (35.2–38.7) 9,716†	28.6 (27.1–30.1) 6,983	60.7 (53.5–67.4) 313	67.5 (64.6–70.2) 1,074	66.0 (63.2–68.7) 1,387	61.0 (56.4–65.4) 839

Table 8. Reported That Their Mental Health Was Most Of The Time Or Always Not Good During The Covid-19 Pandemic by sexual identity: Comparison of heterosexual youth with gay or lesbian youth

Sexual Identity Year	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
2021	28.6 (27.1–30.1) 6,983†	60.7 (53.5–67.4) 313	0.00	● Yes

Table 9. Reported That Their Mental Health Was Most Of The Time Or Always Not Good During The Covid-19 Pandemic; Comparison of bisexual youth with heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Bisexual	p-value	Heterosexual (straight) More Likely Than Bisexual	Bisexual More Likely Than Heterosexual (straight)	No Difference
2021	28.6 (27.1–30.1) 6,983†	67.5 (64.6–70.2) 1,074	0.00	No	● Yes	No

Statistically significant results were also found for bisexual youth who were more likely than heterosexual youth to report that their mental health was most of the time or always not good during the Covid-19 pandemic

Table 15. Seriously considered attempting suicide by sexual identity and sex

Sexual Identity Sex	Total	Heterosexual (straight)	Gay or lesbian	Bisexual	Gay, lesbian, or bisexual	Other/Questioning
Total	22.2 (21.1–23.3) 16,927†	15.0 (13.9–16.2) 12,249	40.3 (35.2–45.7) 507	50.2 (45.5–54.8) 1,806	48.1 (44.3–51.9) 2,313	40.5 (36.7–44.5) 1,448
Female	30.0 (28.5–31.4) 8,010	19.9 (18.5–21.5) 4,926	41.0 (31.8–50.9) 290	51.9 (47.6–56.1) 1,419	50.2 (46.6–53.8) 1,709	40.8 (36.8–45.0) 1,035
Male	14.3 (13.3–15.4) 8,674	11.6 (10.6–12.8) 7,258	35.5 (27.7–44.1) 193	40.2 (31.9–49.1) 346	38.4 (31.0–46.4) 539	34.9 (26.9–43.8) 326

50% Bisexual youth reported seriously considered attempting suicide during the 12 months before the survey in comparison to only 15% of heterosexual youth. Thirty percent of female youth reported seriously considered attempting suicide during the 12 months before the survey in comparison to 14% of male youth. Bisexual females and gay or lesbian youth reported high rates of seriously considered attempting suicide.

Table 16. Seriously considered attempting suicide (during the 12 months before the survey)by sexual identity and sex: Comparison of Gay or lesbian with heterosexual youth

Sexual Identity Sex	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
Total	15.0 (13.9–16.2) 12,249†	40.3 (35.2–45.7) 507	0.00	Yes
Female	19.9 (18.5–21.5) 4,926	41.0 (31.8–50.9) 290	0.00	Yes
Male	11.6 (10.6–12.8) 7,258	35.5 (27.7–44.1) 193	0.00	Yes

Regardless of sex, gay or lesbian youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey.

Table 17. Seriously considered attempting suicide by sexual identity and race: Comparison of gay or lesbian youth with heterosexual youth

Sexual Identity Race	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)	No Difference
Total	15.0 (13.9–16.2) 12,249†	40.3 (35.2–45.7) 507	0.00	Yes	

Sexual Identity Race	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)	No Difference
American Indian or Alaska Native‡	18.1 (10.1–30.2) 97	N/A 4	~	No	
Asian§	11.2 (9.3–13.3) 581	35.8 (10.1–73.4) 33	0.17	No	Yes
Black or African American§	14.2 (11.2–17.9) 1,660	26.8 (15.0–43.1) 96	0.09	No	Yes
Hispanic or Latino	16.4 (13.7–19.5) 2,311	25.8 (16.2–38.5) 75	0.15	No	Yes
Native Hawaiian or Other Pacific Islander‖	16.6 (8.4–30.1) 62	N/A 3	~	No	No
White§	14.9 (13.5–16.4) 6,675	50.8 (41.8–59.8) 250	0.00	Yes	No
Multiple race§	15.1 (11.8–19.1) 617	33.5 (19.3–51.5) 39	0.04	Yes	No

Gay or lesbian youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey. The results show that this is also statistically significant for white and multiple race youth.

Table 18. Seriously considered attempting suicide (during the 12 months before the survey) by sexual identity: Compare gay or lesbian with heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
2021	15.0 (13.9–16.2) 12,249†	40.3 (35.2–45.7) 507	0.00	Yes

Gay or lesbian youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey.

Table 19. Seriously considered attempting suicide (during the 12 months before the survey) by sexual identity: Comparison of gay, lesbian, or bisexual youth with heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Gay, lesbian, or bisexual	p-value	Gay, lesbian, or bisexual More Likely Than Heterosexual (straight)
2021	15.0 (13.9–16.2) 12,249†	48.1 (44.3–51.9) 2,313	0.00	Yes

Table 20. Seriously considered attempting suicide (during the 12 months before the survey) by sexual identity: Comparison of other/questioning youth with heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Other/Questioning	p-value	Other/Questioning More Likely Than Heterosexual (straight)
2021	15.0 (13.9–16.2) 12,249†	40.5 (36.7–44.5) 1,448	0.00	Yes

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Table 21. Actually attempted suicide (one or more times during the 12 months before the survey) by sexual identity

Sexual Identity Year	Total	Heterosexual (straight)	Gay or lesbian	Bisexual	Gay, lesbian, or bisexual	Other/Questioning
2021	10.2 (9.4–11.0) 15,573†	6.3 (5.6–7.1) 11,239	19.1 (14.8–24.4) 472	25.4 (22.3–28.8) 1,717	24.1 (21.2–27.3) 2,189	17.9 (14.7–21.6) 1,386

Ten percent of youth report actually attempted suicide one or more times during the 12 months before the survey. 25% of bisexual youth reported actually attempted suicide.

Table 22. Actually attempted suicide (one or more times during the 12 months before the survey) by sexual identity: gay or lesbian youth compared to heterosexual youth.

Sexual Identity Year	Heterosexual (straight)	Gay or lesbian	p-value	Gay or lesbian More Likely Than Heterosexual (straight)
2021	6.3 (5.6–7.1) 11,239†	19.1 (14.8–24.4) 472	0.00	Yes

Gay or lesbian youth were more likely than heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

Table 23. Actually attempted suicide (one or more times during the 12 months before the survey) by sexual identity: bisexual youth compared to heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Bisexual	p-value	Bisexual More Likely Than Heterosexual (straight)
2021	6.3 (5.6–7.1) 11,239†	25.4 (22.3–28.8) 1,717	0.00	Yes

Bisexual youth were more likely that heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

Table 24. Actually attempted suicide (one or more times during the 12 months before the survey) by sexual identity: gay, lesbian or bisexual youth compared to heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Gay, lesbian, or bisexual	p-value	Gay, lesbian, or bisexual More Likely Than Heterosexual (straight)
2021	6.3 (5.6–7.1) 11,239†	24.1 (21.2–27.3) 2,189	0.00	Yes

Gay, lesbian, or bisexual youth were more likely that heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

Table 25. Actually attempted suicide (one or more times during the 12 months before the survey) by sexual identity: other/questioning youth compared to heterosexual youth

Sexual Identity Year	Heterosexual (straight)	Other/ Questioning	p-value	Other/Questioning More Likely Than Heterosexual (straight)
2021	6.3 (5.6–7.1) 11,239†	17.9 (14.7–21.6) 1,386	0.00	Yes

Other /questioning youth were more likely that heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

Discussion

Overall gay, lesbian, bisexual youth are at much higher risk for poor mental health, suicide ideation and suicide attempts. Female bisexual youth reported highest percentage (56.5) of poor mental health.

In this large survey of high school students, the prevalence of poor mental health was 29.3%. As seen in previous research, females reported poor mental health more than males.

Current mental health-40.77% of females and 18.08% of males reported that their mental health was most of the time or always not good. Mental health during the pandemic- 51% of females and 23.71% of males reported their mental health was most of the time or always not good during the Covid-19 pandemic. This is consistent with findings from Reinherz, et al.[3] "Moreover, consistent with national-level data, females in this population exhibited a significantly greater risk for both mental and physical health issues than males."[3] In addition, "… studies found relationships among physical activity, sedentary behavior, and depression, but more recent information is needed to inform research and practice" [6] This study analyzed most recent 2021 YRBS survey data. Controlling for sexual identity, the statistically significant groups were who were found to have highest increased risk seriously considering suicide among those who reported poor mental health were gay or lesbian youth with OR 8.02.

For Hispanic and White gay or lesbian youth p=0.00, they were more likely than heterosexual youth to report poor mental health. Hispanic bisexual youth 58.7% and white gay or lesbian youth 57.8% reported highest rates of poor mental health. For Hispanic and White gay or lesbian youth p=0.00, they were more likely than heterosexual youth to report poor mental health.

Gay or lesbian youth were more likely than heterosexual youth to report that their mental health was most of the time or always not good during the Covid-19 pandemic. Statistically significant results were also found for bisexual youth who were more likely than heterosexual youth to report that their mental health was most of the time or always not good during the Covid-19 pandemic

For youth, an increased risk of seriously considered attempting suicide among those who reported that their mental health most of the time or always not good. Bisexual females and gay or lesbian youth reported high rates of seriously considered attempting suicide. Gay or lesbian youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey.Regardless of sex, gay or lesbian youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey. Gay, lesbian, or bisexual youth were more likely than heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey. Other/questioning youth were more likely that heterosexual youth to report seriously considered attempting suicide during the 12 months before the survey.

Ten percent of youth report actually attempted suicide one or more times during the 12 months before the survey. 25% of bisexual youth reported actually attempted suicide. Gay, lesbian or bisexual youth were more likely that heterosexual youth to report actually attempted suicide one or more times during the 12 months before the survey.

The findings in this study are consistent with previous research. "Current research evidence suggests that the strongest risk factors for youth suicide are mental disorders and a history of psychopathology, indicating that priorities for intervening to reduce youth suicidal behaviours lie with interventions focused upon the improved recognition, treatment and management of young people with mental disorders."[6] This study controlled for race and gender and found statistically significant results. Moreover, these findings on the association between mental health and physical activity are consistent with research by Wang and Peiper published in Preventing Chronic Disease. "Approximately one in every four to five youth in the U.S. meets criteria for a mental disorder with severe impairment across their lifetime. The likelihood that common mental disorders in adults first emerge in childhood and adolescence highlights the need for a transition from the common focus on treatment of U.S. youth to that of prevention and early intervention."[7]

The results demonstrate an association between sexual identity and poor mental health, suicide ideation and suicide attempt. "The effects of LGBTQ-based discrimination on mental health may be a key area for interventions to reduce suicidal ideation in LGBTQ POC." [8]These findings point for the need for improved school-based services in the area of mental health with a priority need for focus on LGBTQ youth. "We recommend that sexual and reproductive health

[6] A L Beautrais. (2000). Risk factors for suicide and attempted suicide among young people. Jun;34(3):420-36

[7] Merikangas K., He J.-P., Burstein M., Swanson S., Avenevoli S., Lihong C., Benjet C., Georgiades K., Swendsen. (2010). J. Lifetime Prevalence of Mental Disorders in US Adolescents: Results from the National Comorbidity Study-Adolescent Supplement. Journal of American Academy of Child Adolescent. Psychiatry. 2010; 49:980–989. doi: 10.1016/j.jaac.2010.05.017.

[8] M. Sutter, P.B. Perrin (2016) Discrimination, mental health, and suicidal ideation among LGBTQ people of color. Jan;63(1):98-105

services should be accessible to adolescents to address their needs and help to prevent any adverse mental health outcomes."[9] "Schools can be a setting to address mental health needs of sexual and gender minority (SGM) youth. Gender-Sexuality Alliances (GSAs), as extracurricular support groups, provide an existing structure that could be leveraged to reach SGM youth and deliver services"[10] In addition, "data highlighting the unique biological, behavioural, social, and structural contextual factors surrounding health risks and resiliencies for transgender people. To mitigate these risks and foster resilience, a comprehensive approach is needed that includes gender affirmation as a public health framework, improved health systems and access to health care informed by high quality data, and effective partnerships with local transgender communities to ensure responsiveness of and cultural specificity in programming. Consideration of transgender health underscores the need to explicitly consider sex and gender pathways in epidemiological research and public health surveillance more broadly."[11] These findings point for the need for improved school-based services in the area of mental health "The findings of a study indicate a need to target or adapt direct services and programming for sexual and gender minority adolescents."[12] Therefore, there is a need for schools to assess youth for mental health and provide mental health services or referral systems to community resources.

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Methods

Statistical analysis was performed on YRBS data imported into Epi Info 7 using procedures that accommodate the weighted sampling design of YRBS. YRBS is used to monitor priority health risk behaviors among youth in the United States. The national Youth Risk Behavior Survey (YRBS) uses a three-stage cluster sample design to produce a representative sample of 9th through 12th grade students. National data in YRBS High school student survey for 2021 were used to analyze the data. Baseline statistics were carried out and used chi- square to test for differences. Statistical analysis was carried out using Epi Info 7 software. Race and sex were controlled for in the study and odds ratios were calculated for subgroups.

Acknowledgements

I would like to give thanks to my parents for their continuous support and encouragement when undertaking my research on the important topic of mental health.

Pyroplastics as Novel Contaminants in Marine Environments By Eryn Kim

Abstract

As plastic pollution in the environment has increased rapidly in the last half-century, so has the study of plastic pollution and its effects on aquatic, atmospheric, and terrestrial ecosystems. In the present age, called Anthropocene, the occurrence of new plastic formations including pyroplastics, is being reported worldwide. Yet, our understanding of these formations remains limited. Hence, based on the literature, this review paper provides the occurrence, source, and physical and chemical properties of pyroplastics to enhance the overall understanding of this issue. Moreover, the paper highlights their threats to the organism and human health and further suggests future research trends.

Keywords: Earth and environmental sciences; Water science; Marine pollution; Plastic debris; Microplastics; Pyroplastics

Introduction

Plastics have become part of daily life due to their versatility, resistance, low-cost production, and lightweight.[1] Global production of plastics has increased rapidly from 1.5 million tons in the 1950s to 390.7 million tons in 2021.[2-4] However, mismanagement has made plastics one of the biggest environmental concerns as a pollutant with omnipresence on the environment.[5] Plastic waste rapidly accumulates in marine, aquatic, and terrestrial ecosystems,[6] and can be found even in remote locations such as glaciers and the arctic.[7-10]

The ubiquitous presence and persistence of plastics in Earth's environmental sediment samples have made us consider it an indicator of the Anthropocene, a proposed epoch dating from the commencement of human impact on earth's geology and ecosystems.[11] Anthropogenic materials discovered in marine sediments serve as evidence supporting this label. The presence of plastic debris was revealed in the coastal waters in the 1970s.[12] When introduced into the natural environment, plastics can be transported from land to river, eventually reaching the ocean.[13] Marine plastic debris is washed ashore regularly and can be easily fragmented when it crashes against intertidal rocks by waves.[14] Despite this phenomenon, there are few studies on

plastic debris in rocky intertidal habitats, while most research on marine plastic pollution has been concentrated on pelagic environments.[1]

Marine plastic debris can be classified into several groups, which are (a) fisheries-related equipment including fishing nets, (b) ropes and straps, (c) consumer goods such as plastic bags, bottles and bottle tops, and food packages, and (d) pellets. Recently, some researchers reported new plastic forms that may no longer belong to one of the abovementioned classifications. Instead, new plastic formations may result from the interaction of plastic debris with other debris, anthropogenic processes, and elements of the environment.[15] The new plastic composites have been reported chiefly in coastal areas. However, some are found in several countries, indicating that these formations are widespread.

Recently, a novel type of plastic debris called ‘pyroplastics’ was reported on beaches in southwestern England.[16] Pyroplastics, resembling small stones in appearance, comprise encapsulated plastic materials that may release toxic chemicals. They are formed by the combustion of plastic waste from manufactured goods. Since their discovery on other South American, Italy, and Japanese coastlines, pyroplastics are now receiving attention as a new marine pollutant. More recently, there was a report that they were found from shorelines in Jeju island, South Korea. However, distinguishing pyroplastics from natural rocks is complex, and scant information exists regarding their distribution, source, properties, and environmental impact. Therefore, based on literature concerning pyroplastics in marine pollution, this study aims to provide an overview of pyroplastics as a new contaminant in the marine environment and to suggest future research trends.

Method

A literature search was conducted to retrieve articles reporting pyroplastics from two databases, ScienceDirect (https://www.sciencedirect.com/) and Google Scholar (https://scholar.google.com/). Articles published since 2019 were selected in that pyroplastics have recently received attention as the new plastic debris in the marine environment and are still in the infancy of this topic. Thus, a total of fifteen articles was collected. Also, the references of the collected articles were checked. Synthesizing all the articles on pyroplastics, I recognized that current studies are mainly focused on the location where pyroplastics are found, their physical and chemical traits, and their potential environmental influences.

Discovery of Pyroplastics

Pyroplastics were first reported on beaches throughout the county of Cornwall, southwest England by the Cornwall Plastic Pollution Coalition, a group of voluntary organizations.[16] Their sources are campfires or plastic litter burning on beaches.[15] They are observed on the shoreline and rocky outcrops. Pyroplastics may be encrusted on rocky outcrops towards the back beach and cliffs or encountered along the strandline as clasts, with crusts eventually breaking off and becoming a series of clasts.[16] On October 2019, Ehlers and Ellich found pyroplastics from coastal habitats in Giglio island, Tyrrhenian Sea, Italy. They detected them with blue inclusions on a wave-sheltered sandy beach near Campses resort in Giglio. The beach is frequently used for fishing, boating, diving and campfires. They found several blue PET bottles and burnt charcoal near the pyroplastics.[1]

In 2020, other pyroplastics were observed during surveys of organisms that drifted on the Ariho River estuary in the Seto inland sea, Japan. The site is a slightly rocky natural coast.[17] The researchers found that pyroplastics' occurrence density dominated along the strandline. Prevailing onshore winds drive pyroplastics' accumulation on the strandline.[18] This is the first report of pyroplastics from coasts along the Asian side of the Pacific Ocean.[17] The same year, more pyroplastics from the coastlines of the Pacific Ocean were identified in Peru.[19] They were identified on five beaches that are open to the public. All the beaches are popular for recreational, swimming, and fishing activities, influenced by cruise and trading vessel activities, and regarded as tourist destinations. Regardless of their proximity, the number of pyroplastics varied among the beaches, owing to the higher incidence of illegal open-burning waste in less frequented and guarded areas.

In late May 2021, an accident occurred where a container ship caught fire on the coast of Colombo, Sri Lanka. Seventy billion pieces of nurdles (approx. 1680 tons) spilled from the vessel and littered the coastline. Pyroplastics-melted and burnt plastics in previous studies were found on beaches. This study provided a source of pyroplastics of known origin, and partial pyroplastics- a new type of pyroplastics- were reported.[20] Additionally, pyroplastics were reported on beaches from the Orkneys island in Scotland, County Kerry in Ireland, northwestern Spain, and Vancouver in Canada.[16] The occurrence of pyroplastics is being reported at locations around the globe in the era of the Anthropocene (refer to Figure 1).

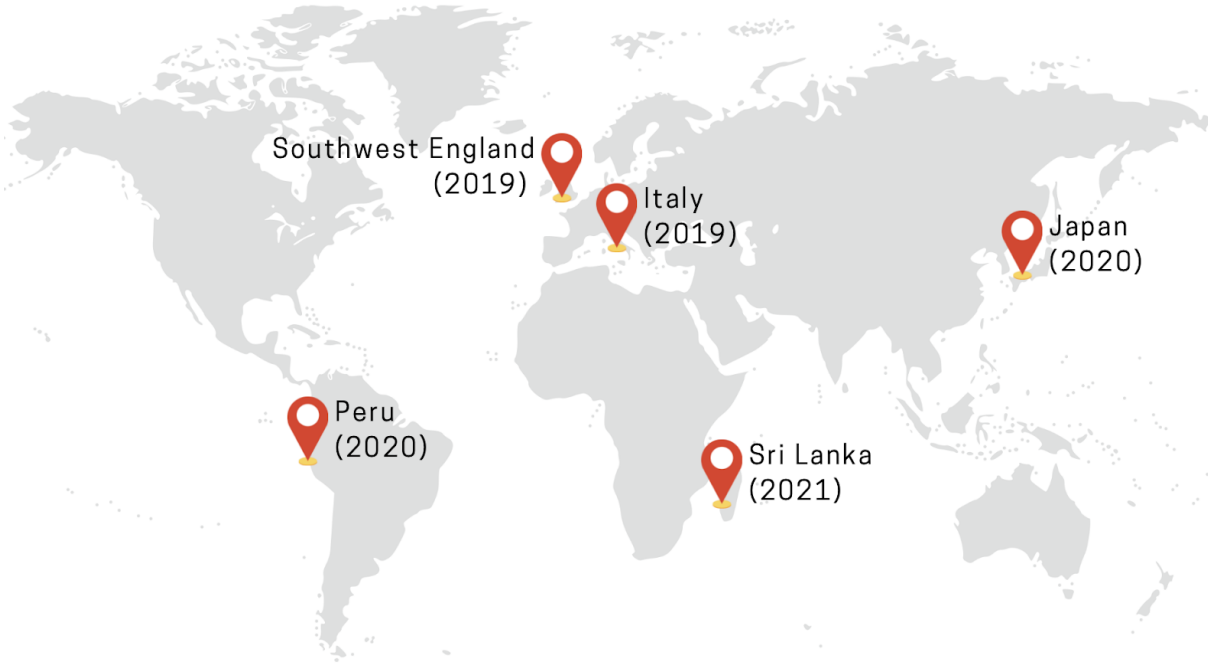

Fig 1: The occurrence of pyroplastics

Studies agree that extremely high temperatures and weathering conditions are necessary to form pyroplastics. They are created via combustion including open campfires and plastic waste burning on beaches. As a subtype of clastic plastiglomerates, pyroplastics are observed along the strandline on the coast and rocky outcrops towards the wave-sheltered beach. Sometimes, due to geographical features, pyroplastics found in estuaries may be incorporated into the strata via river sedimentation.[17]

Characteristics of Pyroplastics–*Visual and physical characteristics*

The pyroplastics found in the literature varied in terms of color and shape. They are gray, yellow, green, and blue and can be confused with stones due to their appearance.[1,18,19,21] Pyroplastics first reported on beaches from southwest England were characterized by a single, neutral color such as black-charcoal-gray, off-white or brown, with occasional hues of green, blue, yellow or pink. Cracks and fractures, pits and cavities accompanied them.[16] The aspect ratio (primary diameter divided by secondary diameter) ranged from 0.42 to 7.5 mm, with a median of 2.04 mm. Generally, higher aspect ratios were accompanied by more angular pyroplastics containing relatively high quantities of agglomerated extraneous plastics. In comparison, lower

aspect ratios were associated with more rounded pyroplastics with relatively few extraneous plastics. The former pyroplastics could be considered better as plastiglomerates, and the latter pyroplastics could be described as a plastic pebbles.[16] The pyroplastics from Giglio island visually resembled those from beaches in southwest England.[15] They were grayish with blue inclusion and had a stone-like appearance. Their size was roughly 2.0 cm (length) x 1.4 cm (width) x 0.5 cm (height).[1]

The pyroplastics first reported from the coast of the Pacific Ocean in Japan had an indeterminate shape and were black across the entire surface due to combustion-with a few white or translucent spots which can be mistaken for original plastic. The once-molten green plastics sticking to a rounded pebble formed some of them. The host rock on which the plastics were stuck was relatively smooth, and the stuck plastics were several centimeters in size.[17] The pyroplastics found in Peru exhibited near rock-like shapes, with smooth surfaces, porous structures or vesicles, and fractures. The diameters of pores or vesicles ranged from 0.17 to 2.23 mm. Their colors were orange, gray, and green. Some of them were considered to be in the early and middle stages of formation, which are recently burned plastics yet maintained their color and partially original shape. For completely melted and weathered pyroplastics, it is improbable to trace their origin based on their physical and chemical compositions. However, in some cases found in Japan and Peru, their source could be easily traced because part of the plastic matrix needed to be fully melted and its original shape was still distinguishable.[19]

Most pyroplastics were buoyant.[3,15] Turner et al.[16] reported that the mass of the pyroplastics in their study ranged from 0.097 to 274 g, with a median mass of 0.358 g. Moreover, it was observed that the encapsulated material within the pyroplastics was primarily plastic rather than sand or rock. Many samples did not appear to have agglomerated any significant quantities of extraneous material, resulting in a comparatively low bulk density that enabled them to float in seawater.[16] Specimens in Furukuma's study also floated in freshwater, confirming that they had a lower gravity than water.[17]

Overall, the colors and shapes of pyroplastics vary. They are generally characterized by opaque green, blue, or white hues, as well as darker tones such as gray and black. They are amorphous matrices composed of angular to weathered-round shapes with or without inclusion. Though similar to plastiglomerates, pyroplastics are distinguished by plastic encapsulation

without agglomeration of extraneous materials, leading to low bulk density and subsequent floating in seawater.[22]

Chemical Characteristics

Pyroplastics exhibit a rocky appearance; however, they are a distinct class of material not of geological origin. They consist of various polymers. In previous studies, Fourier-transform infrared (FTIR) spectrometry coupled to attenuated total reflectance (ATR) was conducted to confirm all suspected plastic matrices. ATR-FTIR analysis is commonly employed for polymer identification. It is necessary to determine the chemical composition of pyroplastics using this analytical technique to differentiate them from other plastic-like materials and understand the sources of plastic pollution.[15,20] ATR-FTIR measurement revealed that pyroplastics from England consisted of either polyethylene (PE), polypropylene (PP), or both.[16] The item from Japan was similar to those from England regarding chemical composition. FTIR analysis determined PE or PP as its polymer type.[17] PE and PP are some of the most widely used synthetic polymers with a specific gravity of less than 1, and account for nearly half of all plastic products manufactured worldwide, such as packaging, containers, toys, etc.[23,24]

Unlike pyroplastics found in the UK and Japan, those from Giglio island were not composed of PE or PP: they were instead composed of polyethylene terephthalate (PET), a typical beverage bottle material.[25] The researchers often found blue PET bottles and witnessed burnt charcoal on the beach where they detected the pyroplastics. The detected pyroplastics may have originated from a PET bottle that melted during campfires. The researchers suggested that the origin of the pyroplastics could be linked to a fire resulting from waste incineration, as they often noticed a pungent odor of melting plastics emanating from nearby fires in private properties during their field surveys.[1] In fact, in pyroplastics found in Peru, more various polymers were identified by ATR-FTIR spectroscopy: PP, high-density polyethylene (HDPE), PET, and polyamide (PA). This is the first report of PA being identified as a component of pyroplastics. PA was found as a small black inclusion in a larger orange HDPE pyroplastic. Given that the orange HDPE pyroplastic was found in a location known for active fishing activities, it is possible that the PA inclusion resulted from discarded fishing gear.[19]

Along with the analysis of polymer identification, some studies were analyzed to determine extraneous elements and contaminants ranging from Na to U on the surface of plastics

using X-ray techniques such as Energy-dispersive X-ray (EDX) spectroscopy or X-ray fluorescence (XRF) spectrometry. The concentration of elements such as Br, Cd, Cl, Cr, Cu, Fe, Pb, Sb, and Zn on pyroplastics was detected,[16, 17,19] which was probably associated with leaching additives.[19] The principal pigment of Pb used in plastics was lead chromate (PbCrO4), affecting a range of reds, yellows, and greens with high tinting strength and opacity by either itself or mixing with other compounds.[19] Among pyroplastics, there was a strong correlation between Pb and Cr by XRF analysis. The analysis revealed variable quantities of Pb in the matrix, often in the presence of Cr, suggesting that materials used in these samples were produced before restrictions were placed on using lead chromate.[16,19]

In brief, most plastic matrices in pyroplastics contain the same polymers such as PP, PE, and PET. However, the sources of plastic are only sometimes determined but are suggested based on the polymeric composition; for example, PET may have originated from plastic bottles. XRF analysis also revealed various elements indicative of polymeric additives and, in some cases, small quantities of extraneous inorganic matter such as sand and wood. Table 1 summarizes the physical and chemical characteristics reported in the previous studies.

Table 1: Summary of the previous studies reporting pyroplastics

Reference	Location	Color of plastic	Dimensions	Polymer composition	Sources of plastic
Turner, et al., 2019	Beaches from SW England	Multiple colors	12.9 x 6.6 mm[a]	PP, PE	Unclear
Ehlers & Ellich, 2020	Giglio island in Italy	Gray with blue inclusion	2.0 x 1.4 x 0.5 cm	PET	Plastic bottle
Furukuma, 2021	Seto inland sea in Japan	Black with white inclusion	Various size	PP, PE	Unclear
De-la-Torre, et al., 2022	Beaches from Peru	Orange, gray, green	7.9 x 3.4 cm	PP, HDPE, PET, PA	Fishing gear, plastic bottle

Impact on The Environment

The environmental impacts of pyroplastics reported in the literature were mostly related to chemical release and plastic ingestion.[1,14,16] Pyroplastics are the source of tiny plastic particles, so-called microplastics since they are physically fragile and easily degraded by burning and weathering.[16,17,21] Microplastics are likely to be taken up by organisms, enhancing the potential for toxicity, and microplastics formed from pyroplastics are predicted to have even stronger toxicity.[17] The physical and chemical properties of particles derived from pyroplastics are likely to differ from those generated from unburned plastic, altering their toxicological properties. For instance, PAHs (Polycyclic Aromatic Hydrocarbons) concentration on pyroclastic-derived particles could increase toxicity.[20] Weathering releases some toxic chemicals from plastic materials in marine biota.[26,27] For example, brominated flame retardants (BFR), one of the industry's most profound plastic additives and known for their detrimental effects on biota, can accumulate along the marine food web and cause reproductive and adverse behavioral effects in biota.[28] Also, bisphenol A (BPA) can cause endocrine disruption, having negative impacts on the marine system.[29,30]

There are concerns about biological impacts if various species ingest micorplastics.[17] Because microplastics are less than 5 mm and very small, a concern of pyroplastics is the potential for chemicals to biomagnify the food web.[16] Secondary contaminants are more easily released in organisms than seawater, resulting in direct toxicity or accumulation in organisms that subsequently transfer along the food chain.[31] Microplastics and associated benzo[a]pyrene could be transferred from nauplii to zebrafish.[32] Therefore, pyroclastic-derived microplastic can enter food webs via consumption by invertebrates and consequently cause biological threats to the affected organisms.[33,34]

As suspected environmental impacts of pyroplastics, De-la-Torre et al.[15] suggested that the buoyancy and durability of the pyroplastics could turn them into vectors of alien invasive species (AIS). In addition, plastics, due to their properties, can create a habitat for microbial pathogens,[35-38] and the biofilms presented on the surface of plastic debris may protect pathogens from mechanical damage, shear by water and predators, and stimulate bacteria growth owing to the more availability of nutrients and metabolites.[39] Like long-lived floating plastic wastes, pyroplastics could potentially be reservoirs of microorganisms and pathogens, which likely accelerates their dispersal in the environment, thus having a role in the spread of microbial

diseases for wildlife and humans. In addition, colonized pyroplastics could encounter effluents contaminated with antibiotics, resulting in the acquisition of antibiotic resistance genes (ARGs).[40] The dissemination and migration of ARGs in plastic wastes increase environmental and human health threats.[41,42] Put together, some of the recognized impacts on the environment of pyroplastics are toxic chemical lease, microplastic ingestion, and potentially AIS/ARGs transport.

Conclusion

Pyroplastics, which have recently received attention as a new marine pollutant, are not local phenomena, but their occurrence is reported worldwide. The sources of pyroplastics are burning and weathering. Their colors and shapes vary, consisting of various polymers, including PP, PE, and PET. Released and disseminated secondary contaminants (e.g., microplastics, additives) can accumulate and be passed up along the food chain, resulting in biological threats to the environment and human health.

Based on the literature, this short review provides an overview of the occurrence, properties, and potential environmental impacts of pyroplastics. However, there remain various knowledge gaps in understanding pyroplastics since this issue is still in the early stage of the investigation. To fully uncover the veil of pyroplastics in the environment, the following suggestions will be worthy of study in the future.

First, more research is required to document the distribution and abundance of pyroplastics. To determine whether these novel contaminants are globally widespread, as suspected, continuous efforts should be devoted to investigating and reporting the worldwide occurrence. Moreover, to avoid underestimating pyroplastics as marine pollutants, including these new plastic litter categories in monitoring guidelines and action plans is significant.

Second, it is necessary to establish unified standards which include classification and units of pyroplastics. Also, there is a need for standardized analytical methods on sampling, pretreatment, quantification, and identification and a standardized toxicity test methodology. As a standard protocol has yet to be established, comparing the results across the studies was difficult, thus blocking the development of relevant research. Therefore, further studies should focus on building standards and unified analytical methods to promote a better understanding of pyroplastics.

Third, understanding the mechanisms of toxic effects is an important matter that needs further research. Are toxic chemical release rates altered by the burning and weathering conditions pyroplastics undergo? What factors may affect the mechanisms of toxic effects on organisms? To what extent can toxicity induce damage? Answers to these questions are uncertain; thus, more relevant data are essential to reveal potential threats to the environment and organisms fully. Studies are limited to reporting the occurrence of pyroplastics than assessing their impacts; accordingly, examining the ecotoxicity should be done.

Lastly, pyroplastics that are the source of microplastics are more accessible to organisms thus resulting in chemical and biological impacts. However, these impacts are probably chronic effects, which are not easily observed, and limited data is available. Therefore, future studies must significantly understand the harmful effects on organisms and human health.

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Dress to Express, Not Impress: Lessons from the 1850s Women's Dress Reform

By Celine Omega

Abstract

More than ever, fashion has evolved to something more meaningful than a chic layer of clothing. At a mere glance, today's people use clothing to communicate their identities and beliefs to the outside world, bringing along new forms of expression and activism. However, this freedom of expression has come a long way. The association between fashion and activism originated from a small group of persistent women. During the 1850s, feminists protested the inconvenience of traditional dress that impeded their productivity, affected their performance in the labor force, and jeopardized their health. This first women's dress reform movement was the origin of the fight for women's freedom to wear what they desired.

This first reform faced severe backlash—which included harassment and moral debates over reforming gender-assigned dress—problems that continue to be a recurring theme today. Though the movement struggled to make its mark, it has opened doors for the use of fashion for human rights activism and provided important lessons for future advocates who fight for women's rights and other civil rights. Future movements benefit from its lessons, such as having visibility to convey their messages, a unity of direction, and the flexibility to adapt to new changes. As movements in history evolve through time, fashion has served as a record of how far society has grown and continually inspired new forms of protest through its visibility.

Woven in History

Imagine working in a garden—stubborn weeds, wet dirt, and the simmering sun beating down with no air conditioning. Under those circumstances, it seems miserable, but now, add a fifteen-pound dress to the picture. Hauling pounds of clothes over mud as lace and stitching catch sticks and stones at every turn, women experience how inconvenient these skirts and corsets can be as they are simply no match for the tumultuous labor of household gardening. Women of the mid-1800s had no choice but fulfilled their domestic duties this way. Wearing clothes that jeopardized her productivity and health, Elizabeth Sarah Miller decided she had had enough of the restrictive dress and wanted to offer an alternative (Kesselman 498).

Arriving at the 1851 Seneca Falls Convention, Miller debuted the earliest version of women's pants: Turkish pantaloons. She introduced this new style as a solution to health and

labor concerns women across the country had been seeking. Other feminists like Amelia Bloomer noticed the innovation's potential benefits. Using her platform, *The Lily*, the first female-led U.S. newspaper, Bloomer published an article about the pantaloons, bolstering their popularity. Her contribution was so significant that people gave the pantaloons a nickname, 'Bloomers.' In response to this nickname, she stated, "I had…no thought of setting a fashion; no thought that my action would create an excitement throughout the civilized world, and give to the style my name and the credit due Mrs. Miller" (Bloomer 67). Unbeknownst to both Miller and Bloomer, their efforts led to a rise in the visibility of women's trousers, creating a new movement that later sparked controversies they would have never expected.

Fashion Flop

The Bloomers created a complex scale of responses from the American public. A group of feminists known as dress reformists believed there was a strong link between a dress reform movement and the fight for women's rights. However, the public's initial reaction was not supportive. The thought of women wearing trousers teetered dangerously into rewriting gender roles and threatened the clear divide between masculine and feminine powers.

The movement advocated two purposes: health and civil rights. Traditional dress and corsets could have harmful health effects, which include the unhealthy compression of bones and muscles and overheating. Thus, society did not view the movement to change women's dress code for health reasons as an issue. However, the patriarchal world did not favor the reformists' use of dress reform to raise awareness of gender discrimination and blur gender distinction, resulting in character attacks to undermine the movement. In a series of John Leech's 1851 political cartoon paintings, *Progress of Bloomerism* and *Bloomerism—An American Custom,* women in Bloomers were often depicted smoking or neglecting their families as a crowd distastefully looked towards them (Leech). Many believed that if a woman were to think freely and dress like a man, she would become a barbarian with immoral desires and a threat to the social structure men had created. During this period, the term 'pants' were a strictly masculine form of expression; as a result, newspaper critics would label Bloomers as 'pants' to incite the dress as a form of intrusion towards male social domains (Kelly 75). Gender distinction became a means to oppress women under the restraints of femininity. Clothing furthered served as physical divides, creating a gender binary and emphasizing who had the power.

The dress reform of the 1850s received mixed support from women. The majority viewed it as an unnecessary disturbance. These women had gender roles engrained in their reputation, and the traditional women's dress was a sign of Christianity and modesty, patriarchal values expected of a perfect woman (Kelly 72). Breaking that image would danger women's safety due to their dependency on men's resources. One woman in an 1894 *New York Times* article wrote that she spoke to a friend and commented that it took moral courage to support dress reform; her friend responded with, "Moral courage! It takes wrestling with the Lord." ("For the Liberated" 18).

There was also a lack of support among feminists. These feminists felt that dressing in pants would only strengthen the idea that power could exist only through masculinity or mimicking men. They wanted to redefine their rights by showing that femininity was as powerful as masculinity. When dress reformists began to appear at women's rights conventions, many fellow activists alienated them (Kelly 70). Despite sharing the same mission to gain women's civil rights, other feminists excluded dress reformists from their activities, believing the reformists' intentions to advocate for women's rights were less credible.

Without true unity among their supporters, the women's dress reform movement severely weakened without a shared agenda. During the 1870s, the Women's National Dress Association, the formal organization of dress reformers, struggled to unite its members. Within this organization, one group, supported by Lydia Hasbrouck, thought women had to fight in smaller battles, such as clothing rights, before going after larger legislative battles (Kelly 73). Another group, including Lucy Stone, argued that they needed to gain power from voting, property, and educational rights before initiating a dress reform and improving other areas of women's rights (Kelly 73). The two groups severely divided the association, leading to inefficient progress toward the dress reform movement.

Due to numerous setbacks, many reformists saw the movement as a lost cause as people were too focused on opposing the movement instead of listening to its message. Eventually, avid supporters of Bloomers, including Elizabeth Cady Stanton and Lucy Stone, began to advise other reformers to put away their Bloomers and revert to traditional dress. In a letter to Lucy Stone, Elizabeth Cady Stanton wrote, "We put [shorter dress] on for greater freedom; but what is physical freedom compared with mental bondage?" (Stanton). The social weight of the new dress

became heavier than the clothes women originally carried, and thus, the first wave of the reform dwindled.

Remodeling the Movement

Despite countless harassments and failures, the movement has never completely died as it has continued inspiring the next generation to fight for women's clothing rights. Reformers adopted subtle changes to fashion activism during the 19th to 20th centuries. These changes included shortening skirts, loosening corsets, and altering the support structure of gowns and undergarments.

By the late 1890s, there was a wider acceptance of Bloomers for health and sports-related reasons. During this time, women also began to travel with bicycles, and many wore Bloomers to add comfort. By the mid-1910s, women were a significant part of the workforce, working in farms and factories to provide supplies for World War I while men fought in it (Fischer 175). Women working in factories wore no-corset dresses with fewer skirts to prevent fire hazards and avoid machine-related injury. Due to these circumstances, society was initially forced to accept women wearing pants out of necessity and for health reasons. However, as women's position in society improved from gaining educational, voting, and property rights, Bloomers or pant-like clothing naturally became more widely accepted. This newfound power allowed women to have more options to dress. Learning from the 1850s reform, the early 20th-century reformists took a different approach. An impactful change would happen from having a unity of direction, visibility to convey powerful messages, the flexibility to adapt to new changes, and relentless persistence.

In the 1910s, suffragettes organized women’s marches called ‘Monster Parades’ in cities like Chicago and St. Louis and created a suffragette uniform that symbolized hope and built unity. The uniform included a white dress, a sash identifying one’s home state, and a matching hat (Atkins 144). The white costume and color represented unity without the need to show that women must act or dress like a man to have power. These events garnered support for the women's suffrage movement, leading to the ratification of the 19th Amendment. In 1919, the United States Congress passed the 19th Amendment that allowed women to vote. A group of feminists dressed in their white uniform witnessed Vice President Thomas R. Marshall and Speaker of the House Frederick H. Gillet signing the new law ("Footage of the Women's

Suffrage Movement, 1910s-20 [Silent]," 2020). Their white clothing later became a common trend among women in politics at national events.

The new amendment and World War I led to the 1920s flapper movement and the second wave of dress reform. Teen girls and young women advocated for less chaste and more expressive liberations that others considered immoral (History.com Editors). During this period, a new fashion of low waists, shorter skirts, and form-fitting silhouettes emerged and continued to push against conventional norms. The flapper movement marked the first-time women could have the type of power or freedom that the 1850s dress reformists initially hoped to gain.

A Timeless Trend

To this day, the 1850s dress reform has opened doors for the use of fashion for human rights activism. Many movements, activists, and well-known figures use clothing to convey messages and fight for civil rights. A few examples of modern-day fashion activism highlight the legacy of the 1850s dress reform.

In response to President Trump's inauguration in January 2017, thousands of Americans protested the administration's threats against women's reproductive health and civil rights, known as the Women's March, in Washington D.C. (Siemaszko, Corky, et al.). The advocates, mainly women, donned pink hats with cat ears, reclaiming a misogynistic term the former president used in past remarks. Modern women, though dressed in pants, still need to fight and advocate for issues of self-expression and women's rights as they continue to combat patriarchal rules and values. However, in today's activism, clothing conveys messages reserved for not only women's rights. Other movements, like the Black Lives Matter (BLM) movement, utilized clothing and slogans to sustain their powerful messages, demonstrating the impact of the dress reform movement in the fight for other civil rights (Abu).

The younger generation also continues the dress reform legacy by speaking up for equality. For example, in 2016, the parents of three female students from a charter school in North Carolina filed a lawsuit against the school dress code. The school's policy stated that all female students must wear skirts. These students felt that the school's dress code violated their rights to express themselves. The U.S. Court of Appeals ruled that the school's policy violated Title IX, a federal law protecting students from gender discrimination, and perpetuated harmful gender stereotypes (Oxenden). Reflecting on the event, a student named Bella stated, "I just threw a fit, [but] now I know that little girls like me can now wear whatever they want"

(Oxenden). This court victory supports an individual's freedom for self-expression, assuring that individual identity has priority over rules supporting gendered clothing.

The fight for equal rights to dress has extended to others who also want to express their true selves. In recent years, there have been movements to advocate for more inclusive school dress codes not only for girls but also for students of color who disproportionately face the consequences for violating these codes (Claybourn). Extending towards LGBTQ+ communities, the dress code expands beyond the constructs of what a 'man' or 'woman' should wear to recognize and embrace everyone authentically. When the 2015 Transgender Movement occurred, visibility was one of the biggest lessons it taught (Singer). Like Amelia Bloomer and her newspaper, *The Lily*, fashion magazines play an important role that allows a spectrum of identities to thrive, resisting a system that determines what a 'woman' or 'man' should wear. Being seen and heard is the purpose of every movement, for its persistence to tilt the needle to a better world.

Fitting the Pieces Together

Today, people still struggle to reverse the damage from systemic gender discrimination and inequality, but the chain reactions of the 1850s women's dress reform have ignited people to keep redefining the status quo. In a *Vogue* article titled "The Year in Fashion: The Trans Movement Went Mainstream in 2015, and Fashion Led the Way," Maya Singer wrote, "People often write off fashion as frivolous, but by including gender-nonconformity…we show our power as a progressive force. Visibility is the foundation of any civil rights movement" (Singer). The most powerful thing about dress activism is the blatant display of people's identities and ideals. History has shown that the dress reform movement had met some failures, yet brave people continue to wear their vulnerability with no physical place to hide. These people put themselves in danger to loudly proclaim their existence, opening the world's eyes and inspiring others to be unafraid of doing the same. Though there is still more work, fashion continues to increase its visibility and political influence, providing outlets for people to dress to express themselves in the face of scrutiny.

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Robotics and Artificial Intelligence in Senior Care: Exploring Three Distinct Functional Categories By Daeun Chung

Abstract

As many developed nations, including the United States, experience population aging, the demand for healthcare and caregiving services is growing rapidly. However, due to the decreasing number of human caregivers and increasing risk of infectious disease like COVID-19, it has become challenging to meet individuals' needs for senior care services. This necessitates the implementation of innovative approaches, such as robots and artificial intelligence (AI) in senior care services. In this article, we explore three distinct functional categories—health monitoring services, emotional and mental well-being services, and social engagement and companionship services—of senior care robots and AI-based softwares and introduce examples for each.

Introduction

The United States, like many other developed nations, has experienced a significant demographic shift as its population continues to age. This phenomenon—population aging driven by several factors including increased life expectancy and declining birth rate—has rapidly increased the proportion of older adults within the population and eventually placed a greater demand on healthcare and caregiving services. Moreover, as the COVID-19 pandemic has demonstrated how vulnerable older adults are to the virus, and thus, how risky conventional on-site elderly care programs are, it has become necessary to explore innovative approaches for senior care services that minimize physical contact but still provide essential support and assistance.

By 2020, 16.8% of the U.S. population was 65 years or older. This percentage is expected to grow to 21.6% by 2024. Additionally, the 85 and older population is projected to more than double from 6.7 million in 2020 to 14.4 million in 2040 (Caplan, 2023). Along with this escalating senior population, the need for caregivers has been growing rapidly. However, ironically, the number of healthcare professionals has continuously been decreasing with no anticipation to increase in the foreseeable future (Rincon et al., 2019). Consequently, this decline

in caregivers has created a significant disparity between the supply and demand for qualified individuals to meet caregiving needs.

The COVID-19 pandemic has amplified those existing challenges. Older adults, particularly those living in communal settings or nursing homes, have been exceptionally susceptible to the virus. In 2020, 66.2% of COVID-19 deaths among adults aged 65 or over occurred in healthcare settings, where on-site senior care services were unavoidable. Furthermore, according to data from the Centers for Disease Control and Prevention (2022), Americans aged 65 and older have made up 92% of all deaths from the COVID-19 virus, suggesting that COVID-19 has posed much more devastating threats to older adults than other individuals from different age groups once infected.

This harsh reality has underscored the importance of a non-contact senior care service. By reducing face-to-face interactions between caregivers and older adults, a non-contact senior care service not only protects vulnerable older adults from the spread of infectious diseases like COVID-19 but also offers safe health care. In this article, we will explore three distinct functional categories—health monitoring service, emotional and mental well-being service, and social engagement and companionship service—of non-contact senior care services that utilize artificial intelligence (AI) and robots and introduce examples for each.

Health Monitoring Service

Equipped with sophisticated sensors and AI, robots are bringing significant changes to the way individuals approach healthcare. Observing the users' activities of daily life, robots are now capable of providing health insights and predicting health declines. For instance, if there is a sudden change made in the users' daily routines and the change is associated with the symptoms of a certain disease, robots will issue warnings to their users and caregivers about any health problems the users may have. This section is dedicated to introducing senior care robots' potential to serve as healthcare professionals and offer support related to their users' health conditions through examples.

Tempo

Developed by CarePredict, Tempo is a wearable gadget that earned the Innovation Award three times at Consumer Electronics Show (CES) in 2021, 2022, and 2023. The most distinct

function of Tempo from other wearable fitness bracelets is that it can predict health problems. Using an array of sensors, including motion, heart rate and pulse oximetry sensors, indoor location data, machine learning, and gesture recognition algorithm, Tempo monitors the daily routines and patterns—eating, walking location pattern, activity level, sleep duration and quality, cooking, bathing, and eating duration—of its users and detects anomalies.

For instance, if behaviors like skipping meals, having restless sleep, staying away from bright lights and sunshine, and reducing outdoor activities are detected, Tempo signals its users and their caregivers about the presence or possibility of depression (Kim, 2021). Also, if the users sleep less and frequently get out of bed at night, Tempo will warn the users' caregivers or family about potential fall risks. Frequent bathroom visits during the day and night will make Tempo notify possible urinary tract infections (UTIs) to the users as well. The predictions made by Tempo are proven to be useful as Wilmink et al. (2020) demonstrated that older adults who used Tempo for 24 months had a 40% lower hospitalization rate and a 69% lower fall rate compared to the elderly who did not in his study (Kim, 2021).

In the case of emergencies, the users can press the built-in assist button to send alerts to their families and caregivers. The two-way audio feature also enables the users to directly communicate with their caregivers or healthcare professionals.

Because the users' daily habits and health conditions are all recorded in CarePredict Enterprise, a smartphone application, the target user of Tempo has been expanded from only seniors with physical discomfort to middle-aged individuals who are interested in self-caring and CarePredict Home Kit is still available on market for the price of $499.50.

Fig 1: CarePredict's wearable gadget Tempo and smartphone application

Sensi.AI

Sensi.AI's Sensi is the world's first in-home virtual care agent which provides 24/7 senior care service through its audio-based AI software.

One notable benefit that Sensi has is discretion. Collecting the audio data in care environments, the data is sent to Sensi.AI's secure cloud and is processed automatically to detect any anomalies. If Sensi notices any unusual, abnormal activities—including calls for help, fall, adverse events, or irregular activities of daily living—in the audio files it receives, it will alert the users' family and caregivers for further assessment. Unlike Sensi's competitors, Sensi does not require a camera for monitoring. Rather, Sensi analyzes only the audio files with no human operator, utilizing AI. Therefore, Sensi safely protects its users' privacy and is compliant with the Health Insurance Portability and Accountability Act (HIPAA) (Hunnicutt 2023). Also, any additional purchase of hardware is not needed in order to use Sensi as Sensi can connect to smart speakers, smartphones tablets, microphones, security cams, or any other audio hardware that its users have had.

By January 2022, Sensi.AI was able to raise $25 million from their investors and is currently available to senior care agents.

Emotional and Mental Well-being Service

Although robots have been described as cold-blooded, emotionless objects that could never build any empathetic interactions with humans, the remarkable development in technology now enables robots and AI to address emotional needs and promote the overall well-being of individuals.

One significant technology that allows robots and AI to be integrated into mental health care is emotion detection. It gives robots and AI the ability to recognize humans' emotions and execute proper responses in different situations. More specifically, there are three ways that robots and AI collect data about their surroundings and eventually interpret human emotions: speech recognition, facial expression recognition, and bio-signal recognition.

Speech recognition uses the fact that emotions can be expressed through several verbal elements. It analyzes pitch, volume, and speed of voice, as well as accent and word choices in verbal communications. Facial expression recognition examines face shape, hair type and color, eye shape and color, and the movement of facial muscles. It first characterizes the users' faces and predicts what feelings they have. Lastly, bio-signal recognition surveys the users' breath, sweat, and body temperature, observing the different responses that the autonomic nervous system has to emotions. With simultaneously accumulated data from various parts of our body, robots and AI conceive the emotions of humans and provide more individualized services to their users (Jeong, 2018).

Some emotional robots are even accepted as medical devices for dementia and depression as they are proven to be capable of providing comfort and emotional support to their users. This section will explore the potential of emotional robots to enhance therapy and foster a sense of connection and understanding in the digital age through examples.

PARO

Invented by Takanori Shibata of the Intelligent Systems Research Institute of the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, PARO was officially launched in 2004. Although its main function is to comfort users and elevate their moods, PARO cannot recognize its users' emotions, unlike other advanced emotional robots. However, as a therapeutic robot designed to provide emotional support and companionship, PARO is still capable enough to evoke emotional responses and release stress from its users.

Imitating the appearance, sounds, and behaviors of a baby harp seal, PARO has five sensors dedicated to tactile, light, sound, and posture. With those sensors, PARO perceives and responds properly to changes in its environment. PARO also skillfully tracks the direction of sounds it hears and maintains a warm temperature similar to that of a live animal. It further engages its users by moving its neck vertically and horizontally, its front and rear fins, and its eyelids as well.

Notably, PARO has three types of behaviors: proactive, reactive, and physiological. While proactive behaviors are generated based on PARO's desires and biological rhythms (Kim, 2016), reactive behaviors are often performed as a response to sudden stimuli. Paro also has a circadian rhythm, which executes its psychological behaviors in the form of sleep and wakefulness (Shibata et al., 2012; McGlynn et al., 2016).

PARO's significant effect on individuals' mood shifting has been proven in various studies. More specifically, Wada et al. (2004) suggested that introducing PARO into senior care centers has fostered an increase in the level of happiness and positivity of older adults in their study. Also, Musha et al. (2002) found that interacting with PARO has improved the cortical neuronal activity of its users, helping some dementia patients to become less impaired after the experiment through an electroencephalogram (EEG) technique. In September 2009, PARO finally got approved as a Class II biofeedback medical device by the U.S. Food and Drug Administration (FDA).

BOMI I and BOMI II

Co-developed by Gyeonggi-do Regional Research Center (GRRC) in South Korea, Robocare's BOMI I and BOMI II were launched in 2020 and 2021 respectively to provide cognitive training services for the elderly who are suffering from dementia. Although BOMI I's functionality is mostly concentrated on strengthening its users' prefrontal cortex, parietal lobe, and temporal lobe through its specialized, interactive content, BOMI II goes above and beyond its realm as an emotional robot.

BOMI II asks its users 30 questions in casual conversations to evaluate them on the geriatric depression scale (GDS) and reads the users' emotions by analyzing their replies through its database. As BOMI II has been already trained with 13,500 possible responses from its users and 36,000 commonly used sentences, BOMI II is capable of identifying 8 distinct

feelings—including happiness, sadness, anger, and disappointment—and generating a proper reaction depending on the users' mood and interest (Lee et al., 2023). With its ability to build emotional bonds with its users, it is anticipated that BOMI II can treat people with depression as well.

Furthermore, BOMI II implements several key features not only to address the emotional and mental well-being of elderly individuals but also to help them with their physical healthcare needs. Through its motion recognition technology, it monitors its users' activities, reminds them of their daily schedules, and notifies the users' relatives and nearby hospitals if an emergency happens. Additionally, BOMI II can self-drive and even go to its charging station by itself without any command when it has a low battery.

With the convenient and helpful services BOMI I and II offer, they are widely adapted into single elderly households in South Korea and especially, BOMI I is currently used for dementia patients at the Robotic Cognitive Therapy Center of Ewha Woman University Mokdong Hospital located in South Korea.

Jennie

Although it is a well-known fact that companion animals promote psychological comfort and physical health of older adults (Clark et al., 2010; Bao et al., 2016; Mičková et al., 2019; Kim, 2021), some of the elderly can barely access those benefits due to various factors. In the case of Nancy Stevens, the mother of Tombot co-founder Tom Stevens, she could no longer safely care for her dog and eventually lost it as her Alzheimer's dementia progressed. Aiming to create a robotic animal that has only the advantages and no challenges of having companion animals, Tombot is developing Jennie, a robotic emotional support dog.

Crafted by the experts at Jim Henson's Creature Shop, a special effects house located in Hollywood, Jennie mimics the appearance, sounds, and behaviors of a golden retriever. Through its voice activation software, Jennie will react to its users' verbal commands. Its tactile sensors enable Jennie to react to its users based on how and where it is being touched. The smartphone application that comes with Jennie even allows users to customize Jennie's functionalities.

By November 2021, Tombot raised $5 million in growth capital through StartEngine and is now receiving pre-orders through its website at an affordable price of $449.

Social Engagement and Companionship Service

Although animal-assisted therapy has proven its positive effects on tackling loneliness and depression experienced by the elderly (Filan et al., 2006; Bernabei et al., 2013; Song, 2022b), as mentioned in the previous section, there are several obstacles—including the risk of allergies and infections from therapy animals and financial and time commitment required to take care of the animals—that have challenged adapting animal-assisted therapy as a component of senior care services. Therefore, social robots have initially been introduced as an alternative to animal-assisted therapy.

The noticeable advantage of social robots over therapy animals or robotic emotional animals is that social robots are capable of expressing their own emotions and forming unique personalities based on high-level conversations they have conducted with their users (Song, 2022b). Social robots may incorporate a few main features of emotional robots like recognizing the users' emotions, but the primary goal of social robots is to provide companionship and encourage the social engagement of their users, rather than offering emotional comfort. This section is devoted to exploring the potential of social robots to foster social engagement and companionship through examples.

Pepper

Pepper is a humanoid robot that SoftBank Robotics developed and presented on June 5, 2015. What makes Pepper so distinctive and advanced from other social robots is its ability to capture its users' speaking patterns and recognize their emotions (Kim, 2016). Pepper is also capable of performing human-like gestures, initiating a casual conversation with the users, and playing cognitive games like "rock-paper-scissors". Additionally, it can be further used to help people exercise as it provides music streaming services and fitness programs.

Unlike other robots available on the market, Pepper has trained with AI platform Watson and Azure, Microsoft's cloud service (Kim, 2016). In 2017, SoftBank also announced that they were planning to collaborate with Every AI, a facial recognition platform, to strengthen Pepper's emotion recognition capabilities.

However, the current version of Pepper still has room for improvement as its hardware is fragile. With a height of 120 cm and weight of 29kg, it is only able to perform simple tasks, such as carrying lightweight objects. Although sensors implemented in Pepper allow it to move freely

by itself without colliding with other objects or people (Rincon et al., 2019), it is impractical to use Pepper for direct physical assistance. Because of this flaw, SoftBank faced weak demand for Pepper and eventually paused its production of Pepper in June 2021.

Jibo

Jibo is a social robot invented by Cynthia Breazeal, a professor at the Massachusetts Institute of Technology (MIT) Media Lab. Launched on Indiegogo in 2014, Jibo gained substantial attention from the beginning. It raised more than $3 million—which added up to over $70 million in funding when combined with venture capital—and got approximately 6,000 orders during this crowdfunding presale. In September 2017, Jibo became available on the market for the price of $899 and it was immediately named one of *Time*'s 25 best inventions of 2017.

The most significant function of Jibo is its unique motion and face recognition that enables Jibo to provide personalized, customized service to each individual. For instance, if Jibo detects that people are cooking, using its two cameras and six microphones, it will ask them whether they need any more groceries and even place an order online. Additionally, with its two spherical halves rotating on a three-axis motor system and a 5-inch rectangular color display, it can tell bedtime stories to children in an interactive fashion—through dancing or purring (Price, 2017).

Jibo's ability to construct endless conversations is also conspicuous from other AI assistants like Alexa or Siri. Jibo can initiate a conversation with its users without prior verbal commands from its users. Even when the user asks questions, after answering the question, Jibo can go above and beyond to continue conversations.

Furthermore, by reminding older adults of medication schedules, appointments, and important tasks, Jibo expands its realms from a household robot to a noncontact senior care robot. Puzzles or brain teasers that Jibo provides keep its users and their brains active and entertained. When Jibo detects the motion of falling or unusual activity patterns of the users, it will alert caregivers or emergency services for timely assistance as well.

Despite Jibo's recognizable capabilities, Jibo, Inc. announced that Jibo's cloud services would not be supported anymore in 2019 and currently, Jibo is not available on the market.

Hyodol

Hyodol is the most widely used social robot for senior care in South Korea as its positive effect on preventing depression and dementia of the elderly has been proven by several studies. According to Jo et al. (2019), Hyodol has promoted a significant decrease in depression among the elderly aged 67 to 98, especially those who had a high depression level of 11 or more on a 15-point scale. Their study also suggested that Hyodol encourages a crucial improvement in its users' self-efficacy and quality of life. Song (2022a) has found that through continuous interactions, older adults have formed empathetic connections with Hyodol, treating it as their personal secretary, colleague, or friend. Additionally, they even have given Hyodol a unique nickname and made clothes for Hyodol by hand. In 2022, Hyodol was already utilized in approximately 2,200 single elderly households and 50 nursing homes.

Those notable contributions of Hyodol originate from its various functions. Having the appearance and voice tone of a 7-year-old child, Hyodol supports 8 different Korean dialects. When its users touch Hyodol's ears, it will play 300 "trot" (one of the most famous music genres in South Korea) and classical music files, along with 90 songs that Hyodol's voice actors have pre-recorded. Touching Hyodol's head will enable users to start a friendly conversation with Hyodol at any time. Furthermore, it reminds the users of their schedules and appointments. If users come back home after going out, Hyodol will greet them by saying "Welcome home." Lastly, a message is automatically sent to caregivers or emergency contacts if there is no motion detected by Hyodol's sensor for a certain amount of time or if a user holds Hoydol's hands for more than 3 minutes. Through Hyodol's Internet of Things (IoT) technology, it directly manages its users' safety. When it detects that the front doors are opened, it will ask users to close and lock them.

With its proven role as a noncontact senior care robot, Hyodol In. announced that Hyodol 2.0, an upgraded version of Hyodol, will be launched September of 2023.

ElliQ

ElliQ is a care companion specifically designed and invented by Intuition Robotics to alleviate loneliness and encourage social interactions among individuals. Before its official launch in Marchin 2022, it already received a Best of Innovation award from the Consumer Electronics Show in 2018 and proved its potential as a future senior care robot.

Consisting of a stationary social robot and table PC, ElliQ starts a conversation, asks questions, and suggests new activities without prior commands from its users (Kim et al., 2022). As ElliQ gains more information about its users from previous conversations, its services automatically become more and more personalized. More specifically, after learning its users' habits, preferences, and daily routines, it will use AI to recommend videos, articles, or any other content that the users might enjoy.

ElliQ offers other wide range of services to its users, including medication reminders, cognitive games, music streaming, local community updates, and health check-ins. The users can also message and share photos with family members through ElliQ. Any questions regarding general health information and interesting facts will be answered flawlessly by ElliQ as well.

Officially launched in March 2022, 800 units of ElliQ were initially provided to single elderly households in New York, the U.S., as a part of an experimental social welfare program. With its great popularity, the original version 1.0 of ElliQ sold out its limited inventory a few months later and Intuition Robotics announced an updated version of ElliQ, ElliQ 2.0, in December 2022. The new features added to ElliQ 2.0 include a virtual cafe and remote art exhibition. A virtual cafe shows ElliQ users pictures of 18 different cities accompanied by local ambient sounds while a remote art exhibition presents a slideshow of famous paintings with a voiceover discussion of the artworks (Vincent, 2022).

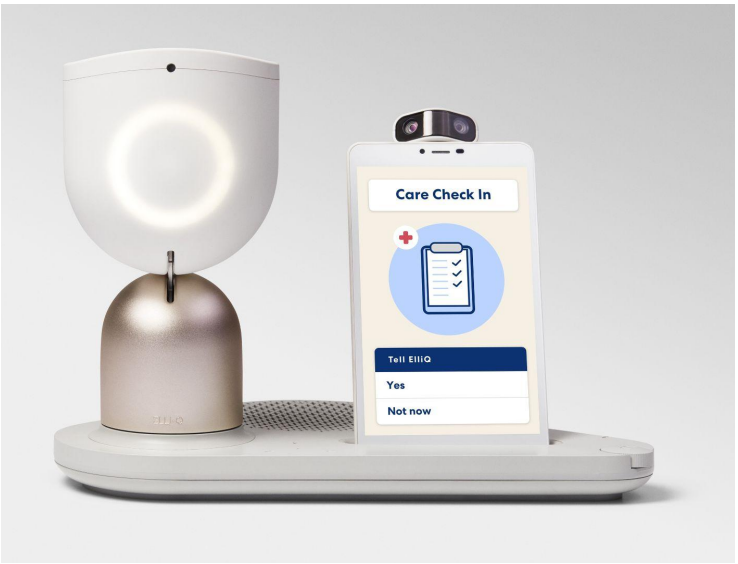

Fig 2: Intuition Robotics's ElliQ

Conclusion

Due to the aging population and COVID-19 pandemic, non-contact senior care services have become widely accepted. This paper designates commonly used senior care robots into three distinct functional categories depending on what kind of service they mainly perform. The first section introduces robots and AI that offer health monitoring services. Most of them learn and follow their users' daily habits through sophisticated, advanced sensors and detect any anomalies, even predicting and warning health problems the users may have. The following section is devoted to exploring emotional robots, which provide emotional comfort and mental support to their users. Although those tasks have been considered impossible for robots to perform, they are now able to read individuals' emotions by implementing emotion recognition technology. They are capable of responding in the specific way that will give the largest emotional comfort to their users, promoting the emotional and mental well being of their users. However, even without emotion recognition technology, some robots can still provide enough emotional support to treat depression the elderly are experiencing. They often mimic animals and are covered with soft fur. Based on what part the users touch, the robots behave and sound differently. Lastly, the paper discusses social robots, which can encourage seniors to be more socially engaged. A common feature that most of them have is the ability to conduct endless conversation with their users. Also, as the robots learn more and more about the users, they provide more and more personalized service, like bringing up the topics that the users are interested in during the conversation. Along with emotional robots, some social robots are proven to have a positive effect on dementia and depression.

However, despite all those innovative approaches to non-contact senior care services, there is a lot of room for discussion and improvement. One of the concerns is that AI and robot-based senior care services might potentially reduce human interactions and replace human caregivers, increasing the sense of isolation and diminishing intimate relationships the elderly have built before. Wright (2023) pointed out in his report that senior care robots have replaced existing social and communication-oriented tasks of human caregivers with new tasks which require more interaction with the robots than the elderly. According to Wright (2023), before using Pepper, the human caregivers led recreational activities like karaoke or had a casual conversation with the residents every Friday at the nursing home. However, when they introduced Pepper to run recreation sessions, all they had to do was boot it up and wheel it to the

front of the room. In the case of PARO, the caregivers spent less time talking with the elderly, and just gave them PARO to play with while monitoring the interaction from a distance. Instead of helping human caregivers to focus more on human labor of social and emotional care, the robots took over those opportunities that human caregivers previously used to build strong connections with older adults.

Also, the other issue that has to be addressed before those senior care robots and AI become ubiquitous is privacy of the users. The users are monitored by robots everyday through cameras and sensors. All of their activities are recorded and sent to the agencies that offer the non-contact senior care services, not families or caregivers of the users. Therefore, the possibility of privacy infringement is not negligible. The legal frameworks and ethics regarding to what extent the data collected by the robots and AI may be used has to be discussed.

The decreasing number of human caregivers and increasing risk of infectious diseases like COVID-19 encourages people to implement these robots and AI for senior care service. With proven positive effects, these robots and AI can significantly make senior care services more efficient and effective, so long as they do not become the primary providers of elderly care services. In order to move forward, it seems necessary to conduct future investigations focused on enhancing robots' ability to foster human-to-human interactions. With an insight of how to integrate robots into our community safely and effectively, more comprehensive understanding of senior care services will be provided.

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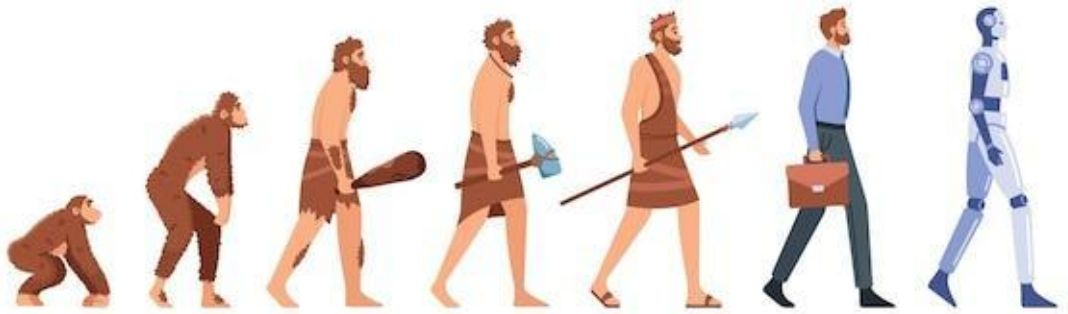
Are Humans Still Evolving As A Species? By Nikhil Srinivas



The story of human evolution is fascinating. How we changed from monkeys to one of the most intelligent species on the planet is truly captivating. Much of this change is due to evolution.

What is Evolution?

In the mid 1800s, the English naturalist, Charles Darwin proposed the theory of evolution. Evolution, in biology, refers to the changing characteristics of species over several generations that relies on the process of natural selection (National Geographic Society, 2022). Darwin explained his theory as follows. Individuals in a population are different in some ways (naturally variable). This means that some individuals possess traits better suited to the environment than others. This gives them some advantage. They tend to survive better and produce more offspring (referred to as survival of the fittest, BiologyOnline, n.d.), than those with less favourable traits. Their advantageous traits are passed on to their offspring. Over a period of time, these traits become common in the population. This is called natural selection, which leads to a new and different species from the original population, a process called speciation. (National Geographic Society, 2022) It is this process that drives evolution and explains the different life forms on our planet.

Variability within our species can be explained through genetic variants, which also underlie the evolutionary process (Hallgrimsson, 2005). Genes affect how an organism's body and behaviour develop during its life. Genetically inherited traits can influence the likelihood of an organism's survival and reproduction. Genetic variants are caused by random mutations or due to genetic recombination in the germ cells during meiosis (Galtier, 2014). They alter the

traits of organisms. Such traits, if beneficial, are then passed on to the next generation as the process of natural selection continues. When the population becomes different to the original species, a new species is created by the evolutionary process. An example is the evolution of humans from our nearest ancestors, chimps, about 6-9 million years ago. (Prado-Martinez, 2013) (Smithsonian National Museum of History, 2022).

To discuss our topical question, let us choose a starting point. But where do we begin our journey? Prokaryotes? Early primates? Our evolutionary journey spans millions of years. We are humans, unlike gorillas or chimpanzees, but we are all primates (mammals having highly developed brain, good eyesight and flexible hands and feet) (Biology Online, 2021). Although we share about 98% of our DNA with the great apes (chimpanzees, gorillas, orangutans etc.) and several other physical features, other primates are not human. What do we mean by humans? Our taxonomic classification is Homo *sapiens*, translating to "wise man", a reference to our status as being the smartest of primates (Tattersall, 2023). Homo refers to our genus, characterised by large head, erect posture, bipedal gait, opposable thumbs, and the ability to use tools (The Editors of Encyclopaedia Britannica, 2022). What makes us distinctly human, is our larger brain size (3 times larger than ape brains), our different anatomy that supports our ability to walk on two legs (erect posture), inability to use our feet to grab and manipulate objects unlike apes, less body hair and relatively less mature, vulnerable but larger human offspring compared to ape babies (Cyr, 2016). Fossil and archaeological evidence have suggested that the last common ancestor between humans and other apes was a chimp like ape. But humans and chimpanzees evolved differently from the same ancestor. Humans diverged from the chimpanzee lineage around 6-9 million years ago (Almécija, 2021). Since then, human evolution has not proceeded in a straight line. Many diverse species of humans developed from this common ancestor (Homo *habilis*, Homo *erectus*, Homo *neanderthalensis*, etc.). Homo *sapiens*, our species, is the only survivor.

To try and understand human evolution, it would make sense to examine our genome with our closest surviving ancestors first. A comparison of human and chimpanzee genomes shows that humans have 46 chromosomes while chimpanzees have 48 chromosomes. If humans have apes as our nearest ancestors, why don't we have the extra pair of chromosomes found in apes? Karyotyping (National Cancer Institute, n.d.) shows that at some point during our complex evolutionary process, there was fusion of 2 ancestral non-human primate chromosomes forming the human chromosome 2 (Poszewiecka, 2022). This has been confirmed scientifically by

demonstrating the presence of 2 centromeres in chromosome 2 (Fan, 2002). This DNA evidence shows how 2 different species have emerged despite karyotypical similarities. Our differences as a species are also attributed to gene expression in addition to the gene itself. What this means is, a gene's activity (genetic expression) can be turned up or down like the volume knob on the radio. The same genes are expressed in different ways in different species which accounts for our differences (YourGenome, 2021).

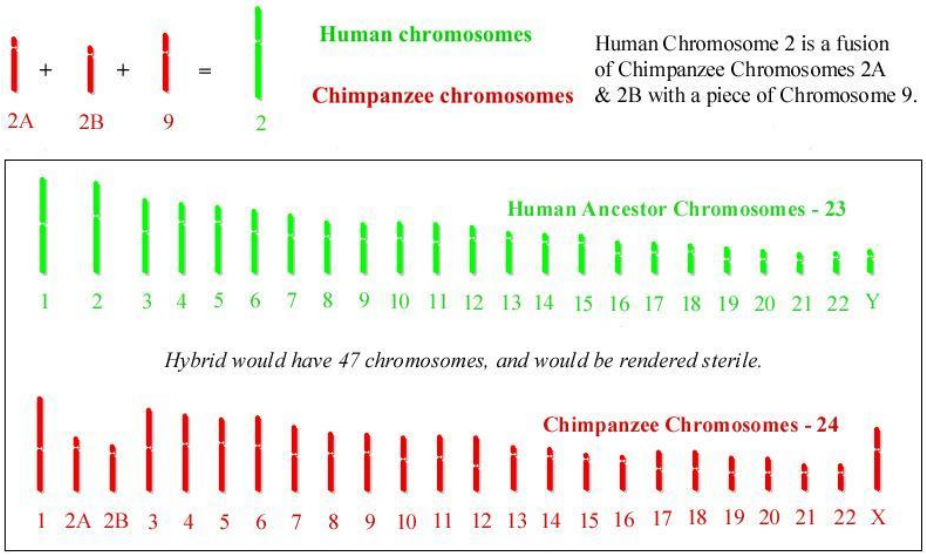


Figure 1 - from https://originalthinkingman.tripod.com/evolution.html

One can speculate at this stage, that due to favourable survival outcome (Darwinian model of natural selection), the chimpanzees and humans survived, although the chimp like common ancestor perished.

We are the only surviving species of our genus. What happened to the others? Several theories have been suggested to explain this, including rapid climate changes, competitive warfare by H. *sapiens* against other archaic humans, ability of H. sapiens to travel etc. All the species of the Homo genus were evolving in the same direction. However, our species crosses a threshold before others in terms of brain ability, social complexity, and reproductive success. An analogy can be drawn to boiling milk escaping the saucepan; H. *sapiens* becomes unstoppable now and has an evolutionary edge over other species of our genus. Examination of our DNA shows about 2% genomic component from the Neanderthal DNA. This suggest that H. *sapiens* interbred with other species of the Homo genus which caused genetic variability. This may have

contributed to better adaptation such as immunity against pathogens and therefore played an important role in survival and evolution (Wong, 2018). Genomic sequencing on fossil established that no genes from H. *sapiens* was found in Neanderthal genome; thus, it does not appear that interbreeding was successful in Neanderthal (Ashworth, 2022). So, it would appear that genetic variation is a key to survival.

Which Brings Us to the Question, Are Human Beings Still Evolving?

Considering that we look very different compared to members of our species who lived ten thousand years ago, it is likely that humans of the future will be very different to us. The population of the world is above 8 billion and rising (Worldometer, 2023). This means more genes, hence more genetic mutations, and therefore more fodder for natural selection to act on.

We are cooling down. Medically speaking, the average normal human body temperature is established at 98.6 degrees but according to a recent study (Protsiv, 2020), the average human body temperature is more like 97.9 degrees Fahrenheit. It has been suggested that the trend is due to better standards of living (comfortable indoor living that doesn't tax our metabolism) and decreased body inflammation (less metabolic rate). We have hence become, fatter and cooler!

Our genes are constantly changing. In 2016, a study (Kothapalli, 2016) found that people on vegetarian diets displayed a genetic mutation allowing them to efficiently process fatty acids from vegetarian sources, absent in their omnivorous counterparts. Genes controlling lactose tolerance is also on the rise (Thompson, 2012). A proposed theory is that as raising cattle has become a larger part of life, gene mutations have sprung up around the world to help people tolerate dairy well. In 2010, scientists found that urban living populations showed resistance to tuberculosis and leprosy, attributed to a genetic evolutionary change in the last 8000 years (Barnes, 2010). Our bones are apparently becoming lighter. This has been attributed to the rise of agriculture and reduction in physical activity (Chirchir, 2014). Malaria infects nearly 200 million people every year, mostly in sub-Saharan Africa. A significant number of people have a genetic variant which protects them from developing malaria. These variants are then passed to their children, conferring malaria resistance, a favourable change (Ko, 2011). Scientific studies on people living in the Andes and Tibetan regions have shown a genetic change which codes for increased haemoglobin concentration in these populations, indicating adaptations of human beings to low oxygen levels at high altitudes (Bigham, 2014). Genetic changes to improve our

capacity to digest starch rich diets have been established. (Perry, 2007). With globalisation, there is increasing intermixing of genetic material in different geographical locations. Genetic expression can be altered due to cultural, environmental, lifestyle change; some of these could be beneficial. Thus, the process of evolution continues.

However, Homo *sapiens* are 'wise men' for a reason. But are we truly wise? Are we fundamentally tampering with nature and acting against the principle of natural selection? Humans have developed modern medicines which has allowed "survival of the not so fittest". Surely, this has evolutionary consequences. Does that mean that there will be an increase in genes which will have no resistance to disease but yet be prevalent, with growing numbers of people relying on medicines to combat these health threats. Consider Caesarean sections for instance. In the past, women with narrow hips were likely to die during childbirth, but now have a higher chance of surviving and passing on their genes. In the era of precision medicine, scientists are manipulating genomic sequences. Who knows what future genetic consequences these could lead to? Genetic modification by Chinese scientists on twin babies to make the twins immune to the HIV virus, caused a genetic change which had the potential to make them smarter (Regalado, 2019). If the genome is altered, will this create an altogether new species of humans/ superhumans?

Based on the cited examples, one can infer that human beings are continuing to evolve. I suppose the question is – is this in the direction intended by nature? Evolution is an extremely slow process. Right now, changes may not be apparent, as on these time scales, 'right now' likely represents only a moment. Like time, evolution is a forward moving process.

The intellectual capabilities of humans are perhaps, at crossroads with nature. Science achieves incredible feats such as space travel, robotics, artificial intelligence, proposed human habitation on Mars, medical breakthroughs like gene editing etc. Some of these have proven to be misadventures with unwanted consequences (Rana, 2018). Nevertheless, evolution will occur, be it natural or otherwise. Along with natural selection, human selection will also co-exist. The mixing of these could put our species in an unknown territory, where our genetic equipment may fall short of natural selection standards. Or perhaps humanity with its powerful intellect be able to overcome nature altogether. Who knows if a millennia down the line, a Homo *cyborgiens* or Homo *bionians* will be writing this essay?

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Economics: What are the Most Likely Implications of the Economic Sanctions Imposed on Russia? By Helena Venturi

On February 24th 2022, in response to the Russian invasion of Ukraine, drastic measures were taken by the European Union, the United Kingdom and the United States in particular. Sanctions were imposed on Russia and Belarus, aiming to weaken Russia's financial ability to fund the war. The economic sanctions imposed on Russia placed restrictions on importation, exportation, the banking system and transportation and also targeted specific individuals. Not only did such sanctions affect the Russian economy, but they also had consequences on a global scale, impacting the economic and social stability of numerous countries.

Implications on Russia

The economic sanctions imposed on Russia aimed to significantly affect its economy. However, their impact on the short term has been largely overestimated. In fact, in contrast to the predictions of March 2022, which expected Russia's GDP to drastically decline by 11% (Figure 1), the updated forecast issued by the World Bank in October 2022 expects a drop of 4.5%. The Russian ruble severely depreciated in March 2022 after a 16.7 % consumer price inflation (Figure 2) led to massive reduction in aggregate demand. It has significantly recovered since.

Figure 1- Russian GDP Source: World Bank, March 2022

Figure 2- Russian Inflation Rate Source: Trading economics

Figure 3- US Dollar/Russian Ruble Source: Trading Economics

The limitation on imports and exports of crude oil is progressive and will only become effective towards the end of 2022, while other measures against refined petroleum products will only be effective in February 2023. This is because many EU countries, such as Germany and Italy, are extremely dependent on Russia for these resources, having no alternative solutions yet. Therefore, Russia is still exporting oil, natural gas and petroleum to Europe. However, those quantities are now limited, forcing Russia to trade their exceeding supply with other countries,

such as India and China. This opened a window of opportunity for Russia to increase its trade with China, with the latest accounting for more than half of oil exported by Russia.

In the long term, the sanctions are likely to have a drastic impact on the Russian economy. The World Bank estimates that Russian trade in goods and services will decline significantly by the end of 2022 (Figure 4). As a result of the ban on imports of commodities- such as coal, gold, steel, iron, wood, cement and certain fertilisers- Russia's non-oil/gas revenues have decreased and are likely to fall more due to the global economic growth slowing down.

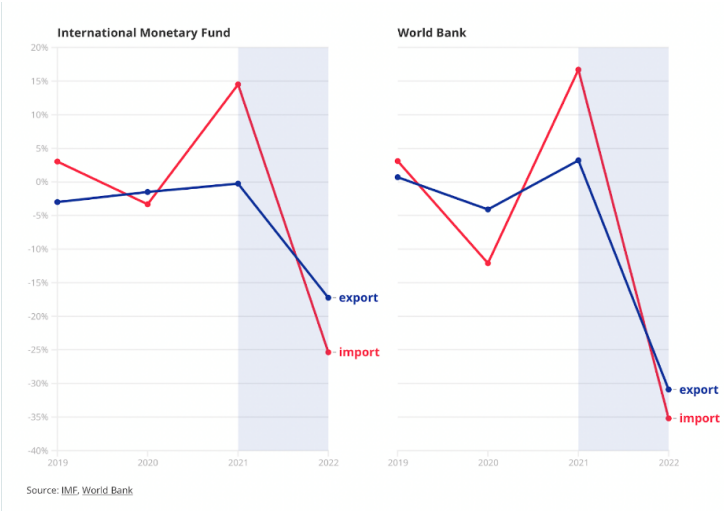

Figure 4- Russian Trade Source: IMF, World Bank

The ban on exports- which incorporates technology, transportation, energy industry equipment and services- further deprives Russia from key sources to increase its productivity. Russia is expected to become more dependent on its energy revenues as the development of value-added industries will decline due to its reliance on foreign supply, and struggle in finding alternative supplying countries.

The restricted access to new technology and equipment lead to a lack in high tech components in Russia, impacting mining and manufacturing sectors, as well as its military strength. The sanctions on transportation via road, marine and aviation in Russia have also contributed to the remarkable decrease in imports, aiming to disrupt commerce and limit trade of essential goods to Russia.

Moreover, the sanctions have caused 700,000 people to flee from Russia, most of whom are skilled workers. Russia will therefore face a brain drain, as labour is a crucial factor of production. The labour shortage will cause a decrease in the country's GDP, as its productivity falls, further weakening Russia's position in the war.

Furthermore, Russian and Belarus banks were excluded from the system SWIFT, meaning that they cannot obtain foreign currencies nor transfer assets abroad. This lack of access to capital, another factor of production, will affect Russia's ability to invest in their economy and pay for the running costs of the war. However, to mitigate the fallout from the decision on oil and gas payments, Gazprombank remains excluded from the sanctions imposed by Europe.

The ban on transactions to the Russian central bank caused the freezing of half of Russia's international assets reserves, which Russia is now unable to use to sustain its economy or war effort. The sanctions imposed on a selected list of people - politicians, high-ranked officials and military, oligarchs linked to the Kremlin, leading business-men, and managers of war - consist of travel bans and assets frozen.

This contributes to Russia facing a decrease in GDP and political support, as the sanctions on individuals will prevent them from financially supporting Russia.

Implications for Europe

Russia is the world's third largest oil producing country, second largest producer of natural gas and fifth producer of metals. The limitations on Russian imports and exports place Europe in critical conditions as it is heavily dependent on Russia for such resources (Figure 5).

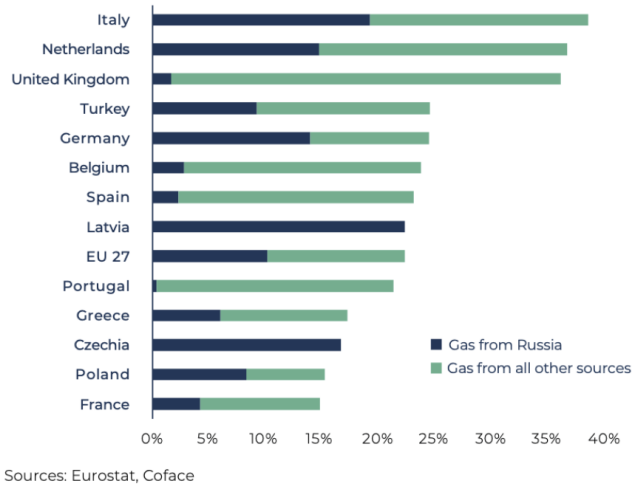

Figure 5- Source: Corface

Europe is now enduring an energy crisis caused by the sanction's ripple effects, due to shortages in oil and gas. Germany is the most affected of the eurozone economies, as its reliance on Russian gas was 55% and 35% on Russian oil. The lack of supply of oil and gas has caused a massive increase in prices of all energy sources, making it harder for people to access and afford electricity and fuel. This has further caused an increase in the price of other products. Rising energy prices, particularly in oil, is impacting transportation, such as airlines which are suffering from higher fuel prices. As inflation occurs, the demand for goods and services decreases. This is causing Europe's economic growth to significantly slow down, threatening a recession to occur. The high risk of a recession is not only damaging Europe's economy, but may also develop social instability and political unrest within EU countries, due to an increase in poverty and unemployment.

The EU wood processing industries notably depend on exports from Russia, which supplies 16% of the global exports of lumber. The trade sanctions limit Russia's export of wood to Europe and could potentially cease the global supply of lumber, causing inflation to increase.

Russia is also a major producer of palladium, steel, aluminium, nickel and copper. Competition for these raw materials due to increased metal prices (Figure 6) causes supply difficulties in Europe and higher risk of shortage of metals. This enormously affected its manufacturing sector, which could eventually stop production if not supplied. As overall prices

increase due to higher costs of production triggered by increased costs of raw materials, cost push inflation occurs. Thus, it is difficult for Europe to control imported inflation.

Figure 6- Source: Corface

Implications on a Global Scale

In Asia, most countries are suffering from the energy crisis because they import more energy than they export, with the exception of Malaysia and Indonesia. The majority of countries around the world will suffer from inflation and the energy crisis. However, oil and gas producing countries, such as Saudi Arabia, Qatar, United Arab Emirates and the US, will benefit from this situation, due to rising demand and higher prices. Similarly, the producing countries of certain goods, for which there is a stronger demand because of the embargo against Russia, will benefit from this situation. In fact, Bahrain, the world's leading producer of aluminium, will massively benefit from higher prices in metal.

The sanctions further placed pressure on the global agriculture industry. Russia is the world's largest wheat producer, accounting for 20% of the global trade while Ukraine is an important producer of corn, sunflowers and wheat (Figure 7). Both nations were responsible for 25% of global sunflower seeds and safflower oil exports in 2019. The sanctions are causing disruptions on exports of wheat, corn and barley to Egypt and Turkey, the two largest buyers of Russian wheat, along with Italy, Cyprus and Lebanon. Moreover, inflation caused higher cereals

prices, leading to higher consumer prices for related products such as edible oil, pasta and flour, further affecting meat prices. Therefore, other major cereal producing countries, for instance the US, will benefit from this situation.

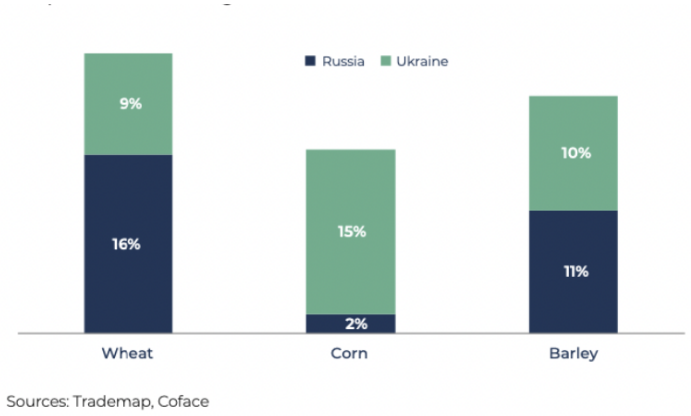

Figure 7- Source: Corface

Increasing prices in the byproduct of higher natural gas, a vital input for fertilisers, led to a decrease in supply of fertilisers, thus weakening agricultural yield and contributing to greater food inflation. Fertilisers play an essential role in India's agricultural system, which creates 60% of the country's workforce and contributes to 15% of the GDP. The primary sector is also crucial for Indonesia and Vietnam, so a decline in crop production would negatively impact these countries' economic growth. These economies will suffer from an increase in consumer price inflation and downfall in consumption. Gulf Cooperation Countries import 85% of their food, conveying that they will significantly suffer from food shortages, along with other countries such as Israel. Furthermore, Russia is one of Turkey's biggest trading partners, accounting for 11% imports, including metals, grains and natural gas, meaning that inflation in Turkey will worsen. Lastly, regions in Africa such as South Africa and Nigeria are large agricultural importers who will be affected by higher prices. Many African economies are dependent on Russia and Ukraine, such as Egypt, who imported 70% of its wheat from Russia.

Considering all of these facts, the economic sanctions imposed on Russia have had detrimental implications on Europe and the rest of the world, although few countries have benefited from it. Their effects on Russia will certainly become more significant in the long term. On a shorter perspective, their success is questionable; they have not caused sufficient economic losses to compel Russia to stop the aggression of Ukraine. Global interdependence and

interconnections between countries and their economies caused sanctions against Russia to affect the rest of the world. While sanctions aimed at exhausting Russia's war effort, they have created a severe global crisis which is unlikely to resolve in the near future: turmoil in the financial markets, rising consumer prices, risk of shortages, threat of long-lasting high inflation and recession, social unrest. The war and sanctions plunged the world into pages of history that seemed to be buried.

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Drug Trafficking: A Diplomatic Crisis (How Authoritarian Countries Interact with the United States in the 21st century) By Miriam Gold

Introduction

Since the founding of the Soviet Union, the United States has outwardly expressed disdain for dictatorships and authoritarianism. This pro-democracy policy has carried over to the USSR's satellite states and allies: the People's Republic of China (PRC) and the Bolivarian Republic of Venezuela (BRV). While autocracy has always been the main point of tension between the U.S. and the aforementioned countries, state-sponsored drug trafficking is a persistent concern. One of the most notorious international crime super syndicates, Sam Gor or The Company, earned at least $8 billion dollars from the Chinese methamphetamine trade in 2018 (Bauchau). While the PRC has contributed to the hunt for Sam Gor's alleged kingpin, the ingredients used to make these illegal substances are easily obtainable in China. Other states, meanwhile, have bans on products commonly found in methamphetamines, implying the PRC has an ulterior motive for allowing the purchase of such items. As an authoritarian country, China is able to restrict the purchasing of any item for any reason, yet they have not done so with ephedrine or other nervous system stimulants. Similarly, the Bolivarian Republic of Venezuela (BRV) has stood to benefit from the drug trade in recent years. Nicolas Maduro, the disputed president of the BRV, is the mastermind behind the distribution of over 400 tons of cocaine along with the Cartel of the Suns. This criminal organization is reportedly headed by high-ranking members of the Venezuelan military and works alongside Mexican cartels to funnel cocaine into Texas (Grantham and Gustavo-Arocha). The trafficked substances are further distributed throughout the United States. In 2021, the International Criminal Court (ICC) opened an investigation into Maduro.

In response to these illegal activities, the U.S. cut formal diplomatic ties with the BRV in 2019. Earlier this year, Washington stopped recognizing Venezuela's acting president, Juan Guido. On the other hand, the United States and the PRC have remained in a diplomatic stalemate, due to their extensive manufacturing ties. Despite the civil behavior both sides try to conduct, the U.S. has openly expressed its disdain for China's democratic backsliding and rampant censorship. Considering the convoluted nature of affairs between the United States, the BRV, and the PRC, exploring how illegal Venezuelan and Chinese drug markets, including, drug

tourism, online drug networks, and syndicate cartels, have altered diplomatic relations with the U.S. in the 21st century will be particularly helpful in understanding the motives behind the creation of new foreign policy.

Literature Review

After the second World War and the hostilities that followed, a new era of international relations (IR) started to take shape. The behavior of countries began to be summarized within a single word or theory. While there are a plethora of IR theories that have been developed and widely accepted by the scholarly community, three of the most prominent schools of thought will be discussed: liberalism, realism, and constructivism (Cristol), (Gold and McGlinchey).

Liberalism: Democracy in International Relations

To promote their respective ideologies and systems of government, nations have looked to global events that emulate their values. Browning, Joenniemi, and Steele, researchers and professors at the University of Warwick, University of Eastern Finland, University of Utah respectively, examine the images world powers craft to establish relationships with others. Virtually all countries have been found guilty of appropriating the activities of other states to an extent. During the War on Terror, Denmark became an "enthusiastic…ally with the United States" (Browning et al.), deploying troops in Afghanistan from 2002 to 2021. When modern-day Israel was proposed and created with the Balfour Declaration and Resolution 181, the United States looked to model their own foreign politics off of the new country. They tried to emulate the policies enacted by Israel and built a new image for themselves on the world stage (Browning et al.). Conversely, the United Kingdom (UK) leaving the European Union (EU) was a culmination of their 'special relationship' with the United States. The UK wanted to act freely in making economic decisions and restricting immigration, two items the EU has opposed through previously passed policy. Great Britain viewed the aforementioned items as goals the United States achieved in the past, and claims they too have accomplished them. Countries continue to take credit for the accomplishments of allies since they are led by dictatorships. Other states likely have more significant ambitions: to gain power in multilateral institutions.

The United Nations and other prominent multilateral organizations have acted hypocritically according to lawmakers by tolerating dictatorships whilst conducting peacekeeping missions (Schmidt). Jessica Schmidt, PhD researcher at the University of

Westminster, details how the promotion of democracy has impacted the creation of international policy, claiming a divided panel of diplomats is most likely to blame for the conflicting policy the UN advocates. The United Nations Security Council (UNSC) is composed of five permanent members with veto power in addition to the rotating ten. The first five are China, Russia, France, the United Kingdom, and the United States. The first two of the five are likely to vote against the last three and vice versa. France, the United Kingdom, and the U.S. are democracies who will vote in favor of virtually any democratic state. Consequently, resolutions are rarely passed and when they are, they are studded with contradictory compromises. Despite the hypocrisy of such international organizations where the United States is a prominent leader, democratic backsliding and the promotion of authoritarianism have remained at the forefront of U.S. concern for decades.

Transitions of power have always been delicate maneuvers marked by joy and change. For example, Xi Jinping, led a massive overhaul of China's government and the image it projects across the world stage during his years in office. As stated by Hackenesch and Bader, a political scientist at the German Institute of Development and Sustainability and a professor of political science at the University of Amsterdam respectively, Xi created new organizations as mechanisms for the PRC to advance its economic agenda (Hackenesch and Bader). The Asian Infrastructure Investment Bank (AIIB), for instance, was meant to utilize the PRC's foreign currency reserves after the 2009 fiscal crisis. The Belt and Road Initiative (BRI) is another one of Xi's ambitious projects and is the center of his approach to foreign policy (Johnson and McLean).

The BRI is a $1 trillion global infrastructure development strategy. Once completed in 2049, the BRI will be able to reshape international trade, with China at the center of a vast land and maritime network. As of January 2023, over 151 countries have signed up for the program (@ClingendaelInstitute et al.). Refer to Appendix L for a visualization of the BRI plan. There have been western concerns for the implementation of the BRI, citing human rights violations, and "debt-trap diplomacy," which can lead to neocolonialism and economic imperialism. The United States has questioned the legitimacy of these organizations, claiming they are responses to the formation of the World Bank and the International Monetary Fund (IMF). Additionally, there is ongoing debate regarding the allocation of profits from these infrastructure projects, considering the PRC's lack of action towards Sam Gor.

Realism: Multinational Drug Trafficking

With the rise of the internet and the dawn of the digital age, shopping, selling, and purchasing goods has become incredibly convenient. In the past twenty years, selling illegal substances online has resulted in the rise of cartels and drug trafficking rates on a global scale. The Global Commission on Drug Policy, a panel of scholars and world leaders based in Switzerland, urges states to launch more investigations into international drug cartels. They ask for increased cooperation and integration between the United Nations and the International Criminal Police Organization (ICPO) or Interpol. There is a significant lack of coordination between the two entities, which has proven to be detrimental worldwide (Global Commission on Drug Policy). With rising overdose deaths and criminal activity, it is pertinent that officials from the UN and Interpol mobilize efforts to enforce laws against organized crime. If the two organizations cannot collaborate effectively, then cartels will continue to grow and smuggle illegal substances across the globe.

The cartels that have experienced the most growth in the 21st century are based in East and Southeast Asia. The PRC has been a significant contributor to cartels in the Golden Triangle. According to Tettey, Douglas, Raithelhuber, Soe, Sim, and Tan, United Nations Office on Drug and Crime (UNODC) chief, regional representative, and researchers respectively, the Golden Triangle is the region where Laos, Myanmar, and Thailand intersect (UNODC). Drug trafficking reportedly funded by China has produced up to $8 billion dollars per year, which is reportedly funneled into the state-controlled economy. The Golden Triangle is widely known for growing opium and manufacturing opioids trafficked through air and maritime routes. The opioids produced in Southeast Asia have been linked to the rise in overdose deaths from the United States, the most notable of which is fentanyl. The UNODC has additionally published another report, the World Drug Report 2022, which is a collection of data that summarizes drug use and drug trafficking activity. The report establishes the PRC's largest drug export is methamphetamines and the BRV's largest drug export is cocaine. Refer to Appendix M for a global representation of drug use distribution.

Taken in a broader context, these statistics serve as evidence for China and Venezuela trying to adapt to a post-Soviet Union world, where their most powerful ally has left them wondering how to thrive in the age of globalization.

Constructivism: Attitudes and Autocracy

After the collapse of the USSR, former satellite states tried to establish regional and global spheres of influence. Some countries, including the PRC, were more successful than others. As discussed by Dukalskis and Gerschewski, professor of international relations at University College Dublin and research fellow of global governance at Humboldt University respectively, the Soviet Union's former allies fully integrated Marxist ideology in response to the sudden political shift in Eurasia (Dukalskis and Gerschewski). Besides the PRC, Vietnam, North Korea and Cuba are also noted as puppet states or allies with the USSR in the mid- to late- 20th century. China and Vietnam can be characterized as reformed regimes, while North Korea and Cuba are considered unreformed. In this context, reformed refers to modernization or adaptation to a new political landscape. Unreformed or "semantic freezing" can be interpreted as remaining rooted in a specific time period and continuing to follow USSR-era norms. The PRC and Vietnam have been able to recognize changing circumstances, turning into economic hubs and developing their own ideologies based upon influential leaders Despite China becoming a rising world power, Rosen, a professor of political science and international affairs at the University of Southern California U.S.-China Institute, points out several missteps that have placed the PRC in a precarious position (Rosen). After Deng Xiaoping took power, the status of the Chinese Communist Party (CCP) became diminished. Senior Party officials were more concerned with maintaining their influence and did not permit any political autonomy from rising social groups. Simultaneously, the CCP passed new economic reform to compete with western markets. Consequently, the Party diminished the value of being a member of the CCP and its own place in society. Social mobility was no longer based on Party status, giving way to the disintegration of the Community Youth League and trade unions The Party's fall from grace and attempt to legitimize their role in China culminated in the Tiananmen Square protests. The protests were a symbol of resistance against a regime struggling to prioritize their goals for the future of the Party.

Recent crises have also plagued the BRV, which began to emerge after the death of Venezuelan dictator, Hugo Chavez. There was widespread economic, social, and political upheaval, as explained by Briceño-Ruiz and Lehmann, professors at the National Autonomous University of Mexico and the University of São Paulo respectively. Several days after Chavez's passing, the BRV had one of the highest inflation rates in the world, which was further exacerbated due to ignorance of the new administration. In 2018, the BRV's rate of inflation was

placed at 3,300,000%, along with increased control over exchange rates, interest rates, and prices, creating a 'pseudo-command economy' (Briceño-Ruiz and Lehmann). The IMF predicted the Venezuelan GDP would fall 25% in 2019, only 3 percentage points below the U.S.'s GDP during the Great Depression (28%). Poverty rates therefore increased during this period of destabilization (Briceño-Ruiz and Lehmann). In 2019, over 80% of Venezuelan households experienced poverty. The BRV's attacks towards the private sector diminished the supply of foodstuffs, leading to mass immigration of over 4 million Venezuelans. Some citizens have also opted to leave because of the "complete destruction of the democratic system." Nicolas Maduro also usurped the office of the presidency, according to the political opposition. The 2018 Venezuelan presidential election was considered illegal by international observers, yet Maduro was sworn in by the Venezuelan Supreme Court. Juan Guaidó then declared himself interim president, although another politician, Luis Parra, asserts that he has rights to the title. The Venezuelan Presidential Crisis still persists to this day, with many countries and terrorist groups considering military intervention.

Although the majority of research available is able to explore a plethora of diplomatic difficulties, none have been able to explore the existence of a correlation between foreign affairs and drug trafficking, leading to the query at the core of this study: how have illegal Venezuelan and Chinese drug markets, including drug tourism, online drug networks, and syndicate cartels, altered diplomatic relations with the United States in the 21st century? This particular study will address the lack of information regarding BRV and PRC drug cartels resulting from censorship. The relationship between diplomatic hostility and presence of drug markets will be discussed further. Previous research has also not provided a holistic overview of the countries of interest in this study. As previously stated, the U.S. and the PRC are permanent members of the United Nations Security Council, which could lead to falsified or exaggerated information regularly published by the UN.

Further research could be conducted that explores the nature of American relationships with BRV and PRC. There is additional insight needed to discuss their roles in the international drug trade, as evidenced by recent data from UNODC. Although neither the PRC nor the BRV have been known for conducting such operations, this study aims to analyze the impact of the drug trade on U.S. foreign affairs. The results of this analysis can identify the faults in conducting diplomacy in multilateral institutions and suggest improvements to linguistic

diplomatic guidelines. These improvements will contribute to the betterment of relations between all autocratic and democratic states in diplomatic settings.

Methodology

To investigate the presence of a correlation between drug trafficking activity and hostile diplomatic relations, conducting a cross-examination of recent drug trafficking data and diplomatic documents will be an exceptionally effective approach. The combined use of qualitative and quantitative methods was employed in order to better visualize the data collected through document and critical discourse analysis (CDA). Due to prior familiarity with Excel and the convenience of quantitative interpretation as opposed to qualitative interpretation, a point system was established within several analytical tools, in the form of checklists and rubrics. Kobayashi, a professor of geopolitics at Queen's University, summarizes researchers of CDA as examples of interpreting "language as a form of social practice, and are concerned with systematically investigating hidden power relations and ideologies embedded in discourse"(Johnson and McLean). Elements of critical discourse analysis are incorporated into the tools, enabling the researcher to efficiently review a significant range of documents using a variety of criteria, therefore making this method the most viable option for investigating the question at the core of this study.

Two countries with significant ties to the Soviet Union, the U.S.'s greatest adversary during the Cold War, were selected for this study. The People's Republic of China, a former puppet state of the USSR was aided during the Communist revolution, is considered a rising world power and is starting to rival the United States in the economic sector. While the Bolivarian Republic of Venezuela was not directly tied with the Soviet Union, the country is currently Russia's most important trading and military ally in Latin America.

Diplomatic statements, communiques, and other assorted documents from the past twenty years will be used to assess the level of hostility expressed towards the United States. The researcher initially opted to reach out to the Chinese and Venezuelan embassies in New York City and Washington D.C. for access to documents, but was ultimately unsuccessful in this endeavor. An unnamed representative from the New York City Chinese Consulate did respond and provided several links for the researcher to follow. These websites later proved to be vital during data collection.

Prior to the investigation, the researcher read The Communist Manifesto by Karl Marx and Friedreich Engels to enhance understanding of the PRC's and BRV's approaches to foreign policy. The preliminary phase of the data collection involved classifying the two states of interest into one of three IR schools of thought: realism, constructivism, or liberalism. Following a method similar to one used by Dukalskis and Gerschewski, the study reviewed foundational foreign policy documents that are at the core of domestic politics. In regard to the PRC, The Governance of China, the CCP constitution, and an infographic titled Three Stricts and Three Honests were all used in establishing the country in question is realist. For the BRV, the state constitution and the Statutes of the United Socialist Party of Venezuela (PSUV) determined this country is constructivist. Documents were analyzed using three different checklists, each specific to a different IR theory. The checklists were developed using previously established characteristics of each IR concept. A point system was developed using guidelines modeled after Dukalskis' and Gerschewski's research, with the intention of using quantitative analysis for data interpretation. The mean scores for each theory are then taken for the PRC and the BRV. The PRC's mean scores were in order of realism, constructivism, liberalism, 5, 1, and 1. The BRV's mean scores were, in the same order, 2, 5, and 1. Hence, the PRC is classified as realist. The secondary phase of data collection used the aforementioned diplomatic documents from two paragraphs previously. All documents were accessed from the Ministry of Foreign Affairs of the People's Republic of China or the Ministry of Foreign Affairs of the Bolivarian Republic of Venezuela. The documents in question were addressed to or targeted the United States. Sixty-nine documents with connections to the U.S. were found on the PRC's website. These documents span from 2002 to 2023, with the most recent being published on March 20th. On the BRV's webpage, 137 documents were found addressed to or targeted towards the U.S. However, the earliest document found was published in 2017. The vast amount of Venezuelan documents may compensate for the lack of range, since the researcher is able to gain more holistic insight into U.S.-BRV affairs. Each document was analyzed twice, once with a hostility checklist specific to an IR school of thought previously assigned, and once with a critical discourse analysis rubric (CDA). CDA was used in this particular case to glean a better sense of how diplomatic language impacts hostility in various social contexts. CDA principles were incorporated into a rubric, with each item assigned a range of point values. Certain items have different weights due to having less influence and importance. The hostility scores and CDA

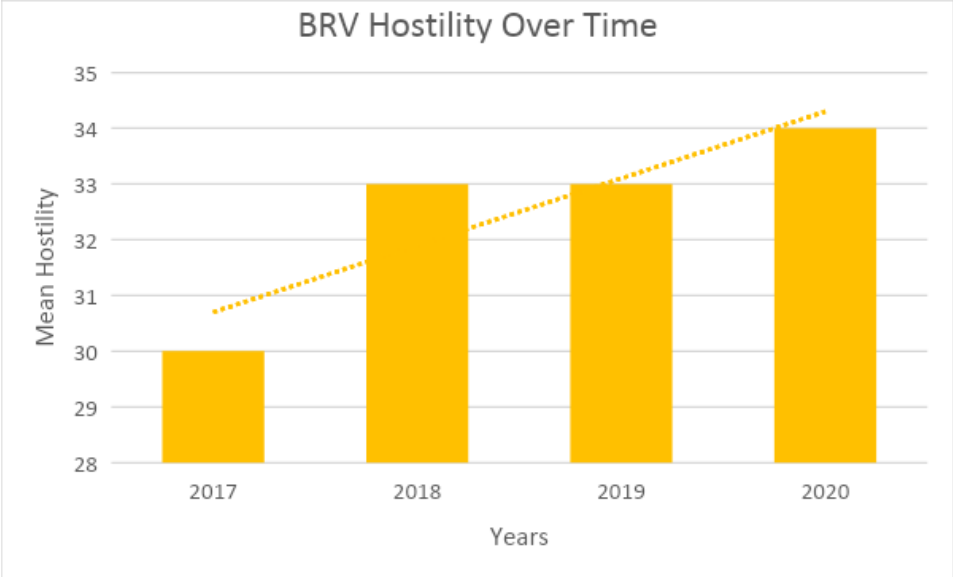
scores from each document were added to create a combined score. The mean combined score from each year was taken and inputted into Excel. Means were rounded to the nearest whole number. The highest hostility score possible is 7. The lowest possible score is 0. The highest CDA score possible is 32. The lowest possible score is 20. The highest combined score possible is 39. The lowest possible score is 20.

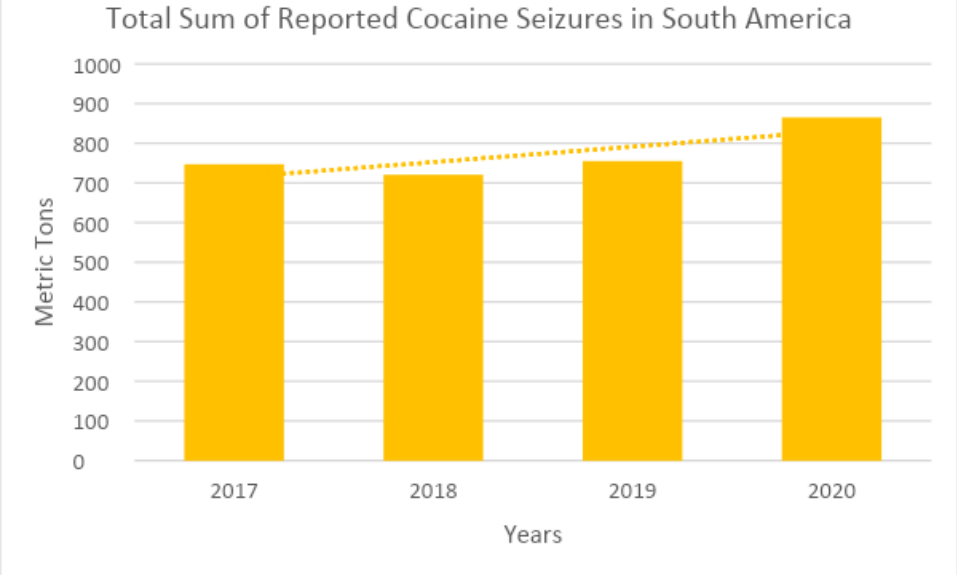
To investigate the presence of a correlation between diplomatic hostility and drug trafficking activity, data was adapted from the 2022 World Drug Report published by the United Nations Office on Drug and Crime. The data includes the total sum of drug seizures of a given substance in a certain continent or region. In this study, the BRV is considered to be a part of South America and the PRC is considered to be a part of East Asia. As previously established, the drug of interest for the BRV is cocaine and the drug of interest for the PRC is methamphetamines.

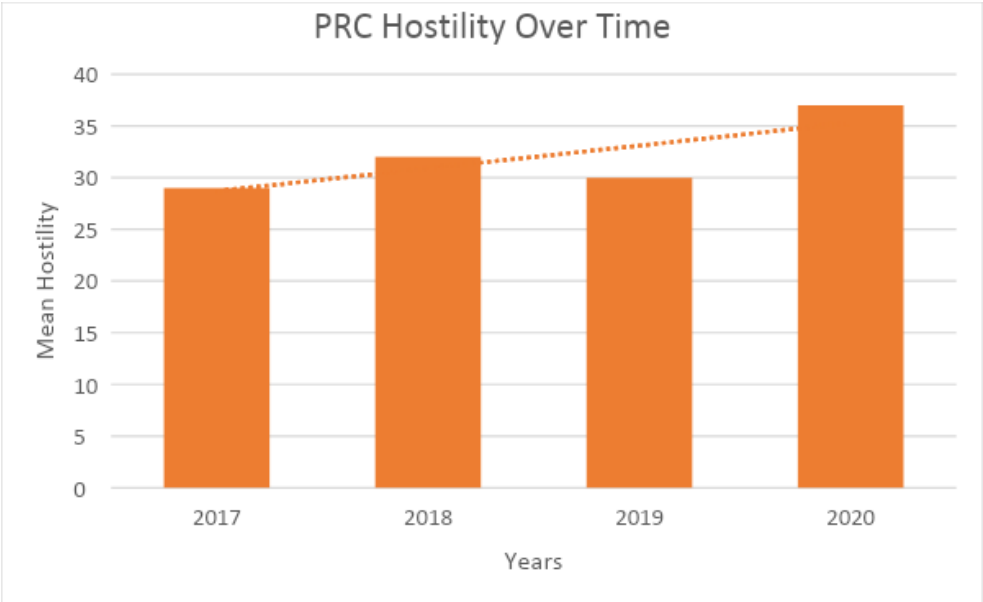
Results

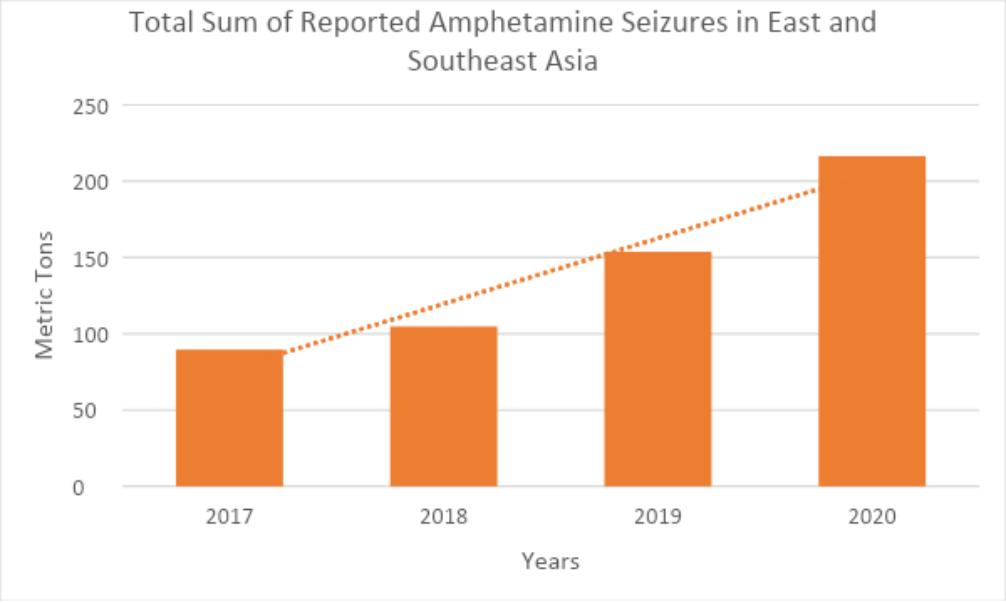
It is evident there is an existing correlation between the number of drug trafficking operations and diplomatic hostility in the context of the U.S.-BRV-PRC relations. The BRV and the PRC have likely participated in some form of state-funding drug operations in recent years, explaining the fluctuation of hostility levels between these states. Domestic and international catastrophes, particularly of the political nature, tend to exacerbate hostilities, resulting in more needlessly aggressive diplomatic language. Venezuela exemplifies this fact, as shown with the Venezuelan Presidential Crisis from 2019 to 2023. The raw data for the BRV is also much more erratic and irregular compared to China, due to the former's lack of formal diplomatic relations with the U.S.. This is partially due to the BRV publishing condolence letters, congratulatory messages, and hostile statements condemning U.S. foreign policy. It can therefore be inferred they have more issues with the government than with the American people as a whole. The People's Republic of China, on the other hand, publishes more formal statements generally relating to fostering a diplomatic relationship with the United States. The PRC only recently began a more antagonistic approach towards the U.S., stemming from the emergence and persistence of the COVID-19 pandemic, from 2020 to 2022.

Results: Diplomatic Hostility and Critical Discourse Analysis









Discussion–Drug Trafficking in a Future Context

The PRC and the United States have a more passive-aggressive relationship compared to the BRV and the United States. Since the relationship between the two former countries hinges upon trade and manufacturing, severing diplomatic ties could have global ramifications. The U.S. and China are both promoting their own economic alliances, with the North American

Trade Agreement (NAFTA) and the BRI respectively. If either country backed out from the American-Chinese economic relationship, then all countries that are members of one of the multilateral projects would be significantly impacted. A global recession or a depression would be the only result from dissolving diplomatic ties. The PRC has also made some effort to appease the United States by coordinating international efforts to reduce drug production in the Golden Triangle.

On the other hand, the United States and the BRV have not had formal diplomatic relations since 2020 due to the Venezuelan Presidential Crisis. Nicolas Maduro was also wanted by the Drug Enforcement Administration for his alleged crimes of organizing the funneling of cocaine into Mexico and subsequently the United States.

The United States and Venezuela used to have economic ties when the latter frequently sold crude oil to the former. The U.S. administration at the time would later decide to transition to Middle Eastern oil exclusively. This policy of removing oneself from a precarious economic relationship ultimately contributed to the current diplomatic situation in the BRV. The U.S. would not be able to back out of its partnership with China as the two states have integrated economic policies. If one country falls, the other will follow. The United States and the PRC are painfully aware of this, knowing they must continue to trade to prevent the global economy from collapsing.

After the 9/11 Terrorist Attacks in New York City, drug trafficking has not remained at the forefront of U.S. concerns. The War on Terror and the subsequent invasion of Iraq, in addition to the vast amount of domestic terror attacks in recent years, have driven national, gubernatorial, and legislative elections for the past twenty years. Although domestic terrorism recently became a concern with a new wave of digital political extremism (Federal Bureau of Investigation), the United States is looking toward a new era of foreign policy focused on relaunching the War on Drugs.

Deficient Diplomacy

It has been well-established language plays an extensive role in diplomacy, but may mislead other countries into believing a relationship is amicable, neutral, or hostile. Miscommunication in a diplomatic setting can have profound consequences, as noted with the Cuban Missile Crisis (Office of the Historian). If the United States and the People's Republic of

China took semantics into greater consideration, tensions could be eased considerably. There was aggressive language and harsh tones used throughout PRC documents, which is unnecessary given their extensive economic ties. If two states rely so heavily on one another, there should be more cordial, if not stiff, language in third person notes. Documents of this nature include memorandums and note verbale, a selection of the most informal diplomatic documents. This solution should be feasible since diplomats are typically bilingual, meaning language barriers are of significance, they are only a major concern in exceptional circumstances.

The critical discourse analysis rubric developed can be expanded and adapted to meet the diplomat's needs. The tool has the potential to be used as a set of guidelines for writing memos and formal letters. Critical discourse analysis is inherently subjective, so it is important that states explicitly establish the nature of their relationship before implementing any tools so as to avoid additional miscommunication. The tool could give diplomats time to contemplate past, existing, and future relationships, driving states to dissolve or foster foreign ties. Similarly, the presence of state-funded drug trafficking itself could function as a tool for those who are not overly conscious, unlike the United States. While doing so could inject hostility into a previously genial relationship, both states will have a clearer understanding of each other's intentions, avoiding miscommunication. The War on Drugs was launched in the 1970s and is arguably still a main concern for the United States as shown by the correlation established earlier. If other countries allied with the U.S. began scrutinizing any covert activities, more drug trafficking organizations could be discovered. Relationships between the U.S., their allies, and allies of other western countries will become more transparent and dynamic, benefitting all parties involved.

IR Schools of Thought and State Identity

This study previously rationalized the categorization of the PRC and the BRV into one of three prominent IR schools of thought. Some may argue this contradicts the section above regarding the ramifications of diplomatic flexibility and elasticity. However, a so-called "happy medium" can be achieved in ideal conditions. Countries may not be able to inherently be what they are because of constitutions, decrees, ideologies, and any other foundational documents legitimize the existence of a state. Countries can find a way to build new diplomatic relationships and still have loyalty to as many constitutions as they please, however. Once states prioritize

economic and social opportunities, they will take precedence over any concerns of ideological neglect or dismissal of founding documents. Countries can approach this proposed solution in multiple ways, from joining or gaining leadership in economic multilateral institutions like the World Trade Organization (WTO), furthering dialogue with their most trusted allies, or establishing new multilateral institutions whilst consulting any competitors to prevent untended provocation. In summary, the steps listed above can be taken to ensure neutral, or perhaps peaceful, coexistence.

Conclusion

There were some limitations prevalent throughout this study that future research could address to provide additional understanding of how international relations fluctuates over time, as opposed to being stagnant. The majority of limitations were a result of a lack of data and information. The amount of content in the 2022 World Drug Report was significantly reduced from the 2021 World Drug Report, yet the study could not justify the latter's implementation due to the risk of using globally unrepresentative data. The UNODC only made the data used by the researcher available to the public in 2015 and stopped publishing recent data in 2020. There were also no BRV statements available before 2017. This could be a result of the BRV not digitizing their Ministry of Foreign Affairs until recently, because of a lack of economic resources. As a result, the entirety of the 21st century is not accurately represented, which means that the initial inquiry is not completely addressed. The methodology pursued is also fundamentally subjective, especially the incorporation of critical discourse analysis principles into a rubric meant to analyze documents have significant implications for the future of diplomacy between the United States, China, and Venezuela. Future studies can explore more quantitative approaches and more conventional, concrete methods of document analysis. Researchers with access to more direct sources, such as multilateral governing bodies or diplomats themselves, should pursue interviews and ask to observe a session in the multilateral organization of interest.

More investigations should also be conducted to assess how language affects specific facets of diplomacy, as opposed to the holistic and therefore less detailed approach pursued in this study. International legal affairs and development would be an exceptionally novel approach to IR research, encapsulating the ICC and Interpol, organizations that were not extensively discussed by this study. Improving the efficacy of international law enforcement has been

debated and a study explores the potential consequences of doing so would be of note. The structure of state-sponsored drug trafficking organizations is another novel topic that would enhance understanding of how world leaders attempt to salvage a struggling economy, provided that the researcher has adequate resources to conduct such an inquiry.

This study was able to successfully investigate and identify a correlation between diplomatic hostility and the presence of covert drug markets. The BRV and the PRC both have unnecessary antagonistic relationships with the United States, with the BRV being more unpredictable in terms of aggressiveness. Domestic and international incidents tend to exacerbate existing tensions and could potentially be used to predict future hostility levels. The presence of drug cartels is provocative from the U.S. perspective, but measures can be taken in order to prevent miscommunication as well as misinterpretation of intentions.

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A More Perfect Union: How the United States Can Model Foreign Democratic Systems By Meghan Derby

Introduction

The cataclysmic victory of the United States in the American Revolution triggered a tsunami of revolutions worldwide, with lives in Haiti, France, and Latin America being sacrificed in the name of the democratic vision first pioneered in America. Today, American democracy remains the prototype for all other democratic systems, whether those systems be consolidated, illiberal, or even barely visible. However, in the twenty-first century, the United States faces the weakening of its institutions, serial policy failure, rampant socioeconomic inequality, and paralyzing societal polarization. It becomes evident that the U.S. government requires structural reform to address these crises, and foreign democracies may have insight into tenable solutions—the nations of the world have served as laboratories for innovative legislative structures, electoral methods, and social policies that mitigate the vulnerabilities of the American system. In order to improve the functionality and legitimacy of its government, the United States must reform its legislative, electoral, and welfare systems based on international models that have effectively promoted the well-being and inclusive representation of their citizens.

Limitations to American Democracy

Despite being the principal model for the majority of democratic systems around the world, the American government has several fundamental defects. First, the structure of Congress is inadequate to effectively represent the citizenry and promote ideological diversity in its membership. The House of Representatives has 435 members each elected by plurality vote from single-member districts, with each state being apportioned an approximately-proportional number of districts to their population. The Senate has 100 members, with two from each state elected by a plurality vote of the entire state. With the population of the United States being approximately 340 million, the ratio of representatives to citizens is 1 to 780,839. For the Senate, that ratio is 1 to 3.4 million (“United States”). In comparison, the lower house of the U.K. Parliament, the House of Commons, has 650 members, and the population of the United Kingdom is 67.33 million (“United Kingdom”). This gives a ratio of 1 member of the House of Commons for every 103,584 citizens. Thus, one member of the House of Representatives

represents more than seven times the number of constituents that a member of the House of Commons represents. This plays a major role in the difficulties U.S. representatives face, as they cannot effectively hear out the demands of more than 780,000 constituents and reliably translate them into policy initiatives ("Expand the House"). Congressional representatives also face difficulties providing the services they are responsible for because of their district's large population size, which leads to citizens struggling to acquire passports, VISA applications, immigration services, healthcare assistance, tax benefits, and all other federal provisions. Therefore, representatives become less legitimate in their role as linkage institutions between government policy and public opinion, as well as less accountable to their constituents' concerns.

The system of single-member districts in the House of Representatives is also defective, as it functions as a filter for minority parties, reinforcing the two-party system and preventing ideological diversity (Lijphart). When only one member can be elected per district, a two-party system tends to solidify because the only viable competitors for a singular seat are political parties with the majority of support or the imminent potential to have the majority. In the United States, these parties have been the Republicans and the Democrats since the mid-nineteenth century, these parties alternating control of the presidency and houses of the legislature. Minority parties cannot secure seats because they almost never garner the momentum to win more votes than either of these majority parties. In this system, all minority parties become obsolete and are often absorbed into the majority parties, reinforcing the lack of partisan diversity in government (Lijphart). Citizens that are aligned with minority positions such as libertarianism and socialism continue to be excluded from the legislative sphere, exacerbating political apathy among these citizens. Two-party politics also promotes congressional gridlock, which prevents the legislature from having productive negotiations and moving forward on legislation. If bills remain caught in partisan politics and never leave the floor of Congress, important policies never come to fruition, which fundamentally undermines the purpose of the government.

While the structure of a democratic government is fundamentally important to how it functions, so is the electoral method used to determine its occupancy. The United States uses the Electoral College, a system that undermines the purpose of democratic elections because it overrepresents certain populations and disincentivizes voter turnout. Currently, the Electoral College is comprised of 538 electors, apportioned to all fifty states and the District of Columbia on the basis of the state's total number of congressional members, or the sum of their

representatives in the House and their two senators. The District of Columbia, having neither representatives nor senators, has three electors based on the district's relative population to the nation. A popular vote is conducted within each individual state and the candidate with the plurality of votes wins all of the electoral votes from that state. The exceptions to this doctrine are Maine and Nebraska, which apportion their electoral votes based on the winner of the popular vote within each district, which can lead to their electors being divided along partisan lines. The system was originally created as a counterweight to the political power of large states and to insulate the electoral process from ordinary constituents, protecting the elite citizens and their interests ("Electoral College"). This winner-take-all system inevitably misrepresents the will of the citizenry because, in the majority of states, the votes in the minority receive no electoral votes and are effectively disregarded, even if the race in that state was highly competitive. If 51% of citizens vote for the Democrat and 49% vote for the Republican, the Democrat wins all of the electoral votes. The 49% of citizens in the minority, potentially accounting for tens of millions of votes, are thus irrelevant to the outcome. The effects of this misrepresentation are statistically significant, as there have been five elections where the candidate that won the popular vote lost in the Electoral College: when Andrew Jackson lost to John Quincy Adams in 1824; Samuel Tilden lost to Rutherford B. Hayes in 1876; Grover Cleveland lost to Benjamin Harrison in 1888; Al Gore lost to George W. Bush in 2000; and Hillary Clinton lost to Donald J. Trump in 2016 ("Electoral College"). Popular sovereignty, a fundamental democratic principle, determined these elections to have one outcome, yet the Electoral College produced the opposite, thus demonstrating the inefficacy of the Electoral College to represent the citizens and their political will.

Also, as some states definitively lean towards one political ideology or the other, the outcome of their electoral votes is predetermined. This decreases voter turnout in these states, as there is less—or even no—incentive to vote if it is understood that your vote will have no bearing on the outcome ("Electoral College"). In "solid" states such as New York, West Virginia, and Arkansas, the effects are seen in their voter turnout rate being among the lowest of any U.S. state. Overall voter turnout in the United States reflects the effects of the Electoral College, having been only 66.8% in 2020 (the highest rate since the 1900 presidential election), which is comparatively low when considering the rates of other developed nations, which tend to be between 75 to 85% ("United States"). Candidates also campaign less in these "solid" states and

allocate less attention toward these constituents' issues because they will instead contribute their limited resources to a state that is in "swing," or one where the electoral votes are in real contention. This is the case in New York, where it is widely accepted that the state will be won by the Democratic candidate, thus there is no incentive for the Republican candidate, who acknowledges they will lose, nor the Democrat, who is certain they will win, to campaign there or be highly concerned with that state's political interests. Some citizens thus become less important than others, which is uncharacteristic of an effective democracy where all voices are given an equal opportunity to be heard ("Electoral College"). This system is inadequate to accurately represent the will of the citizenry and promote the legitimacy of the government, which directly harms society at large.

Another feature of a democratic state is the welfare system, which is the set of publicly-funded services that the government provides for the benefit of its citizens. The welfare system in the United States is ultimately inadequate to promote societal well-being and address the rampant socioeconomic inequalities afflicting this country. A key facet of social welfare is healthcare, and a new international study by The Commonwealth Fund states that "[a]mong the 11 [similarly developed] nations surveyed, the U.S. is the only one without universal health insurance coverage. Other research suggests that the U.S. spends less than other high-income countries on social services, such as child care, education, paid sick leave, and unemployment insurance, which could improve population health" (The Commonwealth Fund). While the U.S. Congress was able to enact the Affordable Care Act—a monumental healthcare reform program instituted to address medical care costs—during the Obama administration, the program is not sufficient to address the nation's worsening healthcare crisis: "The Patient Protection and Affordable Care Act of 2010 (ACA) led to historic reductions in the number of uninsured persons, yet nearly 30 million remain uninsured, millions more are underinsured, and the number of uninsured persons is expected to grow" (Crowley et al.). Socio-economic inequality in the U.S. is creating and exacerbating this crisis, as citizens cannot access healthcare and therefore continue to experience cyclical poverty without the care they need. Healthcare in the U.S. is not a right but a privilege only guaranteed for the wealthy, structurally disadvantaging those of low socioeconomic status and contributing to a decline in living conditions (Crowley et al.). When citizens remain unhealthy and in a state of poverty due to a lack of accessible healthcare, the

vitality of democracy is ultimately undermined; thus, it becomes the obligation of the government to address the crisis through structural reforms.

Innovations By Foreign Democracies

Multiple countries around the world have made important contributions to the democratic model, developing innovative structures of legislative representation that improve upon the design of the United States Congress. Mexico has instituted a dual system of representation of the Chamber of Deputies, the lower house of the Mexican Congress of the Union. The Chamber of Deputies is elected using a parallel voting system, with 300 "majority deputies" elected by plurality vote in single-member districts and 200 "party deputies" elected by proportional vote of the general population (Ramirez 3). This structure both incorporates district-based members to represent subdivided groups of constituents more intimately, similar to the U.S. House of Representatives, and permits a diverse multiparty system to emerge because minority parties can win portions of the 200 seats elected by proportional representation. The benefits of this system manifest in Mexico's well-functioning multiparty system, with three prominent parties—the Institutional Revolutionary Party (PRI), National Action Party (PAN), and National Regeneration Movement (MORENA)—occupying the executive and legislative branches because the representational structure permits more than two parties to coexist. Mexico also has a gender parity rule in legislative elections, mandating that 50% of political candidates and elected representatives be women. This rule has been substantially beneficial to correct a history of political discrimination on the basis of sex, ensuring that the interests of Mexico's female population are given equitable consideration in the government that defines their livelihoods (Ramirez 7).

Nigeria, a country afflicted by ethnic and regional divisions as a product of past colonial subjugation, also uses quotas to facilitate consensus on the viability of candidates in national elections. In order to be elected in the first round, candidates must receive a plurality of the national vote and over 25% of the vote in at least 24 of the 36 states and the Federal Capital Territory (Freedom House). This has forced the reconciliation of regional divisions because in order to even be viable, candidates must be broadly favored throughout the country rather than being strictly partisan or only supported by one ethnic group.

Even illiberal democracies provide insights into effective governmental innovations, as seen in Russia, where President Vladimir Putin has created eight federal districts to act as macro-organizational structures of the eighty-five smaller regional entities in the nation (Stahl). As the government remains relatively authoritarian, these federal "super-districts, " or Okrugs, have primarily functioned as a system of oversight for the federal government to exert greater control over Russian citizens. However, this system of federal districts presents an avenue to introduce new representatives to a legislative body, with these members representing the constituents within the entire federal district rather than a singular district. This additional level of governmental organization enables better legislative representation for Russians, promoting more citizen participation and public trust.

China, another country that is considered authoritarian in practice, is innovative in that its National People's Congress is the largest legislative body in the world, with 2980 members (NPC Observer). This reflects the population size of China, a nation of 1.412 billion citizens, the largest population of any country ("China"). The large size of the legislative body is an innovative democratic feature because the greater the number of members, the fewer the number of constituents each individual member represents, thus citizens can be represented more interpersonally and effectively. Larger legislative bodies can be more democratic and have closer connections with the citizenry, facilitating greater democratic legitimacy.

In terms of innovations to democratic electoral methods, Australia's opt-out compulsory voting system is an effective advancement of the American election process that better promotes citizen participation. In the Australian system, all eligible voters are automatically registered and mandated to vote in national elections, with the exception that voters may opt out of being registered if they decide they do not intend to participate ("Compulsory Voting"). This is highly successful to increase voter turnout, which is greater than 90% in Australia, as there are no barriers to registration and the national political culture has fully accepted voting to be an obligation, not a casual practice. Candidates that have been elected by a more comprehensive survey of the general population have a more definitive mandate to govern, which promotes a government that can operate more effectively on behalf of its citizens ("Compulsory Voting"). Thus, high voter turnout is beneficial for democracy because it provides legitimacy to those that are elected into power and promotes general public trust.

Further, consolidated democracies, particularly those in Europe, have built comprehensive welfare systems that improved the government's capacity to provide for their constituents. One such nation is the United Kingdom and its National Health Service, the universal healthcare system available to all U.K. residents (NHS). This system is a contribution to democracy because it provides equitable access to healthcare for all, serving to reduce inequality in the U.K. and promote citizen well-being. However, Denmark has a universal welfare system that extends even further than the U.K.'s National Health Service. Their welfare provides services that are conventional for a functioning government system to subsidize, such as public schools, national defense, law enforcement, and a court system. The Danish system goes further, also providing extensive welfare services such as subsidized daycare centers, cultural activities, social clubs, student grants up through higher education, child benefits, and housing allowance ("The Danish"). This system, facilitated by the relatively high rates of income tax that are instituted on Danish citizens, represents a profound democratic innovation in its scale and services provided, drastically improving the living conditions in Denmark, and thus the health of democratic society. Ultimately, these democratic improvements provide important insights into effective practices that could resolve limitations to American democracy, becoming effective models for government reforms.

Reforms to the American System

Using insights from other democratic systems, the U.S. government would be substantially improved by reforming the structure of Congress, eliminating the Electoral College, and implementing universal healthcare. First, the United Kingdom, having 650 members of Parliament, demonstrates the benefits of having a large number of representatives in the legislative body so that legislators can perform their responsibilities more effectively, as they oversee fewer constituents ("Expand the House"). The relatively small size of their constituencies has permitted members of Parliament to do casework and represent the citizens' interests more interpersonally than U.S. representatives. Thus, the House of Representatives should be expanded by 165 seats to 600, followed by regular expansions depending on the national population recorded in the census. Similarly, the Senate should be expanded by 50 seats, with 1 seat allocated to each state, and also be subject to future expansion. This will permit the

U.S. Congress to represent the citizenry and serve their interests more intimately, thus garnering greater public trust and democratic participation ("Expand the House").

Second, Mexico's dual system of representation in the Chamber of Deputies exhibits the benefits of having a portion of congressional representatives elected by proportional vote, as the multi-party system that results from this promotes ideological diversity (Ramirez 4). In comparison, the members of Parliament in the United Kingdom are all elected in single-member districts, which has led to the emergence of a two-party system. With the exception of a few third-party representatives from minority-populated districts, the majority of MPs are from the Labour or the Conservative Party, which does not promote the degree of partisan diversity that facilitates competitive democratic practices like earnest deliberation and negotiation. As the United States currently experiencing gridlock and political polarization due to its rigid two-party system, it would be beneficial to institute a reform to congressional representation modeling Mexico's Chamber of Deputies. The House of Representatives should be reformed so that 200 of the newly 600 (per the reform discussed previously) total seats are elected by a proportional vote of the entire nation. Thus, a minority party that garners 4% of the vote will be apportioned 8 seats in the House of Representatives. This will permit third parties in the United States such as the Libertarian Party or the Green Party to win seats, diversifying the legislative body. Having other parties in the legislature will force greater cooperation because the seats occupied by these parties will become key votes necessary for the passage of legislation, obligating majority parties to accommodate the interests of these political groups and the citizens they represent (Ramirez 5). Gridlock will be mitigated, as there will no longer be one entrenched faultline between the two majority parties. The representatives from minority parties will bridge the gap and enable fluidity in legislative negotiations. Thus, this reform is fundamentally necessary because productive negotiations and movement in the legislative process are paramount to a truly successful, deliberative democracy.

Third, nations where the president is elected by direct popular vote, such as Mexico, have greater electoral legitimacy because all votes are recognized to have been counted equally and had an equal effect on the outcome, which is not the case under the Electoral College system ("Electoral College"). The Electoral College should be abolished so that presidential elections in the United States are determined on the basis of a popular vote. The Electoral College is ultimately an antiquated system that was intended to prioritize the interests of the elite and

disproportionately represents some states over others, undermining the principles of democracy ("Electoral College"). Using a direct popular vote will ensure that all votes, regardless of state or party affiliation, are equally significant to the outcome. If every vote matters, every citizen will recognize they equally matter, which will promote political efficacy and voter turnout, thus contributing to a higher-functioning democracy.

Fourth, several European nations such as the United Kingdom and Denmark have universal healthcare programs that substantially benefit their citizens' well-being and reduce socio-economic inequality. These systems have been revolutionary to promote healthcare access, leading to improvements in social conditions and public trust ("The Danish"). The U.S. federal government should implement a universal healthcare system for all residents. A system similar to the United Kingdom would provide healthcare access to all while still permitting citizens to select private options if those services are within their financial capability (NHS). Universal healthcare will be a profound advancement of the welfare system, reducing socioeconomic inequalities and promoting general health. Citizen well-being will be improved substantially, meaning that civic participation, quality of life, and economic productivity will improve, which are all conducive to a more successful democracy (The Commonwealth Fund).

Conclusion

In a globalized, technologized world, the United States faces existential threats never foreseen by the original architects of the democratic system. Fortunately, the solutions are not merely theoretical, but rather only an ocean or a border crossing from us: other democracies have proven the efficacy of well-structured legislatures, direct elections, and improved welfare systems to facilitate a more broadly-representative and legitimate government, thus promoting a well-functioning society. Throughout the past few decades, the United States has profoundly benefited from the technological, scientific, and entrepreneurial innovations of foreign countries—it is time that we also find inspiration in the foreign innovations of government.

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Ice Fishing Automatic Jig Model and Equipment By Sijia Zhu

Abstract

Ice fishing is a popular activity where anglers drill holes in frozen bodies of water and use specialized equipment. Experienced anglers understand the importance of rhythmically jigging the fishing rod to attract fish. By using artificial bait, the movement of injured fish can be simulated, enticing other fish to bite. This simulated movement serves as a lure, triggering the predatory instincts of fish. We have developed a theoretical model by simulating the movement of injured small fish in the water. To address the issue of cold hands during manual jigging, we have created an automatic jig device. Implementing our theoretical framework, our device offers three advantages: realistic bait movements, automatic motor shut-off when a fish is caught, and an alarm system for immediate alerts. Overall, our device enhances the fishing experience and improves outcomes compared to other alternatives.

Introduction

Ice fishing is a popular outdoor activity that entails fishing on the surface of a frozen body of water. It involves drilling a hole in the ice and lowering a fishing line with a baited hook into the water. Specialized equipment, such as ice fishing rods, lines, and lures, are utilized. Once the line is in the water, anglers patiently await fish to bite, utilizing the rod to detect their movements and reel them in.

Experienced anglers understand the importance of continuously and rhythmically jigging the fishing rod in order to effectively catch fish. This technique aims to imitate the movements of aquatic creatures or small fish using artificial bait.

However, the freezing temperatures experienced during ice fishing can cause the angler's hands to become uncomfortably cold while manually shaking the fishing rod. To overcome this inconvenience, an automated jigging device has been developed, enabling the fishing rod to jig automatically in a consistent pattern. This innovation allows anglers to free up both hands and enhance the overall experience of ice fishing.

I. Our Model

In order to optimize the functionality of our device, it is crucial to comprehend the

motion of the artificial bait. We can replicate the swaying and vibrations of injured fish, attracting the attention of other fish. This simulated movement can be considered as a lure, arousing the predatory instincts of other fish. The bait's movement in the water can be segmented into four distinct steps:

Step 1: The bait gradually ascends from the bottom.
Step 2: Once the bait reaches the upper portion, it pauses momentarily and undergoes a shaking motion.
Step 3: Subsequently, the bait rapidly descends back down to the bottom.
Step 4: Upon reaching the bottom, the bait pauses again and undergoes another shaking motion.

To effectively attract fish, the first and third movements exhibit greater intensity, while the second and fourth movements have reduced amplitudes, providing fish with an opportunity to strike the bait. To replicate these four movement patterns, we have selected a DC motor with a gearbox to drive an eccentric driving wheel. This driving wheel, as illustrated in Figure 1, orchestrates the motion of the fishing rod, imitating the continuous shaking action associated with manually maneuvering a handheld fishing rod.

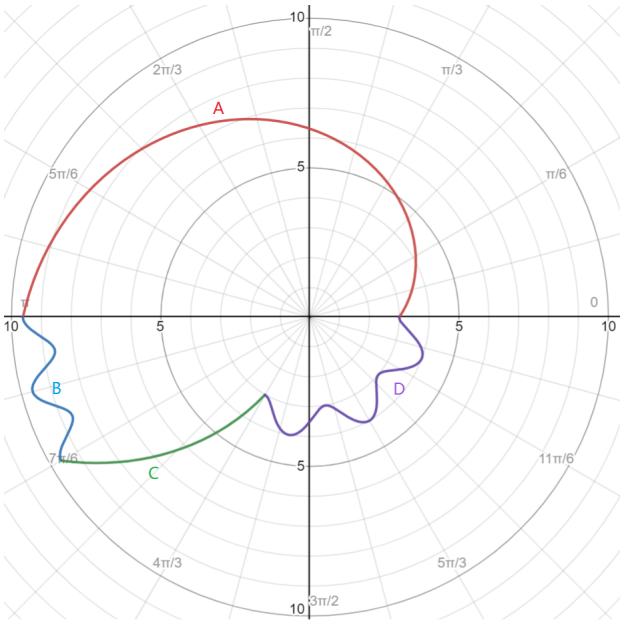

Figure 1. Driving Wheel

To accurately simulate the model depicted in Figure 1, we have divided it into four sections within one cycle in polar coordinates:

A: The outer edge of the driving wheel is designed as a constant pitch helix. In this section, the fishing rod gradually lifts up, causing the bait to move upward in tandem with the rod's upward movement. The mathematical model for this section is as follows:

$$r = 3.0 + 2.1\theta \quad \theta \in [0, \pi)$$

B: The outer edge of the driving wheel is approximately resembled a cosine wave shape. As the driving wheel rotates, the fishing rod reaches its highest point and then undergoes a shaking motion. The bait follows the shaking motion accordingly. The mathematical model for this section is:

$$r = 9.1 + 0.5\cos(24(\theta - \pi)) \quad \theta \in [\pi, \frac{7}{6}\pi)$$

C: The outer edge of the driving wheel is a rapid descending constant pitch helix. As the driving wheel rotates, the fishing rod swiftly descends, causing the bait to rapidly reach the bottom. The mathematical model for this section is:

$$r = 9.6 - 12.6(\theta - \frac{7}{6}\pi) \quad \theta \in [\frac{7}{6}\pi, \frac{4}{3}\pi)$$

D: The outer edge of the driving wheel roughly resembles a sine wave shape. The fishing rod shakes once more as it rotates with the driving wheel, and the bait mimics the shaking motion, enticing fish to strike. The mathematical model for this section is:

$$r = 3.5 - 0.5\cos(9(\theta - \frac{4}{3}\pi)) \quad \theta \in [\frac{4}{3}\pi, 2\pi)$$

At the point of the drive rod, the movement of this point is a piecewise function in Cartesian coordinates. The function is:

$$y = \begin{cases} 3.0 + 2.1x & 0 \le x < \pi \\ 9.1 + 0.5\cos(24(x - \pi)) & \pi \le x < \frac{7}{6}\pi \\ 9.6 - 12.6(x - \frac{7}{6}\pi) & \frac{7}{6}\pi \le x < \frac{4}{3}\pi \\ 3.5 - 0.5\cos(9(x - \frac{4}{3}\pi)) & \frac{4}{3}\pi \le x < 2\pi \end{cases}$$

As a result, Figure 2 represents the combined graph of the aforementioned four sections,

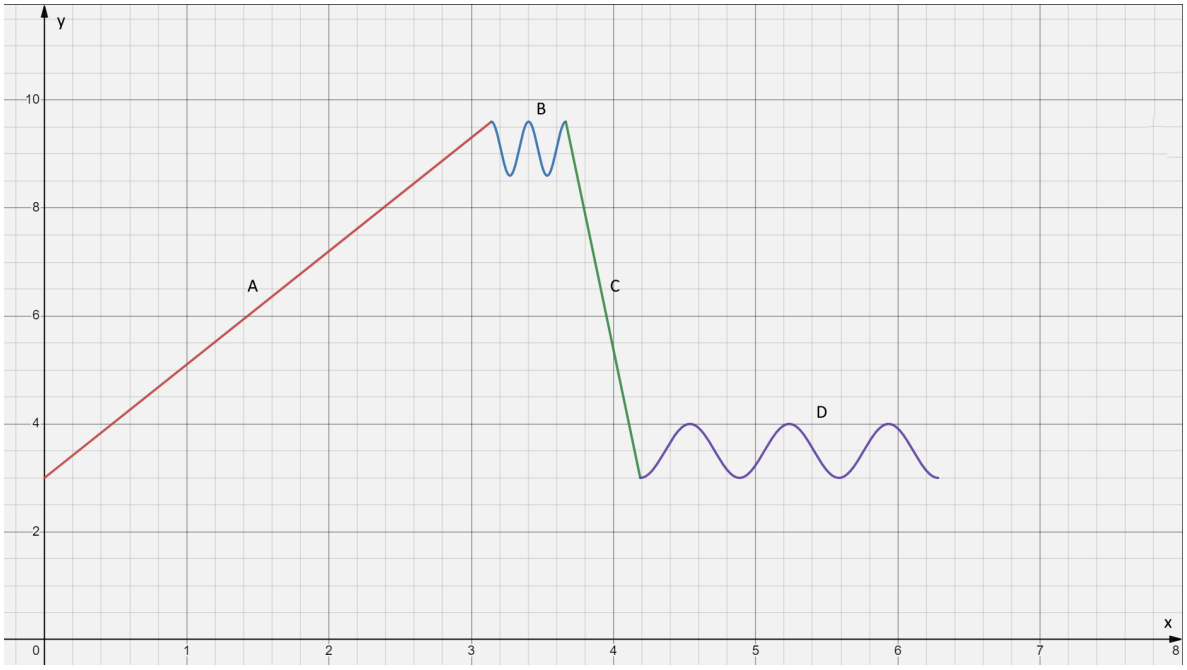

Figure 2. The graph of our model in one cycle

II. Our Device

Based on our theoretical model, we have developed a physical representation of the driving wheel, as shown in Figure 3.

Figure 3. The Physical Driving Wheel

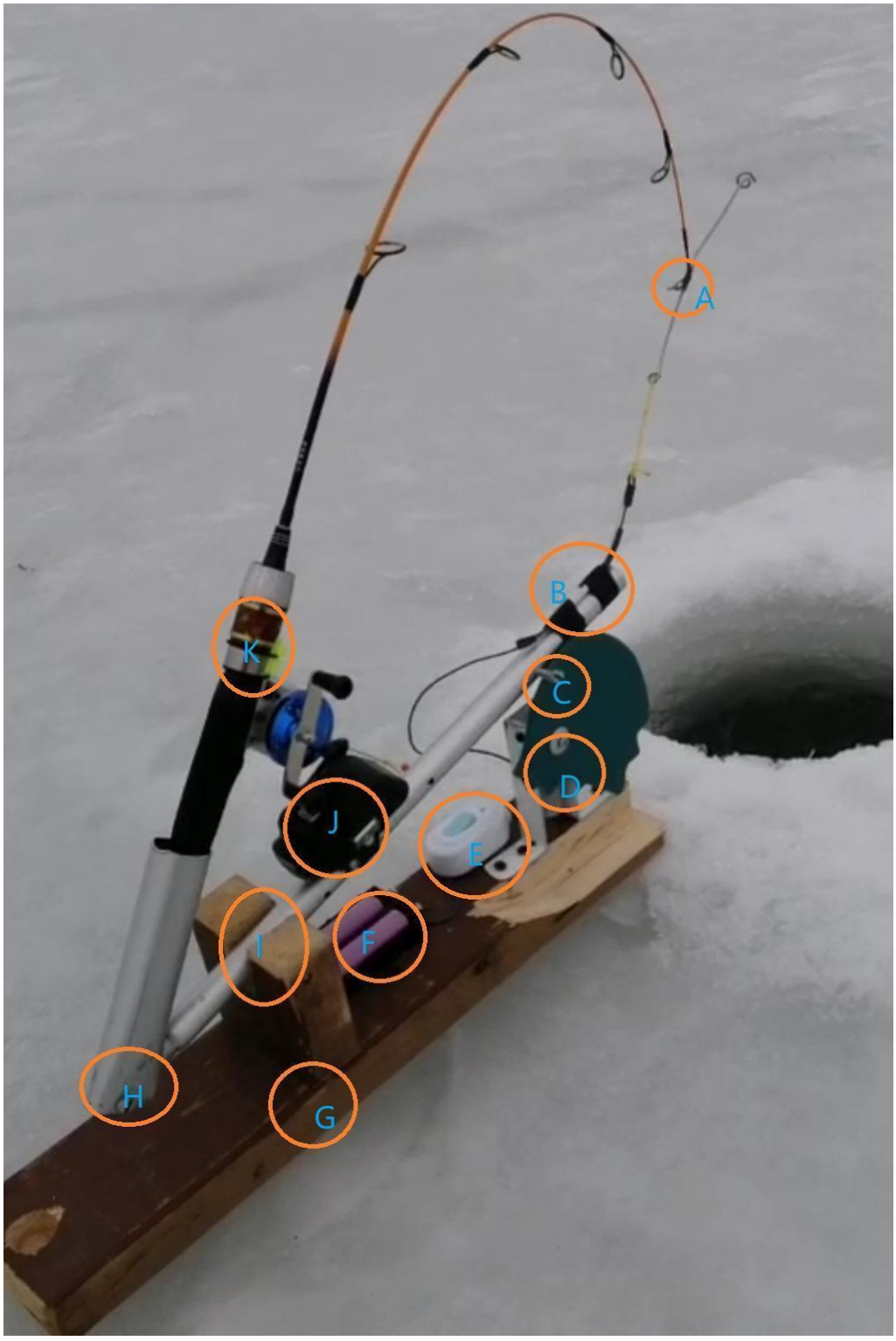

Figure 4. Automatic fishing device

Figure 4 illustrates our automatic fishing device, with the following component names and functions:

A: Fish bite trigger device. When a fish bites the bait, it tugs on the fishing line, activating this device. The front part of the fishing rod detaches from this device, causing the fishing rod to spring up and the hook to penetrate the fish's mouth.
B: Auxiliary power switch
C: Drive rod. This component makes contact with the outer edge of the driving wheel and swings the fishing rod holder in a regular pattern as the driving wheel rotates.
D: Driving wheel and driving motor
E: Main power switch
F: Power supply battery
G: Base
H: Fishing rod holder
I: Pivot point of the fishing rod holder
J: Sound and light alarm
K: Ice fishing rod

The operational process of this device is outlined as follows:
1. Begin by drilling a hole in the ice and positioning the device in the desired location.
2. Insert the fishing rod into the fishing rod holder. Adjust the length of the fishing line based on the water depth and place the jig and hook into the ice hole.
3. Connect the front guide of the ice fishing rod to the fish bite trigger device A and thread the fishing line through the trigger device A. As the fishing rod bends, it generates tension that pulls the pull line connected to the auxiliary power switch B, causing the switch to close. Additionally, the tension activates the alarm switch, keeping the alarm in the off state.
4. Switch on the main power switch and the alarm power switch. The motor receives power and begins rotating, driving the driving wheel, fishing rod holder, and fishing rod to execute a jigging motion. This motion entices fish to attack the moving bait underwater. The alarm is also in pre-alarm state.
5. When a fish attacks the moving bait and pulls the fishing line, it triggers the fish bite trigger device A. The front end of the fishing rod disengages from the device A, causing the fishing rod to spring up. Simultaneously, the auxiliary power switch B resects and disconnects the power, halting the rotation of the reduction motor D. Additionally, the sound and light alarm J is

triggered, emitting an audible and visual alarm signal.

Figure 5 showcases a fish caught during this winter using our device.

Figure 5 Catching a fish using our device

Conclusion

After conducting theoretical analysis and practical implementation, we have successfully

developed the ice fishing automatic jig device. Compared to other existing devices, our device offers three key advantages:

Firstly, our device incorporates subtle shaking motions at the highest and lowest points of the bait, closely resembling the natural movements of aquatic organisms. This realistic simulation significantly enhances the bait's ability to attract fish, increasing the chances of successful bait attacks.

Secondly, our device features an auxiliary switch that allows the motor to be automatically shut off once a fish is caught. This prevents any potential damage to the motor caused by the fish's struggles, ensuring the device remains in optimal working condition for future use.

Lastly, our device is equipped with an audible and visual alarm system that activates immediately after catching a fish. This alarm function ensures that individuals are promptly alerted, even if they are not actively monitoring the device.

In conclusion, by mimicking the movement of injured fish, our ice fishing automatic jig device provides anglers with an enhanced fishing experience and improved outcomes compared to alternative devices.

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Mausk By Addison Moss

This past year, in 2022, the McMinn County School Board in Tennessee banned *Maus*, a Holocaust memoir created by Art Spiegelman between 1980 and 1991. At the meeting, a member of the board contended, "Being in the schools, educators and stuff, we don't need to enable or somewhat promote this stuff," which reflected a flawed conflation of promoting and bearing witness. Indeed, the content of the Shoah is horrific and gives rise to visceral discomfort. The testimony of survivors is painful and grim. But, to prohibit the teaching of this history denies its existence and engenders an inaccurate and dishonest whitewashing. How then, does one interpret and present the specter of genocide? Navigating this daunting material, Spiegelman embraces an uncanny approach relying on both image and text. The composite establishes a forum wherein the author constructs a metonymy of animal visages that represent disparate categorizations of people. This use of masks, both literal and metaphoric, acts as an artistic device to effectively convey meaning as it allows for a process of understanding that is oblique and incremental.

Spiegelman employs masks as signifiers of cultural identity. With a cursory glance, Jews are portrayed as mice, Germans as cats, Poles as pigs, Americans as dogs, French as frogs, etc. While these characters might initially present as anthropomorphic, on closer inspection, they are always and already human, donning quasi full head masks (with no visible ties at first) that categorize them into discrete groups. The depiction is one of a cipher rather than a chimera; the mask tactic operates as a code that can be read as opposed to a hybrid creature that constitutionally embodies the qualities of two species. From the frontispiece of Chapter I, despite animal assignment, these beings have bodies, hands, traits, postures, and behaviors that are distinctly and exclusively human. They inter-species speak to and understand one another regardless of animal assignation. Spiegelman unequivocally draws this distinction as Anja is frightened by actual rodents while hiding in a storage locker in Szopienice: "AIEE!... Th-there are RATS down there!" (147) This is further affirmed by Vladek: "There, I'm starting to feel human again!" (271) thereby confirming he has been a person from the start. Consequently, both author and audience are together "in the know" and see beyond the disguise that Vladek et al are, in fact, people; former and latter are united in this privy understanding, establishing intimacy and trust. In collectively accepting this sign system, the resulting categorization provides a shorthand

for the visual construction of ethnicity and nationality. Here, the cat-mouse cliché of predator and prey as well as the Nazi propaganda characterization of Jews as vermin (164) are immediately recalled and create an incipient framework of communally agreed upon indexes. The animal mask imagery allows for characters to conform to behavioral expectations anticipated by their social group, a role being played. The artistic device offers a seemingly facile means to present complex issues in an accessible manner, a convenient approach to depicting uncomfortable and irreconcilable realities. Like Kafka's use of mice instead of people in *Josephine the Singer, or the Mouse Folk*, Spiegelman is able to immediately ascribe qualities of vulnerability and sympathy to the Jews. Further akin to Kafka's story, the use of mouse heads in *Maus*, creates a sense of distance and detachment that allows for a more objective examination of the story's themes. In other words, it portrays unimaginable, "unreal" events in a likewise fantastical way. One can better bear the barbarity because the veneer creates a layer of separation; the narrative is too horrific to be presented unmasked.

While the use of animal masks literally shows the dehumanization of all people associated with the Holocaust, as the tale progresses, the limitations of the technique are laid bare. Ultimately this categorization and otherness are too reductive. Hence, Spiegelman embarks on his operation of "unmasking," but by degree. In the face of complexity and atrocity, he uses masks to ease the reader in, allowing for an education by increments. As volume II develops, the author challenges the narrative orthodoxy he originally set forth, subverting the mouse-metaphor; he deliberately intimates the artifice of veneer. The bestial qualities evolve from prominent to vestigial and mark an important shift: identifying mice as humans rather than jews as mice. As whiskers and tails vanish while obvious mask strings materialize, the constraining cartoon characterization dissipates. The collusion of consenting to the mask model is disrupted, and both the subterfuge and the effectiveness of the metaphor as a normalized aesthetic device, are exposed. Eventually, masks can be donned and doffed at will. They become a mere figure of identity which is pliant, even manifold, rather than fixed. Spiegelman himself presents a "double-mask" as he occupies the roles of author/ narrator and character within the story. Meanwhile, on a single two page spread, a Jewish Israeli American wears the mask of a mouse; a (Christian?) American, a dog; a German American, a cat; a Jewish Czech American Holocaust survivor immigrant, a mouse; and a Jewish American second generation survivor, a mouse. (42, 43) While there exists some alignment in the representation, there are also distinct

inconsistencies. The ciphers have lost their rigor, and the rules have become muddled and blurred. The insufficiency and failure of this signifier system is made clear and a corresponding truth emerges: identity (i.e. ethnicities and nationalities) is fluid, and as such, is a deficient justification for societal stratification, much less eugenics and violence.

While masks denote, they also paradoxically conceal. Spiegelman exploits this Lacanian dual capacity of masking throughout *Maus*. By their very construction, these devices hide what exists beneath; although they can exhibit an outward presentation of identity, masks simultaneously and literally obscure a reality that pre-exists their apparatus. As a metaphor throughout the book, masking emphasizes a permeating sensibility of "the unknowable." Initially as the animal heads signify ethnicity and nationality, they simultaneously thwart a deeper understanding of particular personalities. Often rendered with a simplified, blank, sameness, these masks frustrate the communication of nuanced emotion. As they relate only behind mouse disguises, true connection between Art and Vladek seems even more challenging. This extra layer underscores the separation between father and son. One of Art's central projects is to bridge this alienation. The urgency to authentically perceive his father, to penetrate the surface and genuinely understand one another, becomes even more palpable. This absence of transparency, however, persists and Art bemoans, "I mean, I can't even make any sense out of my relationship with my father… How am I supposed to make any sense out of Auschwitz? …Of the Holocaust?...I feel so inadequate trying to reconstruct a reality that was worse than my darkest dreams." (176) Here, Spiegelman identifies the potential futility of his other, parallel endeavor as well; to comprehend and document his father's narrative as a survivor of the Nazi regime. As a second generation survivor, the author's mask resonates in these frames as it confirms his spatial and temporal distance and detachment from the actual events. The fundamental opacity of these experiences is reflected by this artistic device; not having been there, can the author ever see the truth, and consequently can the audience actually discern the reality of this difficult history through this mediated rendition?

Spiegelman's use of masking confirms these extant doubts, and in their acknowledgment he establishes credibility with the audience. Contingent on the benefit of that faith, he is then able to push the limits of the metaphor, and in chipping away he introduces the possibility of a "way in," an opening to authentic insight, albeit small and indirect. The panels of Art's "shrink" Pavel, (203-206) a Czech Jewish survivor of the concentration camps, exemplifies a breaking

down of this sign system. One such indication is that the text is not exclusively capitalized. Additionally, from the first frame, the text block and graphic indicate actual dogs, and lower on the page, even a drawn desk photo of a pet cat. Similar to the inclusion of actual rodents in Volume I, the metaphor is dissembling (and in a meta-reference, Art calls this out.) Moreover, Pavel never dons the mouse head nor a more specific indicator of his country of origin; from the outset he is clearly rendered as a man wearing a mouse mask with ties. Approaching laterally from the side, the audience perceives glimpses of the real human beneath: while his face is mostly hidden, there are teases of an ear, sparse hair, a balding head. These peeks pique interest and invite one to look more closely. There is, in fact, a truth that lays behind and is waiting to be discovered. This uncovering requires work. From the efforts in the therapeutic session wherein Art and Pavel probe the complexity of survival, a degree of clarity and peace regarding Vladek is achieved. Growth is possible, and Art literally transforms from a boy's stature to a man's following this sequence. Here, the problematic impenetrability of conceptualizing and representing the Holocaust is also faced as Pavel speculates "Look how many books have already been written about the Holocaust, what's the point? People haven't changed…." At first, Art mirrors this pointlessness: "…Samuel Beckett once said: 'Every word is like an unnecessary stain on silence and nothingness…." But, Art fights against this notion of utter opacity and futility and exclaims, "On the other hand, he SAID it." Here, the author critically establishes the opening for understanding, even in the face of daunting challenges. Having gone through this process, the audience is now primed and receptive, as Spiegelman then illustrates the most detailed twenty pages of the tome, an unflinching and engrossing depiction of Vladek's experience in Auschwitz. Indeed, the detail and the horror of the Holocaust are, at least in part, obliquely, "knowable."

Although with greater subtlety, Spiegelman uses the genre of his work as a mask as well. *Maus* initially presents as a comic book, replete with all the recognizable elements: speech bubbles, capital letters, panels, frames, and onomatopoeic sounds. The medium can be quickly identified, and the associated connotations of playfulness are conjured. The author himself alludes to Mickey and Walt Disney (with some irony) while the first page depicts childhood games. Comic books often signify collectively embraced notions of good and evil wherein the former inevitably triumphs after a melodramatic struggle. Here, the genre might indicate: the Allies beat the Nazis, and Art's parents survived. These traditional narratives, coupled with

likable anthropomorphic characters, are simplistic, recognizable, and easily approachable. These associations, even if subconscious, provide certain shortcuts for Spiegelman. The work eludes the often "too precious," too onerous characterization of Holocaust art. One is compelled by a visually dynamic component while not mired in a burdensome word count. The structure of this genre also tempers the experience of the difficult content. While comics are intended to be consumed sequentially, their spatial nature allows for a more flexible reading. The linear expectation is not as didactic. The eye can jump around a facing two-page comic spread more easily than one of just text, following and rapidly processing various optical cues. One can take in gruesome scenes but quickly pivot to another frame without digesting the content whole. As the German cats raid the Srodula ghetto, Spiegelman illustrates horrific violence against a child as he is thrown against a wall (108); the gaze, however, is not forced to dwell and linger on this image and can hastily skip to another, a triptych of Tosha composed to draw attention on the opposite page. The audience might better bear these scenes, as one has more agency in this format. Moreover, the sphere of comics is, by definition a fantasy, emphatically not real. Consequently, it constructs a layer of distance, a per se mask, between the world of *Maus* and factual existence, thereby buffering the horror of events and themes depicted therein.

But similar to Spiegelman's "unmasking" in regard to identity and knowableness, he also begins to break down the mask of genre that he initially constructed. Although he retains the framework and some associated advantages, the author starts to defamiliarize the medium. The narrative becomes less simplistic; characters, ethics, and outcomes are more fraught and muddled. The sequencing is also more elaborate than a classic comic as it frequently shifts temporally and perspectivally. When Vladek describes his experience in the Polish army fighting the Germans, the frames from the war and Rego Park are literally blurred with Art's body extending across both. (48) Likewise, the visual language defies easy categorization. In contrast to comic book conventions, the illustrations in *Maus* completely lack color and the use of Ben Day dots (small dots in a grid pattern used for shading and texture.) Instead, the exclusively black and white drawings reflect a heavy chiaroscuro, resembling cruder woodblock prints. The aesthetic is flat and the articulation of emotion is limited. This is especially noticeable in the juxtaposition of the comic within a comic: Spiegelman's own *Prisoner on the Hell Planet*. (100-103) His earlier work embodies a disparate visual language characterized by dramatic facial expressions, exaggerated renderings, a multiplicity of hatching textures and depth, and an overall

pulsating energy. Hence, the minimalism of *Maus* diverges not only from conventional comics, but from Spiegelman's own style as well. This schism is furthered in the ultimate publication of the work by Pantheon in two bound volumes, resembling a standard book format (originally it was serially published in Spiegelman's *Raw*.) Yet, if *Maus* is not quite a comic book, what is it? Both the Pulitzer Prize Committee and the New York Times have struggled with the same incertitude. The former avoided complications and simply awarded *Maus* a "Special Citation." The latter first assigned the work to the "fiction" category until Spiegelman wrote a letter insisting on "nonfiction" status. The author has also rebuffed the "graphic novel" label as "novel" is often associated with fiction. In eschewing a clear classification, Spiegelman encourages the audience to engage more actively; they must do more of the heavy labor. This ambiguity compels one to reexamine prior biases and assumptions as well as question the medium and the content therein, giving rise to a more profound exploration and intimacy with the material.

Curiosity is borne out of the unexpected, and Spiegelman's dual operation of masking and unmasking allows new possibilities and insights to flow from this method of discovery. Using masks as provisional constructs, he identifies collective preconceptions, then moves to question and reveal the limitations of these very notions. In the wake of this schema, queries arise: How is identity determined? Can one actually understand historical horrors like genocide? Is it possible to interpret and present these events effectively and appropriately? While Theodor Adorno asserted the futility, even indecency of such projects: "…to write poetry after Auschwitz is barbaric," through his strange but dexterous approach, Spiegelman offers tempered hope. The narrative reflects a work in progress, with Art achieving incremental successes. Embracing a hermeneutic sensibility, the author suggests that meaning is not fixed, but constantly renegotiated and reinterpreted. Similarly, understanding is not straightforward but rather obtained obliquely, requiring a dynamic dialogue that navigates multiple perspectives and interpretive strategies: personal, historic, and artistic. It is an imperfect and slow process about which Art laments: "I feel so inadequate trying to reconstruct a reality that was worse than my darkest dream…There's so much I'll never be able to understand or visualize…so much has to be left out or distorted."(46) But, on the other hand, he CREATED it.

Epigenetics of GDM and its Effects on Offsprings By Isabella Guo

Abstract

This paper investigates the epigenetic factors underlying the increased risk of type 2 diabetes (T2D) in the offspring of gestational diabetes mellitus (GDM) patients. GDM is a condition characterized by insufficient insulin production during pregnancy, leading to carbohydrate intolerance. It is associated with various pregnancy complications and long-term risks for both mothers and children. The findings highlight the importance of early intervention and preventive measures to improve long-term health outcomes for both mothers and their children. Future research should focus on targeted interventions and personalized approaches to mitigate the impact of GDM and reduce the risk of T2D in affected individuals.

Introduction–Defining Key Terms

Gestational diabetes mellitus (GDM) is a condition that arises during pregnancy when the body fails to produce sufficient insulin. Insulin, a hormone produced by the pancreas, plays a vital role in allowing blood sugar to enter cells for energy utilization ("Gestational Diabetes | CDC"). GDM is characterized by carbohydrate intolerance, ranging from mild to severe, that emerges or is first recognized during pregnancy. The condition is also associated with various pregnancy complications such as preeclampsia and macrosomia ("Gestational Diabetes | CDC").

Type 2 diabetes (T2D) is a chronic metabolic disorder characterized by high blood sugar levels ("Type 2 Diabetes | CDC"). This paper will explore the epigenetic risk factors associated with the development of T2D in offspring of GDM patients.

Epigenetics refers to the mechanisms that control gene activity without altering the underlying DNA sequence (Lehnen and Haaf). Epigenetic modifications, including histone modifications and DNA methylation, play a crucial role in regulating gene expression and can be influenced by environmental factors such as diet and drug usage.

Justification and Background Information

The justification for this research stems from the prevalence of GDM among pregnant women and the subsequent increased risk of developing T2D later in life. From data given by the CDC, an evident increase of GDM rate from 2016-2020 is shown. Studies estimate that up to

70% of patients with GDM will develop diabetes within 22-28 years after gestation (Dłuski et al.). Diaz-Santana et al. found that the risk of developing T2D among women with GDM was approximately ten times that of those with normoglycemic pregnancies.

Furthermore, evidence suggests that offspring of GDM patients are more likely to develop T2D in their lifetime. These children face potential long-term complications, including insulin resistance, impaired glucose tolerance, and T2D itself, collectively referred to as disorders of glucose metabolism (Bianco and Josefson). Observational long-term follow-up studies have established a cycle of diabetes between mothers and children, reinforcing the association between GDM and metabolic diseases in offspring (Bianco and Josefson).

Aim of Paper

This paper aims to investigate the epigenetic factors underlying the increased risk of T2D in the offspring of GDM patients. Exploring the epigenetic changes associated with GDM and their potential impact on offspring offers insights into the mechanisms linking GDM and T2D and reveals novel avenues for intervention and prevention strategies.

Section 1: Epigenetic Changes in Gestational Diabetes Mellitus (GDM)

Gestational diabetes mellitus (GDM) patients have alterations in genetics and epigenetics. This section explores the genetic and epigenetic changes observed in GDM patients, shedding light on potential pathogenic target genes and their implications.

Transgenerational Effects and Animal Models:

Advancements in animal models, primarily mice and rats, have indicated that developmental programming in GDM can have transgenerational effects (Damm et al.). Additionally, most research has focused on maternal contributions to offspring which makes the transgenerational transmission of traits in GDM a growing area of interest (Damm et al.).

Epigenetic Changes in GDM

Epigenetic alterations play a crucial role in GDM. Elevated levels of certain urinary metabolites, such as 3-hydroxyisovalerate, 2-hydroxybutyrate, and choline, have been observed in GDM patients (Dalfrà et al.). These metabolites reflect changes in biotin status, insulin

resistance, and potential markers for the onset of type 2 diabetes (Dalfrà et al.). Furthermore, the genetic architecture underlying type 2 diabetes and GDM show partial similarities, as susceptibility genes for type 2 diabetes have also been associated with GDM (Dalfrà et al.), which might account for the increase of type 2 diabetes risk later in life for GDM patients.

Recent studies have identified several genes that exhibit altered expression and methylation patterns in GDM patients. Oas1, Ppie, and Polr2g are suggested as possible pathogenic target genes of GDM (Dłuski et al.). Moreover, GDM patients are observed to have reduced mRNA expression and increased DNA methylation in the glucose-6-phosphate dehydrogenase gene which can result in an increased risk of hemolytic anemia (Richardson and O'Malley; Dłuski et al.). The interplay between genetic variants associated with type 2 diabetes and GDM has also been explored, revealing a significant association between known type 2 diabetes variants and GDM (Dalfrà et al.).

Epigenetic modifications in GDM influence both maternal and fetal health. Lower DNA methylation levels on the maternal side of the placenta have been linked to higher insulin resistance during pregnancy and increased circulating adiponectin levels. These alterations in DNA methylation can impact glucose metabolism in both the mother and offspring throughout their lives (Dalfrà et al.).

Section 2: Epigenetics in Offspring of Gestational Diabetes Mellitus (GDM)

In addition to maternal health, GDM can also have significant implications on the offspring's health. This section explores the symptoms and epigenetic changes observed in the offspring of women with GDM, highlighting the long-term consequences and intergenerational effects of this metabolic disorder.

Symptoms in Offspring:

The offspring of GDM patients have a possibility of experiencing illnesses such as hypoglycemia, hypoxia, or respiratory distress syndrome (RDS) (Dłuski et al.). Furthermore, these offspring have an increased risk of developing diabetes and obesity that extends from childhood into adulthood (Alba-Linares et al.). Studies have shown a higher amount of cases of prediabetes/diabetes in offspring of women with GDM and type 1 diabetes compared to those from healthy women (Zhu et al.). An example would be the studies on the Pima Indians which

demonstrates a higher prevalence of diabetes in offspring of women with abnormal glucose tolerance during pregnancy (Chu and Godfrey).

Epigenetic Changes in Offspring:

Epigenetic modifications play a crucial role in transmitting the effects of GDM to the offspring. Cross-sectional studies have identified DNA methylation alterations in children born to mothers with obesity or obesity accompanied by GDM during pregnancy (Alba-Linares et al.). These alterations can be observed at single CpG positions and genomic regions, and they persist at least during the first year of the infants' lives (Alba-Linares et al.).

A study by Dalfra et al. suggests that specific genes such as the MEST gene and the glucocorticoid receptor NR3C1 gene show significantly lower methylation levels in offspring from mothers suffering with GDM than those with healthy mothers (Dalfrà et al.). Furthermore, a lipid-rich diet during pregnancy can cause hypermethylation in the offspring's liver, indicating the lasting effects of intrauterine exposure to GDM on the epigenome (Dalfrà et al.). Excessive food intake and weight gain during pregnancy can also lead to lower adiponectin expression, higher leptin expression, and hypermethylation of adiponectin which are all hormones associated with metabolism in fetal tissues (Dalfrà et al.).

Long-Term Consequences and Transgenerational Risk:

GDM patients have a higher risk of developing type 2 diabetes later in life. Additionally, the children of the GDM patients also have an increased risk of developing T2D which highlights the transgenerational nature of the epigenetic markers in GDM. This trait is also accentuated by studies that identified DNA methylation biomarkers which distinguish children born to mothers with obesity or obesity accompanied by GDM (Alba-Linares et al.). These epigenetic changes affect genes and pathways involved in fatty acid metabolism, postnatal developmental processes, and mitochondrial bioenergetics which can cause the increased risk of type 2 diabetes. Epigenetics plays a crucial role in the transmission of GDM health effects and impact on gene expressions from the patient to their offspring.

Section 3 Analysis of Association between Maternal Metabolism and Offspring Development

In recent years, growing evidence suggests a link between maternal metabolic condition during pregnancy and the long-term health outcomes of offspring. Epigenetic modifications, particularly DNA methylation, have emerged as potential mediators of this relationship. This section aims to discuss and analyze key findings on the relationship between epigenetic changes that are present in GDM patients during pregnancy and its impact on the offspring of the patients.

Developmental Epigenetic Alterations: DNA Methylation

Alba-Linares et al. revealed significant epigenetic alterations, specifically differentially methylated positions (DMPs) and differentially methylated regions (DMRs), during early childhood development of the GDM offspring. These alterations were particularly prominent during the first six months of life, highlighting a critical period for the establishment of epigenetic modifications (Alba-Linares et al.). The results support the notion that maternal metabolic condition influences the developmental trajectory of DNA methylation patterns, suggesting a potential link between the two.

Animal Models and DNA Methylation Changes

Animal models have provided valuable insights into the mechanism of the relationship between maternal metabolic condition and DNA methylation alterations in offspring. For instance, studies involving pregnant rats fed a protein-restricted diet demonstrated changes in DNA methylation and expression patterns of specific genes, such as the glucocorticoid receptor Nr3c1 and peroxisome proliferator-activated receptor alpha Ppara, in the liver and heart of their offspring (Lillycrop et al.; Slater-Jefferies and Lillycrop). These findings suggest that maternal dietary factors can exert lasting effects on the epigenome of the developing fetus.

Insulin Secretion and Beta Cell Compensation in T2D and GDM

In addition to epigenetic alterations, differences in absolute insulin secretion and beta cell compensation have been implicated in the development of type 2 diabetes (T2D) and GDM. Dalfrà et al. contributes significantly to the existing knowledge of the pathophysiological mechanisms underlying these conditions. By elucidating the factors involved in insulin secretion

and beta cell compensation, it is possible to target these factors which points a pathway of improvement in research and therapeutic aprroaches into the development and progression of T2D and GDM (Dalfrà et al.).

Potential DNA Methylation Biomarkers and Risk Assessment

Identification and characterization of DNA methylation biomarkers associated with maternal metabolic condition possibly provides a pathway in estimating the risk of developing cardiometabolic diseases in offspring (Alba-Linares et al.). While further investigations are warranted to evaluate their feasibility, these biomarkers may serve as valuable tools in assessing the long-term health implications of maternal metabolic conditions on the next generation. Understanding the epigenetic basis of these diseases is crucial for early intervention and preventive strategies.

Conclusion

Collectively, the research provides evidence of systemic intrauterine fetal programming that affects the childhood methylome beyond birth, establishing a connection between maternal metabolic condition and early childhood development. Epigenetic alterations, particularly DNA methylation, play a crucial role in mediating these effects. Furthermore, the identification of DNA methylation biomarkers associated with maternal metabolic condition holds promise for risk assessment and early intervention strategies. This research advances our understanding of the pathophysiological mechanisms underlying T2D and GDM, opening avenues for targeted interventions to improve long-term health outcomes in offspring.

Conclusion

In conclusion, this paper has examined the key terms and background related to gestational diabetes mellitus (GDM) and its association with the development of type 2 diabetes (T2D) in offspring. GDM is characterized by a deficiency in insulin production during pregnancy, leading to carbohydrate intolerance. It is linked to various pregnancy complications and poses long-term risks for both mothers and their children.

The justification for this research lies in the high prevalence of GDM among pregnant women and the subsequent increased risk of developing T2D later in life. Studies have indicated that a significant percentage of GDM patients will develop diabetes within a couple of decades after gestation. Additionally, observational studies have highlighted a cycle of diabetes between mothers and children, emphasizing the intergenerational impact of GDM.

Epigenetic factors play a crucial role in understanding the increased T2D risk in the offspring of GDM patients. Genetic and epigenetic changes have been observed in GDM patients, including altered expression and methylation patterns of specific genes. Animal models have further contributed to our understanding of the transgenerational effects of GDM and the role of epigenetic modifications.

Furthermore, epigenetic changes have been identified in the offspring of GDM patients, which can persist throughout early childhood. These alterations in DNA methylation have been associated with metabolic disorders and may serve as biomarkers for assessing the risk of developing T2D and other cardiometabolic diseases.

The analysis of the association between maternal metabolism and offspring development has revealed significant epigenetic alterations during early childhood. Animal models and studies on insulin secretion and beta cell compensation have provided insights into the underlying mechanisms of T2D and GDM. Additionally, the identification of DNA methylation biomarkers associated with maternal metabolic conditions holds promise for risk assessment and early intervention strategies.

Overall, this research enhances our understanding of the epigenetic factors contributing to the increased risk of T2D in the offspring of GDM patients. The findings highlight the importance of early intervention and preventive measures to improve long-term health outcomes for both mothers and their children. By elucidating the mechanisms involved, future research can focus on targeted interventions and personalized approaches to mitigate the impact of GDM and reduce the risk of T2D in affected individuals.

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How Imitation and Pop Culture Combine with Fine Art By Lin Ma

Abstract

This article delves into the dynamic relationship between imitation, pop culture, and fine art throughout history. Traditionally, art was perceived as either a creation or an imitation. However, with the emergence of avant-gardes in the late 19th century, the focus shifted towards artists expressing their emotions and unique perspectives. The avant-gardes mirrored societal themes and challenged existing artistic and societal norms. The rise of mass production and electronic media in the mid-20th century, as foreseen by Marshall McLuhan, led to the birth of pop art. Lawrence Alloway coined the term "pop art," defining it as an aesthetic influenced by popular and mass culture. Artists like Andy Warhol revolutionized the concept of art by embracing everyday life and consumerism. Richard Hamilton's artwork exemplified the incorporation of media symbols and the fascination with popular icons. These developments prompted artists to explore the intersection between artistic expression and the demands of a consumer-driven society. They employed techniques such as photography, reworked advertising images, comic books, performances, and improvisation to redefine the boundaries of art. Ultimately, this transformative journey marked the end of a millennium-long era in the art world.

Keywords: imitation, pop culture, fine art, existing artistic, societal norms, boundaries of art, artistic expression

Since its origins, art has been a method used by humans to materialize ideas, messages, and symbols. Inspiration, genius, and creativity have always been seen as qualities that have allowed man to act on a symbolic level, rendering the reality that surrounds him abstractly through art and culture. It is an intrinsic ability of human beings to express their ideas through a visual medium. This article explores how imitation and pop culture interact with fine art, leading to significant changes in artistic expression over the centuries.

In the common way of thinking about art, it is customary to oppose two main concepts: art as creation and art as imitation. Anyone who speaks of art as creation underlines the absolute freedom of the artist, who has no fixed rules to follow or knows how to subordinate them to his

own will and inventiveness, to his own genius, and to his own inspiration. On the other hand, those who speak of art as imitation underline art's dependence on nature or reality in general.

In the past, artists commonly depicted saints, rulers, and landscapes in their works, but then art began to draw inspiration from common people, comics, billboards, and even supermarket products.

In the art world, starting from the end of the 19th century, the focus on imitation faded: the protagonists of the works became the artists themselves, their emotions, and their way of seeing the world and representing it in art.

This is how the avant-gardes were born: the artistic activity of the avant-gardes developed internationally and crossed all the arts (painting, theatre, music, cinema, and literature) with close links between one art and another.

Each avant-garde is linked to very specific themes, firmly united with the culture, with the dynamics of its time: works of art become a mirror of society.

The end of the avant-gardes, considered briefly, coincides with that of great history. More specifically, it is linked to the birth of a methodology of art that has abandoned the imperative of originality, in the sense of a radical origin, and has ceased to conceive of itself as the unconditional search for ends that go beyond the codes in use, that are it artistic codes or social and intellectual conventions.

In the USA, on the moral and human ruins of the Second World War, a society took shape at the end of the 1950s that saw in the mass production of consumer goods and in modern domestic technologies an evident sign of progress.[13]

In 1951, the Canadian sociologist Marshall McLuhan[14] published *The Gutenberg Galaxy*[15], a book that anticipated the revolution in the field of electronic communications: photography, cinema, and then television and computers would increasingly threaten the exclusive role of artists as creators of images.

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On both sociological considerations destined to cause a sensation for over a decade, in 1954 the English critic Lawrence Alloway[16], reflecting on the value of images in mass society, coined the term: pop art (where pop stands for popular).[17]

These are more or less the connotations that will be given to this new nascent aesthetic: easy, transitory, suggestive, commercial, and massified.

Pop culture is a type of culture characteristic of societies that have entered the stage of mass consumption. This is characterized by the action of influence that the mass media have on it. It is a type of culture that also influences the economy of a particular society. In fact, it spreads through the laws of the free market. The most important ideas and concepts are disseminated through newspapers, cinema and above all through television: in mass culture there is a very close link between influences from television and consumption.[18] So, much of the population directs its expenditure precisely according to those rules implicitly dictated by the mass media. Hence, the mass media exercise a tight control over society itself.

One of the greatest figures of American mass culture is certainly Andy Warhol[19] – he revolutionized art and the very concept of the artistic gesture, and he did so through the 'banality' of everyday life, mass culture, the “kitsch” (the term kitsch has German origins and was initially used to describe ugly objects).

Through photography, the silk-screen repetition of popular images – whether they were the road accident or the Coca-Cola bottle – filming, and writings, he recorded or rather consumed, everything that surrounded him. He did this by setting up a real commercial enterprise, the famous Factory, the result of the idea that art is nothing more than an industry and therefore falls within the commercial logic.[20]

On these sociological considerations destined to cause a sensation for over a decade, in 1954, the English critic Lawrence Alloway, reflecting on the value of images in mass society, coined the term: pop art (where pop stands for popular). These are more or less the connotations that will be given to this new nascent aesthetic: easy, transitory, suggestive, commercial, and massified.

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Then in England, there was the artist Richard Hamilton, who created a revolutionary work: Just what is it that makes today's homes so different, so appealing?

A lot is already understood from the title: the artist represents a room containing a variegated combination of popular symbols, starting from media such as a newspaper and television. Various imaginative and oversized objects such as a lampshade with the Ford logo, and elements that arouse mystery such as Mars, draw attention to the UFO phenomenon that was all the rage in those years.

The first thing one realizes, however, is a bodybuilder and a pin-up represented as a lamp woman. The two icons represent the ideal types of human beings of their respective sexes, often featured in advertising campaigns.

The avant-gardes of the beginning of the century had expressed the individual's need for freedom with respect to an oppressive society, some had exalted war as a possibility of redemption, as a starting point for the birth of a new social order. Post-WW2, a new world emerged that was hungry for images, which produced and consumed like never done before.

In conclusion, artists began asking completely different questions from those investigated by their colleagues of the past. They wondered how they could have preserved the exclusive character of art and, above all, how it was possible to create a mix between artistic needs and consumer society. They attempted to answer these by creating new artistic methods like photos, a reworking of advertising images, comic books, performances and, in some cases, even works improvised by the artist in front of the spectators. This was the end of an era of art that lasted for over a millennium.

The Legalization of Marijuana's Economic Ramifications By Jared Shear

The legalization of recreational and medical marijuana has significant economic effects that must be considered. Among these effects are the impact on housing values, the resources freed up in law enforcement, and the tremendous tax revenue effects. Thousands of jobs will be created with the legalization of cannabis, and the economy will benefit greatly. However, legislation is heavily debated and highly polarized. Bill Fay, an award-winning author who writes on financial happenings, discusses how law enforcement will benefit from the legalization of marijuana as it frees up law enforcement's time and resources. Fay clarifies this by pointing out that "$10.7 billion could be saved each year from the country's $193 billion in annual criminal justice expenditures if marijuana arrests – 5.54 percent of all criminal apprehensions – were stopped" (1). Fay also analyzes the massive tax revenue that the legalization of cannabis has brought to Washington, a state that has legalized recreational marijuana, by sharing that "$2 billion in tax revenue will be raised over the next five years" (1). With the significant boost the legalization of marijuana brings to the economy due to the tax revenue generated and fewer government resources devoted to law enforcement, it begs the question: should the United States federal government legalize marijuana?

Police departments will benefit economically from the legalization of marijuana due to the reallocation of resources previously devoted to marijuana enforcement, decreasing crime rates, and reducing the black market for cannabis. Meredith Buettner, the Executive Director of the Pennsylvania Cannabis Coalition, claims that "police departments that are freed from marijuana arrests will have more resources to devote to serious crimes" (1). Budgets, jobs, and resources solely dedicated to marijuana in law enforcement can be reallocated with the legalization of marijuana. This can benefit society greatly, with law enforcement and the government being able to devote their means to more pressing matters. Jesse Burkhardt, who has a Ph.D. in Environmental and Resource Economics, and Chris Goemans, who has a Ph.D. in Economics, conclude that their research's statistics prove that crime rates decrease with the legalization of cannabis by pointing out "that new dispensaries result in 13% fewer non-marijuana (hard) drug and alcohol crimes per month…" (182). Burkhardt and Goemans also discuss the Americans affected when claiming "that the opening of dispensaries actually decreases violent crime rates in above median income neighborhoods" (163). Illegal marijuana

distribution runs through the black market, so law enforcement has to devote many resources to enforcing the current marijuana statutes. Dr. Michael Amlung, who has an M.S. and Ph.D. in Psychology, and James MacKillop, an addiction researcher at McMaster University, discuss marijuana's prominent presence on the black market. Amlung and MacKillop explain that "with the elimination of marijuana on the black market, law enforcement resources will become freed up." If marijuana were federally legalized, police departments' finances and assets would benefit significantly because they would no longer have to fund projects and commit resources to enforce marijuana laws. After all, the black market for cannabis and crime rates overall will significantly decrease.

Despite research disagreeing on whether the legalization of cannabis generates positive or negative tax revenue, considerable tax revenue emerges from legalization due to the decreased demand for tobacco and alcohol products. Ian Irvine, an economics professor at Concordia University, and Miles Light, a researcher at the University of Colorado, believe that "the net tax revenue from legalization will be limited" (314). Irvine and Light do not think that the legalization of marijuana has economic benefits, contrary to popular belief. The authors add that "This should warn advocates of legalization" (314). Essentially, they believe that Canada's data from the legalization suggests that tax revenue is not as significant as legalization proponents make it out to be. Bill Fay disagrees with Irvine and Light by stressing that "$2 billion in tax revenue will be raised over the next five years; for Colorado: $600 million in taxes and savings over the same period." Boyoung Seo, a professor at the Kelley School of Business, and Keaton Miller, who holds a Ph.D. in Economics, disagree with Bill Fay by believing that if cannabis were legalized federally, it would decrease tax revenue because the legalization would decrease alcohol and tobacco revenues. After all, the data suggests they are substitutes. Miller and Seo point out that "...roughly 40 percent of the tax revenues earned from the cannabis industry in its first full calendar year were cannibalized from other substance revenues" (134). Seo and Miller's model provides evidence that the demand for substances goes down with the legalization of cannabis, pointing out that alcohol goes down the most when they conclude that "Assuming constant prices, liquor demand decreased by 16 percent and cigarette demand decreased by 5 percent. These results suggest that the intensive margin response to changes in cannabis prices may also differ across substance products" (120). Even though the net tax revenue from

legalizing cannabis is unclear, the alcohol and tobacco industries will undoubtedly see a decrease in tax revenue if marijuana is legalized.

The federal legalization of cannabis affects the economy due to the increasing home values and the impact the legalization has on the real estate market. Taylor Covington, a graduate of Champlain College, discusses how states that have legalized recreational cannabis have seen their housing prices increase. She explains that "After legalizing recreational marijuana, home prices grew at rates above the national average in 60% of states: Colorado, Washington, Oregon, Michigan, Maine, Nevada" (1). Covington also alludes throughout her article that states that have legalized recreational marijuana longest (Colorado and Washington) have experienced the most housing growth (1). Yanling Mayer and Walter J. Mayer, a finance professor and economics professor at the University of Mississippi, respectively, along with Cheng Cheng, a Senior Economist at Amazon, discuss how the legalization of marijuana has resulted in increased home values. The authors claim that "legalizing retail marijuana leads to an average 6% housing value appreciation" (1600). They conclude and stress that their research shows that legalizing marijuana will help the economy and provide net profits. Aviva Sonenreich, a commercial real estate broker, agrees with Y. Mayer, W. Mayer, Cheng as well as Covington through her discussion of how, due to the legalization of marijuana in Colorado, there was a "42% increase in demand for warehouses, and 27% saw an increase for storefronts, and 21% increase for land." Sonenreich agrees with Covington in that "of the states that have had legalized recreational and medical marijuana the longest, 32% saw commercial lease addendums addressing the growth, and 30% saw lease addendums addressing sales of marijuana" (1). Sonenreich believes this effect is due to the massive influx of cash with a new industry rapidly emerging. With the legalization of marijuana, more jobs and businesses are created, which in turn creates more money for people to buy homes. Consequently, the increased demand drives the price of homes up. The legalization of marijuana has a significant and consistent effect on the real estate market, which lawmakers should keep in mind when evaluating the economic effects of marijuana being legalized.

Legalizing marijuana on a federal level would be a significant and controversial action by the government. When considering such action, lawmakers must realize that the legalization of marijuana has more positive economic benefits than not. Despite the unclear effect of legalization on tax revenue, legalization provides relief to police departments and positively

affects housing prices. Covington adds to the legalization's positive effects on the economy: Colorado has “made $1B in marijuana tax revenue since 2014, and these dollars are being used toward preventing youth consumption, protecting public health and safety, and investing in public school construction.” In conclusion, federal legislation that makes marijuana medically and recreationally legal generates more positive benefits than adverse effects for the economy.
Word Count: 1299

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Cinematography: When to Use Animation, Visual Effect, and Live Action By Ziyun Zhou

Abstract

Cinematography technology has advanced rapidly in recent years as new mediums of visual communication begin to emerge. With technology such as 3D modeling and 2D animation, directors can create scenes that they never could have envisioned before. These can be combined to help produce magnificent movie scenes. This paper attempts to compare live-action movies, visual effects, and animation with the aim of informing general readers when each should be used most effectively during film creation. This paper will (1) define animation and visual effects, (2) analyze their production phases, genres, emotions, and costs/budgets, and (3) summarize when to use each to achieve different results of visual communication in cinematography.

Animation refers to all animated works, whether they are hand-drawn or computer generated. Live-action films, on the other hand, are films or scenes that need actors, settings, and camera operators to create the action physically. VFX (short for visual effects) is a process where the computer creates scenes, images, and special effects that cannot be produced by human filmmakers, physically. Anything that cannot be fulfilled in reality can be achieved by computer-animated visual effects. VFX is typically used with live-action to create difficult scenes that look realistic. Animation and VFX, in general, are used for films that are abstract or to film objects that cannot be achieved in real life—objects such as, but not limited to, mecha, anthropomorphic non-humans, UFOs, and aliens. Generally, animation is a heavily visual-based medium, while live action can be a combination of many elements.

The key difference between animation and live action is the procedure and the product. The process for all filmmaking includes developing, planning, shooting, and post-production editing. While having the same elements in a film: setting, plots, character development, and themes, the process that each goes through will differ (Marques, “Why Understanding the Differences”). This paper aims to provide some insights into how live-action and animation can impact the film differently and which one to choose under certain circumstances.

Development & Production Phases

The development process for animation includes choosing a specific type of animation and deciding whether it will be done in 2D or 3D modeling. The director needs to make decisions about the storyline, theme, illustrators, and voice actors. Live action also needs to decide on the story, ideas, and themes while choosing actors who fit the characters. Both types need to have a general idea of how long the project is going to last, who their audience is, and approximately how much of a budget they will need.

The pre-production phases are similar for both types of filmmaking: they include planning, scriptwriting, and storyboarding. Creating the overall story differs from the genre of the film, but it involves the same process. While the pre-production is similar, the compiling of scripts differs slightly. Animation scripts might need a detailed description of the scenes, which allows for a clear understanding of the imagery to be used before the production. Scripts for live-action will mainly consist of lines that the actors are going to say and are mainly used for actors to practice. Another slight difference is that a script could change, even during the production phase for live action, but scripts for animation will likely be locked (Marques, "Live Action vs Animation"). Both types of films use mood boards, which are guides for film design using different visual elements such as images, colors, or videos (Fezza, "What is a Mood Board"). The mood board for live shooting tends to give clients a complete vision of the film—a product that is close to the final result. Animation's mood boards will be more vague but are developed further during the process of production. Storyboards for live action are used for pre-visualizing scene setup, while storyboards for animation lay out the director's vision and imagery to illustrators.

During production, live-action films need to set up scenes and require a specific number of days for shooting. Scenes may require a change of location, and they have many variables to deal with, such as the weather or unforeseen scheduling conflicts. Animation may take longer during the production phase because the illustrators need extensive time to create the scenes. Voiceovers will also be done during the production phase of the animation. This takes an incredible amount of time because the illustrators must precisely time the voiceover and the scenes and ensure that they fit each other with the exact length, which is quite difficult. So, while live shooting may take only a few weeks, animation production may take a few months.

The post-production phase takes longer for live action than it does for animation. Live-action directors must go through a process of choosing footage and video editing. They also need to make decisions about sound effects, visual effects, and music. Sound effects and voiceovers may be more critical if used in animation, depending on the type of animation. Narrative-based animation does not use voiceovers; the film depends only on the character development and the plot. If the story uses content-based animation, it will rely on voiceovers to deliver the message, as this is used for more abstract themes and content-heavy films (Stormy Studio, "Live Action vs Animation"). Thus, for the post-production phase in animation, sound design, composition, and color grading are three vital decisions directors must consider. Adding or cutting scenes will also be done during post-production for animation.

Genre

Animation can be used in any genre. *Minions* and other Disney animations are examples of Western animation, while anime such as *Your Name* and *Haikyuu* are examples of Japanese anime culture. Sports anime is a popular genre, even though the topic is not supernatural. The reason why directors choose to use animation for sports is that it is difficult to find people with exceptional physical abilities to perform the movements required. Also, real-life professionals and elite athletes typically do not have the acting talent for films. It makes sense because they spend all their time training for their sport, so they would never have time to learn how to act. If they did try to act in a film, they would have to leave their training, which would be detrimental to their athletic performance and team performance. At the same time, talented actors can take time to train for the sports requirements, but they cannot promise a satisfactory final result. However, in animation, how fast a character can run or how high they can jump is decided by the illustrators. Anything that seems hard to achieve is easy with computer animation, and they do not need to worry about training—which requires a tremendous amount of time and money. Animation for sports films achieves these scenes with much greater results than live action under these conditions unless it is a documentary for a specific sports team. Western animation also includes elements of fantasy, as seen in movies like *Frozen* and *Aladdin*. As *Aladdin* has a live-action remake, VFX is added to create similar effects as the animated version.

Live-action films, on the other hand, are usually about realistic topics such as romance, documentary, and crime. Films such as *Little Women*, *Green Book,* and *The Shawshank*

Redemption are examples of films that are shot in live-action. These movies convey emotions effectively using camera composition and editing techniques to show the actor's expressions. Since VFX is not added, color grading and camera movements are vital for conveying ideas and emotions effectively. However, animation is sometimes used in live-action films when imaginary realms come into the story. As a combination, the animated layer will be on top of the live-action footage to show audiences an imaginary world.

VFX is generally used in films that are supernatural, such as science fiction films, horror, and fantasy (Maio, "What is VFX"). Science fiction films such as *Ready Player One*, *Inception,* and *Interstellar* used VFX constantly to show the audience a world that they imagine. *Ready Player One* uses 3D modeling to create *the Oasis*—A Virtual Reality (VR) where the characters often go in the film to escape the pain in their real lives. The VR scenes are computer generated, so they look slightly different from the real world, which allows the audience to separate the two worlds. Many scenes with crazy backgrounds are created with green screens, so the backgrounds are VFX as well. Fantasy movies are hard to create using live action due to complex VFX, but *Harry Potter* is a great example of how VFX is used to deliver the magic world to the audiences.

Emotion

It is easier to communicate emotions to the audience with live action since people can relate more to the emotions of human actors than animated characters. Actors are more authentic because they are human. But is live action always better than animation to convey emotions? Some Disney live-action remakes of their classic animations are not as good as the animation according to many audiences and critics (Carter, "Mulan (2020) VS Mulan (1998)"). One example is the film *Mulan*. The animated version of *Mulan* was released in 1998, while the live version of *Mulan* was released in 2020. Though these films tell the same story, the live-action version of *Mulan* certainly got lower ratings and negative comments than the animated version of *Mulan*. Why is that? First, the directors chose to convey time differently. The director of 2020 *Mulan*, Niki Caro, decided to eliminate the time length of important plots, such as Mulan spending time with her father before the male villagers are called to war (Carter, "Mulan (2020) VS Mulan (1998)"). The live-action movie also decided to increase the time length for establishing characters in the first twelve minutes of the movie, while the animated version used only a fraction of the time to do the same thing.

In fact, the problem with most live-action remakes is that time is not used effectively as the animated version. They rush scenes, which could show the audience how a certain character's internal conflict develops, and they prolong scenes that seem to be of little significance to the overall theme and purpose of the story. The animated version of *Mulan* effectively portrayed the dynamics of family relationships. Even though Mulan failed to bring honor to the family, her father tried to make her feel better first. These actions impacted Mulan hugely, which resulted in her deciding to join the army for her father. Powerful scenes during this stage were cut from the live action, with the director deciding to use a flashback later in the story, which lessened the emotional impact. The details of Mulan's struggle during her training sessions were edited to portray Mulan as perfect in every aspect, which made her seem superior. This is one of the major changes that bothered many *Mulan* fans because the powerful scenes about perseverance and personal growth were removed. The changes in plot, time use, and emotional appeal all contribute to the argument that the live-action version of *Mulan* is far less effective than the animated version of *Mulan* (Carter, "Mulan (2020) VS Mulan (1998)"). These problems also occur with other Disney remakes such as *Lion King* and *Beauty and the Beast*. Thus, live action will only be better than animation in conveying emotions if the editors maintain the original intentions and work hard to make the emotions as realistic as possible.

A director may choose to use live-action or animation for a film project based on the budget, time limits, audience, and overall purpose. When a director first decides to create a film, various things need to be considered: The emotion that a director wants to deliver to the audience is one of the major elements that will impact whether animation or live-action is a better choice. Live action is a better medium to deliver a relatable message and to create empathy and compassion. Animation, on the other hand, can explain complex ideas and build excitement. In short, if a director has a low budget and is creating an abstract concept, animation might be the more logical choice. If a director has a high budget and is creating an emotional concept, live shooting might be better.

Cost

When it comes to the cost of animation and live action, research shows that a sixty-second animated explainer video will cost about $7,972 on average and will take about five weeks to create (Hayes, "How Much Does an Explainer Video Cost"). Freelance animation costs

and studio animation costs also differ, with studio animation costs being slightly higher. Having more illustrators will cost more, but the time of production will also accelerate. Production will be more or less expensive depending on the number of professionals on the team for live action. More actors raise costs because they not only need to be paid, but they also need to be fed and transported, which is an exponential increase. The location for shooting also needs to be accessible. Research shows that the real estate of Hogwarts in the movie Harry Potter is valued at around $22,675,000 (Grimminick, "10 Real Life"). In general, more budget always results in a more sophisticated outcome for both animation and live action (Stormy Studio, "Live Action vs Animation: A comparison.").

Another important element to consider when choosing animation or live-action is the potential reception of the film. Using popular actors and actresses in live-action may increase the popularity of the film since a number of fans will support the actors. This also applies to directors or scriptwriters (Cross, "How Much Does Live Action vs Animation Cost"). However, animes don't need actors because they are more based on the story and character design, they may need more effort to make them popular.

Pros and Cons

The pros and cons of using live-action and animation are obvious. The budget, time consumed, efforts contributed, and results differ significantly. Animation does not require a specific film location which saves a lot of money and energy. Workers (illustrators) can simply work in the comfort of their homes or office in front of their screens. Animation also doesn't require actors, and voice actors might be needed depending on the content. Animation allows the audience to visualize a scene that they might not be able to imagine on their own. Animation is also more flexible than live action. Scenes can be added or deleted even after the production phase, as long as the voiceover scenes are not changed. If the product and expectations change during the process, animation can be easily updated and adjusted. Animation can bring a simple theme to life and can break down a message visually, which is more challenging in live-action film production. On the other hand, animation can feel impersonal to certain audiences depending on the subject. It also might take longer to produce than live action. Even though time and effort are saved, it can be hard for animations to become popular without a lot of money for

advertisement and special voice actors. Animations start from zero, though, unless a well-known company or director is involved.

Live action is also faster to create. However, the more complex the live-action video is, the more it costs. Sets, camera equipment, actors, insurance, video editors, visual effects, food, transportation, and other costs must all be considered. The director needs time to find actors that suit the characters, and he or she has to communicate with the actors during the shooting process (Melvin, Animation vs. Live Action). For example, the director needs to tell the actor how to pose, where the camera is shooting, and what kind of emotions he wants them to convey. The actors also need time to learn about the characters that they portraying. This might take a long time if the actors are assigned to complicated characters. Live-action films are hard to adjust in the post-production phase because the video editors need to stick to their footage because the actors and the filmmakers might not be able to film another round if they find a scene missing or if they have a scene to add.

In conclusion, animation and live-action can be used together and separately to achieve different goals. There are benefits and drawbacks to both animation and live action, and if used wisely they will have different outcomes that impact the audiences in the way that will best.

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To What Extent is There a Correlation Between GDP Per Capita in European Countries and Renewable Energy Consumption in 2019? By Alex Knight

Abstract

This paper analyzes and investigates the relationship between GDP per capita in European countries and Renewable energy consumption as a % of final total energy consumption. The data used is from 2019. The investigation found no correlation between the two variables however does identify a correlation between Renewable energy consumption as a % of final total energy consumption and a countries geographical location in Europe.

Introduction

Climate Change is a global environmental issue caused by excess emissions of GHGs into the atmosphere through human activity. This is known as the anthropogenic greenhouse gas effect. Climate change and its effect on global temperatures have many consequences including increased natural disasters, droughts and damage to food production systems(Causes and effects of climate change).

The issue of climate change is relevant to renewable energy consumption as a primary factor contributing to climate change is the combustion of fossil fuels. In the USA 65% of GHG emissions are from fossil fuels (EPA). Thus renewable sources of energy are an alternative to fossil fuels and a possible solution to the issue.

GDP Per capita(GDPPC) is relevant to this investigation as fossil fuels currently have an economic competitive advantage over renewable energy sources. This is as transitioning away from fossil fuels to renewable energy is less profitable than maintaining fossil fuels (Chrobak). Therefore the issue of climate change is economic as well as environmental.

This investigation will examine whether higher average incomes lead to increased demand, and a subsequent increase in supply, for renewable energy consumption (REC) since higher costs are a primary barrier to REC. The investigation will focus on the REC and GDPPC of European countries. Figures from 2019 from the World Data Bank will be used.

The results of this investigation can provide insight into whether a reduction in GHG emissions can be achieved by increasing individuals' incomes. The investigation is also relevant to the debate on whether emerging economies should focus on economic development, with the

assumption that environmental awareness is a byproduct of development or that development through environmentally friendly methods will prevent the need for high-cost transitions to renewable energy.

It can be hypothesised that higher GDPPC will lead to higher REC. Since a barrier to renewable energy use is the price, higher incomes suggest a higher demand and subsequent supply of renewable sources of energy. Furthermore, countries with higher GDPPC may be wealthier and therefore invest in renewable energy infrastructure more. A study in Brazil also suggests higher incomes lead to higher environmental awareness (Philippines & Angeoletto,39–44).

The independent variable of this investigation is the GDPPC of countries in Europe from the most recent year which is 2019. The REC is the dependent variable. This will be measured as a percentage of total energy consumption in a country.

Methodology

Data for REC as a percentage of total final energy consumption and Nominal GDPPC (US$) for European countries with data was collected from 'Data World Bank' for the year 2019. Only countries from Europe were sampled to prevent the influence of uncontrollable variables such as environment, politics and EVSs. This included Turkey, Russia, Ukraine and Cyprus.

Justification of Sampling

This investigation sampled all European countries. San Marino and the Vatican City are excluded from this investigation as both do not have data on REC from 2019. All European countries are sampled as it provides both a large enough sample and limits the effect of uncontrollable variables including politics and geography.

Safety and Ethical Considerations

Safety considerations are not applicable to the data source. The data presented does not threaten or endanger any group or viewer. The data is from the World Bank which enables the public to access its data and is a reputable site. All information and sources are cited from reliable sources and credit is given.

Data

Figure 1: Table to slow GDP per Capita and REC for European Countries in 2019 (Renewable Energy Consumption) (GDP per Capita) Countries GDP Per Capita (US $) PPP Renewable Energy Consumption (% of final total energy consumption)

Andorra	40, 898 18. 20
Austria	50, 114 33. 77
Belarus	6, 838 7. 83
Belgium	46, 599 10. 21
Bulgaria Croatia Cyprus	9, 879 19. 34 15, 312 31. 60 29, 206 12. 60
Czech Republic	23, 660 15. 85
Denmark	59, 776 37. 52
Estonia	23, 398 31. 29
Finland	48, 629 45. 76
France	40, 579 15. 53
Germany	46, 795 17. 17
Greece	19, 134 18. 51
Hungary	16, 736 13. 64
Bosnia and Herzegovina	6, 120 37. 02
North Macedonia	6, 070 16. 32
Italy	33, 674 17. 24

Kosovo	4, 416 26. 1
Latvia Norway Lithuania	17, 927 41. 52 75, 720 62. 37 31, 186 33. 53
Malta	47, 1507. 70
Moldova	4, 492 22. 04
Montenegro	8, 910 38. 74
Netherlands	52, 4768. 54
Poland	15, 732 12. 18
Portugal	23, 331 28. 19
Romania	12, 889 23. 54
Russian Federation	11, 5363. 22
Serbia	7, 417 21. 53
Slovak Republic	19, 304 17. 64
Slovenia	25, 943 20. 86
Spain	29, 555 17. 27
Sweden	51, 939 52. 88
Switzerland	85, 335, 24. 76,
Turkiye	9, 122, 14. 12
Ukraine	3, 662, 7. 44

United Kingdom	43, 071 12. 24
Luxembourg	113, 219 16. 45
Iceland	68, 942 81. 07
Ireland	80, 887 12. 34
Liechtenstein	169, 049 56. 13

Figure 2: Scatter Graph to Show GDP Per capita vs REC for European Countries in 2019

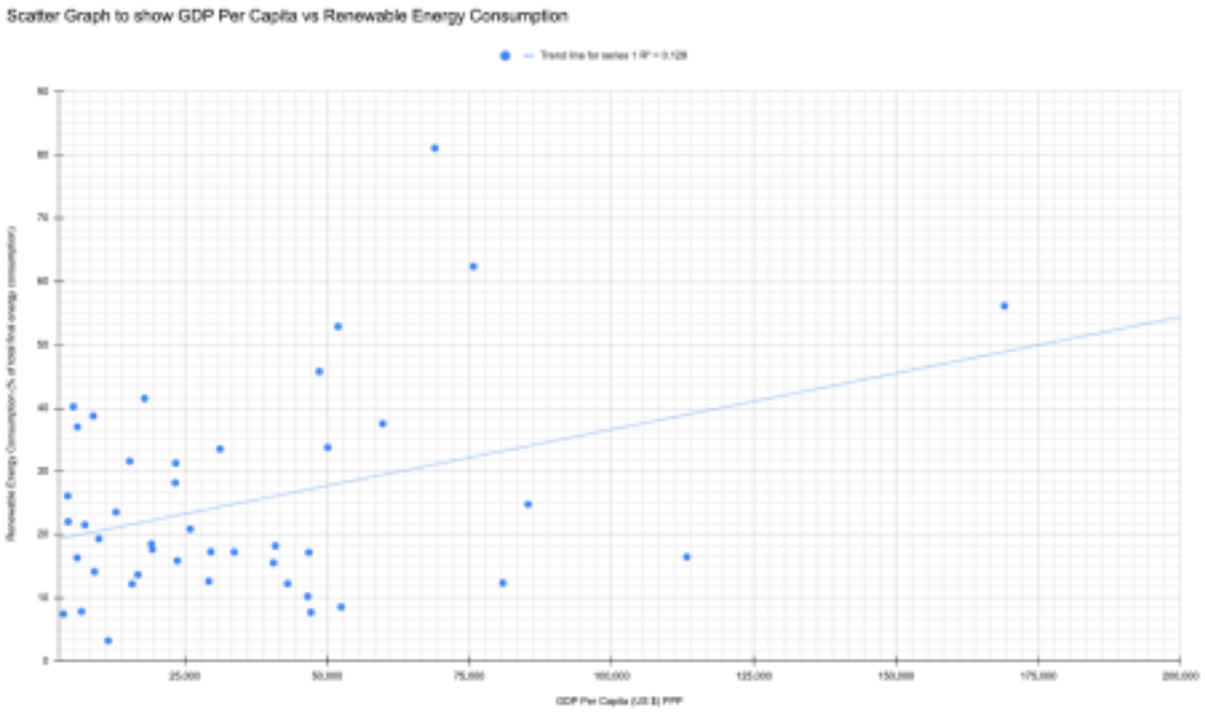


Figure 3: Scatter graph to show GDP Per capita vs Renewable Energy Consumption excluding outliers for European Countries in 2019

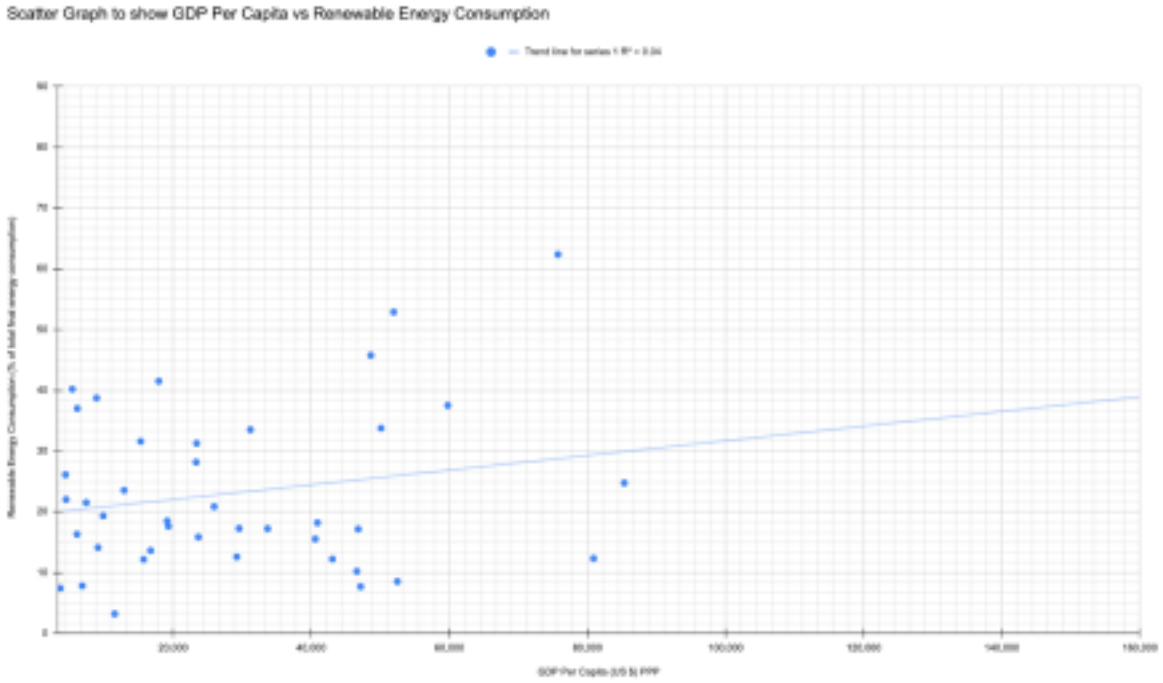
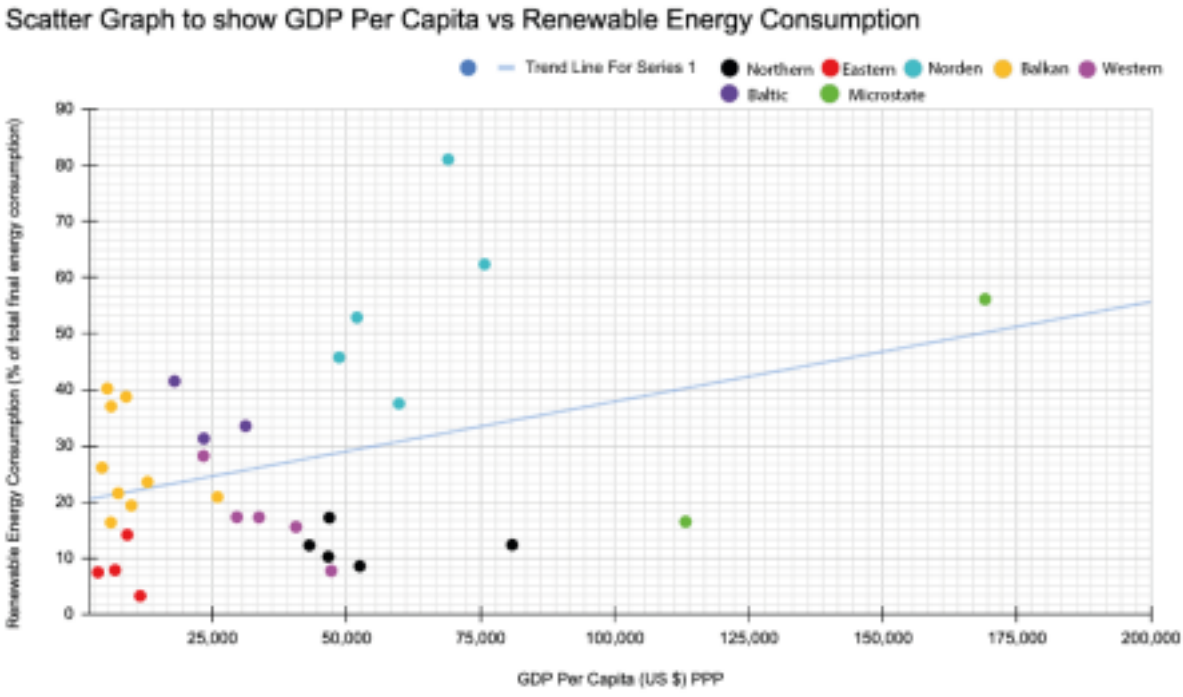


Figure 4: Scatter graph to show GDP Per capita vs Renewable Energy Consumption by regions for European Countries in 2019



Analysis and Discussion

Figure 1 suggests that there is a weak correlation. However, the graph highlights the presence of outliers. Outliers for figure 3 have been removed with the following formulae:

$$3 + (1.5 \times)$$

$$1 - (1.5 \times)$$

$$3 = h$$

$$1 =$$

$$=$$

The following cut-offs for outliers were calculated:

$$= 93,246.75$$

$$= -46,775.25$$

$$= 63.31$$

$$= -15.78$$

The three outliers were Luxembourg and Liechtenstein, high GDPPC, and Iceland, high REC. Luxembourg and Liechenstein's anomalous nature is possibly due to both countries having small populations with low tax rates. Iceland's anomalous nature is due to the country's geography which allows the nation to source 65% of its energy from geothermics alone. Removing the outliers did improve the reliability of the results as the standard deviation decreased from 328 in figure 2 to 220 in figure 3. This suggests that the data was closer to the mean in figure 3. The correlation coefficient (r) decreased from 0.337 in figure 2 to 0.200 in figure 3. This is significant, as the r value for figure 1 suggests a weak correlation, which is identified as being between 0.3 and 0.7 by Kognity, while figure 3 suggests a lack of any correlation (Pearson's r-correlation).

While in figure 3, Norway, with the highest REC has the second highest GDPPC there appears to be no trend or pattern in terms of the two variables. This is evidenced by the fact that the two countries with the highest GDPPC, Ireland and Switzerland in figure 3, have relatively low REC at 12.34% and 24.76% respectively. Inspection of the data suggested that a trend based on regions may be present. This is presented in figure 4.

The Norden countries for example composed 4 of the top 5 countries for REC. From

figure 4 it can be seen that the Norden countries have comparatively high REC. These countries predominantly use hydroelectric (HEP) and biofuel power (Facts about Hydropower). This is partially due to favourable environmental conditions but also similar political views. A two-sample t-test produced these results when comparing the mean REC of Norden countries (μ) against all the other regions ( ) at a 5% significance level: $_1\mu_2$

$$H_0 = \mu_1 = \mu_2$$

$$H_1 = \mu_1 > \mu_2$$

$$P_{val} = 0.0000004$$

Since the Pval is less than 0.05 there is sufficient evidence to reject that Norden countries have a lower REC. This evidences the claim that the Norden countries have a significantly higher REC. Eastern European countries defined as Russia, Ukraine, Belarus and Turkey have low REC as well as low GDPPC. Russia, Ukraine and Belarus, three neighbouring countries make up 3 of the lowest 4 countries in terms of REC. Russia, Ukraine and Belarus arguably do not consume renewable energy as all nations are natural gas rich. Furthermore, all four countries have low GDPPC in comparison to Europe. The four countries are also authoritarian.

The Balkans have relatively high REC despite low GDPPC. For example the 6th and 7th highest RECs are Montenegro and Albania. While Albania uses HEP predominantly, Montenegro for example uses geothermal (GTP) as well(Albania Hydropower) (Energy sector in Montenegro). The use of these resources are arguably caused by once again favourable environmental conditions. A t-test of GDPPC and then REC between the Balkan countries and Eastern European ones presented the following:

$$P_{val} = 0.304$$

$$P_{val} = 0.00150$$

Since the P value for GDPPC is less than 0.05 there is sufficient evidence to reject the claim that Balkan countries do not have a higher REC than Eastern European countries. This is supported by figure 4. However the Pval for GDPPC is greater than 0.05 so it can be concluded that despite the difference in REC, there is no significant difference between the regions' GDPPC. Suggesting that the regional differences were of more significance.

The Northern Countries (UK, Ireland, Germany, Netherlands, Belgium) and Western countries (France, Spain, Portugal, Italy, Malta) all had low REC, below 20%, despite higher GDPPC. Despite these nations being wealthier than the Balkan countries, for example, the findings

suggest that the western and northern countries may not be inclined to invest in the expensive infrastructure required. These regions can be grouped together as there is no statistically significant difference in their REC:

$$\text{[illegible]} = 0.192$$

The two microstates, Luxembourg and Liechtenstein, have the highest GDPPC. While Luxembourg's REC is low in Liechtenstein it is high. This is most likely because Liechtenstein's mountainous terrain is favourable for the HEP used.

The Baltic States while having similar GDPPC to western countries have slightly higher REC. The use of renewable energy is similar between the countries. This may be due to the nation's similar politics in relation to Russia as the three nations have been reducing their energy reliance on Russia's natural gas.

Other European nations including Central Europe were left out of this graph as there was no detectable trend between them. While the region arguably did not affect these countries' REC it does not detract from the differences between regions discussed above.

Conclusion

Overall, there is no correlation between GDPPC and renewable energy consumption as a percentage of total energy consumption in European countries. This was especially evident after removing outliers in the data set. This falsifies the hypothesis that REC increases as GDPPC increases. The t-tests also suggested that regional differences, not GDPPC, were statistically significant in affecting REC in Europe due to the political, cultural and geographical factors explored in the discussion.

Evaluation

The lack of a correlation between GDPPC and REC is arguably rationalised by the fact that practical reasons including the environmental suitability of renewable sources of energy had a greater effect on energy usage. This may have explained the regional differences. However, the regional disparities may have also been due to ecocentric or anthropocentric value systems that were common within the regions. These value systems may have influenced the respective countries' politics as well as the general consumer demand. This being said, the categorization of regions in Europe is open to interpretation with countries such as Turkey arguably not being

European countries. Nevertheless, technological feasibility and governmental or individual value systems may explain why the purely economic justification of REC was falsified. This point is strengthened by the fact that countries that had high REC often sourced energy from HEP and GTP, both of which require infrastructure investment and environmental suitability.

The literature on REC and GDPPC suggests that in emerging economies real GDP(RGDP) has a positive effect on REC. This was presented by a study from Energy Policy (Sardosky). There were differences with the study from Energy Policy as RGDP, REC per capita, and emerging economies were used. Therefore, another explanation for the results is that the results were too limited as Europe did not have sufficient variability in economic development to extrapolate results to a global scale. A solution to this could be sampling all countries including emerging economies.

The results were also arguably limited by the use of GDPPC. Firstly this metric of income does not account for the distribution of wealth or inflation. This may have overestimated or underestimated the incomes of countries therefore reducing the validity of the results. This can be mitigated by using real GDPPC.

The sample size for each respective region was arguably too small to draw conclusions. For example, there were only 4 Eastern European countries reducing the reliability of the t-tests conducted. By increasing the sampling to the entire world, regions categorised by geographical features for example can have greater sample sizes, as they are not confined to those in Europe, improving the results of the tests.

The investigation's method also had strengths. The sample size was sufficient to analyse trends with 44 different countries. The sampling region, data source, time period and GDP metric were kept constant by following the methodology.

The removal of outliers was a strength of the investigation as more reliable data was presented reflected by the decreased standard deviation. Without removing the outliers the lack of a correlation between the variables would not have been illustrated. Another strength of the investigation was the identification of trends within regions of Europe.

Further Investigation

A further area of study could be investigating HDI as the IV. This is as HDI while encompassing GDPPC, also takes into account other variables of development such as life

expectancy. This may provide a more holistic approach to quantifying the effect an individual's standard of living has on REC. This may control more uncontrolled variables that may affect REC, increasing the reliability and validity of the results.

Application

As discussed, climate change is partially caused by fossil fuel combustion for energy. Since average incomes do not contribute to REC but factors such as politics do, government spending can be used to invest in renewable energy infrastructure. The investigation has shown that countries with high REC often used HEP or GTP that require infrastructure spending that is often financed by the government.

HEP and GTP have significant strengths. Both energy sources are renewable and do not contribute to climate change. Damns, from which HEP energy is sourced, are relatively cheap to run after construction(Davis & Nagle). Both sources of energy are also reliable as they do not depend on variable environmental conditions like wind or solar energy.

There are disadvantages to HEP and GTP however. Firstly, the construction of dams are expensive. Furthermore vast areas can be flooded leading to habitat and farmland loss, displacement of people and the restriction of the flow of sediment impacting ecosystems and farms further downstream(Davis & Nagle). Similarly, GT plants are high in cost ranging from $2-7 million for a plant with 1-megawatt capacity(What are advantages and Disadvantages of Geothermal Energy). Furthermore, they are location dependent as the plants need to be in areas where the energy is accessible.

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